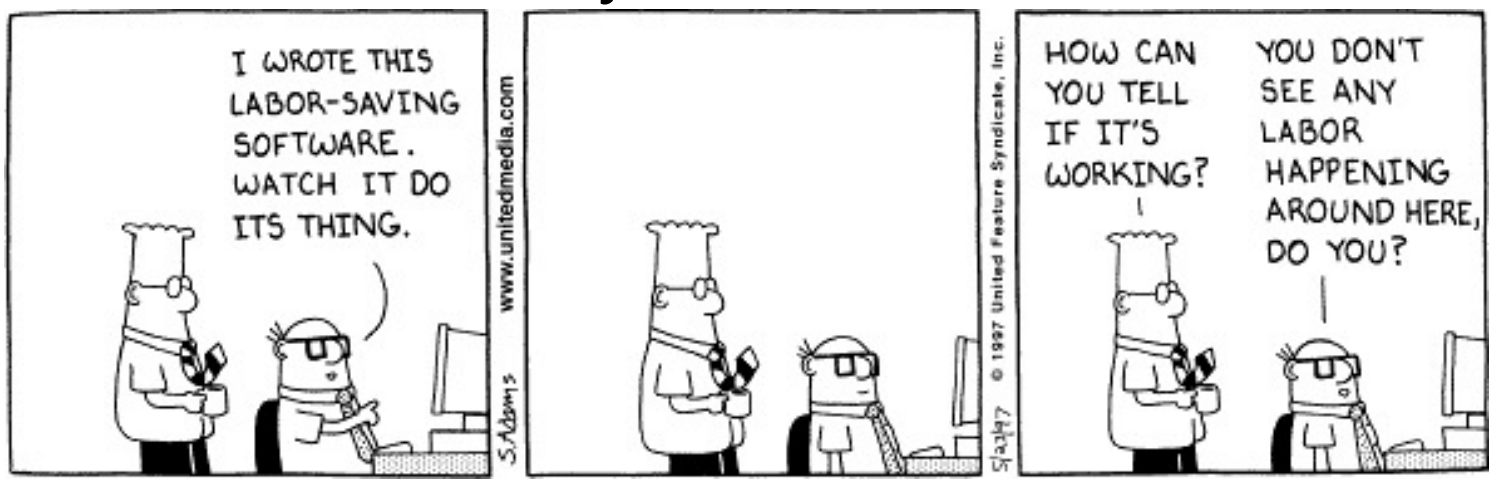
Week 6: Processes

CS211: Programming and Operating Systems

Thursday, 18 March 2021



Usual reminders...

	Mon	Tue	Wed	Thu	Fri
09:00					
10:00					
11:00					
12:00					
13:00				***Recorded***	
14:00					
15:00	**LAB**		***Recorded***		
16:00	**LAB**				

1. This week, we have just one recorded classes: Thursday at 13:00.
2. The lab next Monday (22 March) will be a continuation of the one that started this week.
3. An introduction to the lab wa srecorded, and is now available.

Feedback on Feedback

- Thank you to the 8 of you that completed the feedback form circulated by Noelle Gannon.
- On average, it took 6 minutes, 33 seconds to complete.
- Mostly very positive.
- Several people are “unsure” or “disagree somewhat” with the statement that “The feedback I have received is helping me to improve my learning”. Which is fair! (Will do better!).
- The “live-but-recorded” lectures seem to be popular (which I was unsure of, since the quality is not very high).
- Some good suggestions for improvement:
  - ***“Exam style questions with some worked solutions near the end of the module”***. [Response: will post last year’s exam, and solutions.]
  - ***“... it would be great if the lecturer did more examples step by step”. “ more time explaining and repeating the basics and the syntax at the beginning would help”. “Would be really helpful is if we could see the program being written and run during the lecture!”*** [Response: very helpful – will try to do this]

Feedback on Feedback

- ***"Getting worked examples of the assignments after they've been submitted would be really helpful too"***. [Response: Yes! Will do this once I get the assignments graded].
- ***"I think it would be better to have the homework posted a few days before the live lab session"***. [Response: Good suggestion, and I hope the new approach of having an assignment running over two weeks will help. But I can't promise more, since I'm already stretched getting it posted the night before the 3pm lab.]

This week in CS211:

1. Part 1: The Process
   - Process API
   - Process State
2. Part 2: Process Creation
   - Example 1: `fork()`
   - Example 2: `02Fork2.c`
   - Example 3: `getppid()`

This week of “Programming and Operating Systems”, we segue from **Programming** to **Operating Systems**, starting with the concept of a **process** (OS). But we will write C programs that manipulate processes (Programming + OS).

CS211
Week 6: Processes

Start of ...

PART 1: The Process

Part 1: The Process

As we now move towards the “Operating System” part of the course, the need to learn some classical OS Theory. The presentation given here is quite standard, and you should find equivalent descriptions in any OS text-book.

Material from this point one relates to Chapters 4 and 5 of Operating Systems: Three Easy Pieces by Remzi H. Arpaci-Dusseau and Andrea C. Arpaci-Dusseau:

Processes: `http://pages.cs.wisc.edu/~remzi/OSTEP/cpu-intro.pdf`

Process API: `http://pages.cs.wisc.edu/~remzi/OSTEP/cpu-api.pdf`

"A Process... is a running programme" (OSTEP, p25)

Most OS will give the impression that many programmes are running at one time. The user/programmer does not know or care of the CPU is currently busy: the OS gives them the impression that it is available for their (exclusive) use.

This is made possible by abstracting the concept of a running program as a **process**.

"*The OS creates this illusion by virtualizing the CPU*": we will study, later, how this scheduling achieved. For now, we will take it that we need the concept of the **process** to do this.

Every process consists of:

- the ***Process Text*** - the code of the program
- the ***program counter*** – the address of the next instruction to be executed.
- the ***process stack*** (temporary data, e.g., local variables, return addresses, etc)
- the ***data section*** – global variables.

A process is ***not*** (just) a program: if two users run the same program at the same time they create different processes.
A program is a ***passive*** entity, whereas a process is ***active/dynamic***.

Often, the terms *process* and *job* can be used interchangeably.

Here is a minimal set of operations that an OS must be able to apply to a process.

Create a new process, e.g., when you click on an icon.

Destroy (or terminate) a process,

Wait that is **pause** the process until some other event occurs.

Suspend and resume: like wait, but invoked more explicitly.

Status report: information about a process, such as how long it has run for, how much memory has been allocated to it, etc.

The **state** of a process is defined (in part) by the current activity of that process:

new:	The process is being created
running:	Instructions are being executed
blocked:	(also called “waiting”). The process is waiting for some event to occur
ready:	The process is waiting to be assigned to a processor
terminated:	The process has finished execution.

Here is a diagram of the process life-cycle, featuring

new • **running** • **blocked** • **ready** • **terminated**

CS211
Week 6: Processes

Start of ...

PART 2: Process Creation

In this section, we'll see how to create a process in C using the `fork()` function. Unfortunate, this won't work under Windows/codeblocks. So use one of the online compilers, such as `https://repl.it` or `onlinegdb.com`

Part 2: Process Creation

A parent process creates children processes, which, in turn create other processes, forming a tree of processes.

After a parent creates a subprocess it may:

- execute[1] ***concurrently*** with the child
  or
- ***wait*** until child terminates before it continues.

The parent may share all, some or none of its resources with the child (resources include memory space, open files, the terminal, etc.)

It is usually the case that the child will share the parent's memory only in the sense that it receives a copy.
The child can then mimic the parents execution, or it might over-write (or "*over-lay*") its memory space with other instructions.

[1] "Execute" in this context means "run" or "preform operations", as in "to execute a plan"

All processes have a unique **Process Identification Number** – ***PID*** for short. If we create a subprocess in a C program using the `fork()` function, a new process is created:

- The new process run concurrently with its parent, unless we instruct the parent to `wait()`.
- The subproc is given a copy of the parents memory space.
- At the time of creation, the two processes are almost identical, except that the `fork()` returns the child's PID to the parent and 0 to the child.

In order to use this function, we must include the *`unistd.h`* header file. This provides various functions including

- `fork()`
- `getpid()`
- `getppid()`

Example 1: `fork()`

04Fork.c

```
1  // An example of forking a process

3  #include <unistd.h>
   #include <stdio.h>
5  #include <stdlib.h>


   int main(void )
9  {
     int pid1, mypid;

     pid1 = fork();
13   mypid = getpid();

15   printf("I am %d\t", mypid);
     printf("Fork returned %d\n", pid1);
17   return(0);
   }
```

When I compile and run this (e.g., on https://www.onlinegdb.com/) I get something like

```
I am 7791. Fork returned 0
I am 7790. Fork returned 7791
```

IMPORTANT: *unistd.h* is not included in the installation of `code::blocks` on Windows. Try

- https://www.onlinegdb.com/online_c_compiler
- https://www.jdoodle.com/c-online-compiler
- https://paiza.io/projects/
- https://rextester.com/l/c_online_compiler_gcc
- But not https://www.tutorialspoint.com/compile_c_online.php or http://www.compileonline.com/ or https://www.codechef.com/. Also problematic: https://ideone.co

02Fork2.c

```
// An example of forking two processes
#include <unistd.h>
#include <stdio.h>
#include <stdlib.h>

int main(void )
{
  int pid1, pid2, mypid;

  pid1 = fork();
  pid2 = fork();
  mypid = getpid();

  printf("I am %d\t", mypid);
  printf("1st fork returned %d\t", pid1);
  printf("2nd fork returned %d\n", pid2);
  return(0);
}
```

Running that we might get:

```
I am 7802. 1st Fork returned 7803. 2nd Fork returned 7805
I am 7803. 1st Fork returned 0. 2nd Fork returned 7804
I am 7804. 1st Fork returned 0. 2nd Fork returned 0
I am 7805. 1st Fork returned 7803. 2nd Fork returned 0
```

Discuss: Why do we get this output?

Example 3: `getppid()`

The parent knows the child's PID because it is returned by `fork()`. The child can find out its parent's PID, by using the `getppid()` function:

06ParentsPID.c

```
6  int main(void )
   {
8    int pid1;
     pid1 = fork();
10   printf("I am %d\t", getpid());
     printf("fork returned %5d\t", pid1);
12   printf("My parent is %d\n", getppid());
     return(0);
14 }
```

OUTPUT:

```
I'm proc 7825. fork() returned 0. My partent is 7824
I'm proc 7824. fork() returned 7825. My partent is 5394
```