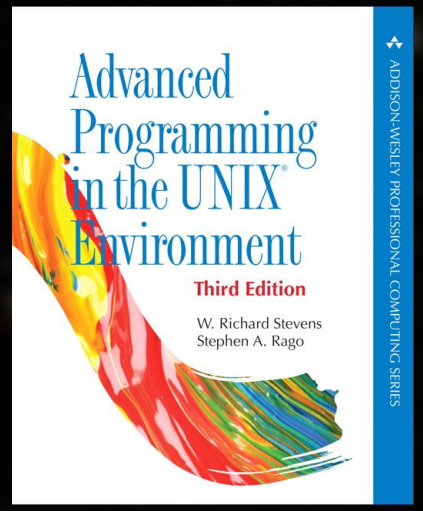
Kill Bill (2003) - Quentin Tarantino

Lab08 and Lec08 → Nov. 17
Lab09 and Lec09 → Nov. 24



Chapter 10: Signal

Chapter 15: Inter-Process Communication

Multiprocessing

aka multiprogramming

Single Processor ~~Multiprocessor~~

Inter-Process Communication

Parent ↔ Child

Any Process ↔ Any Other Process

Single Processor ~~Multiprocessor~~

Parent → Child

Passing Tasks

Passing Information

Parent → Child

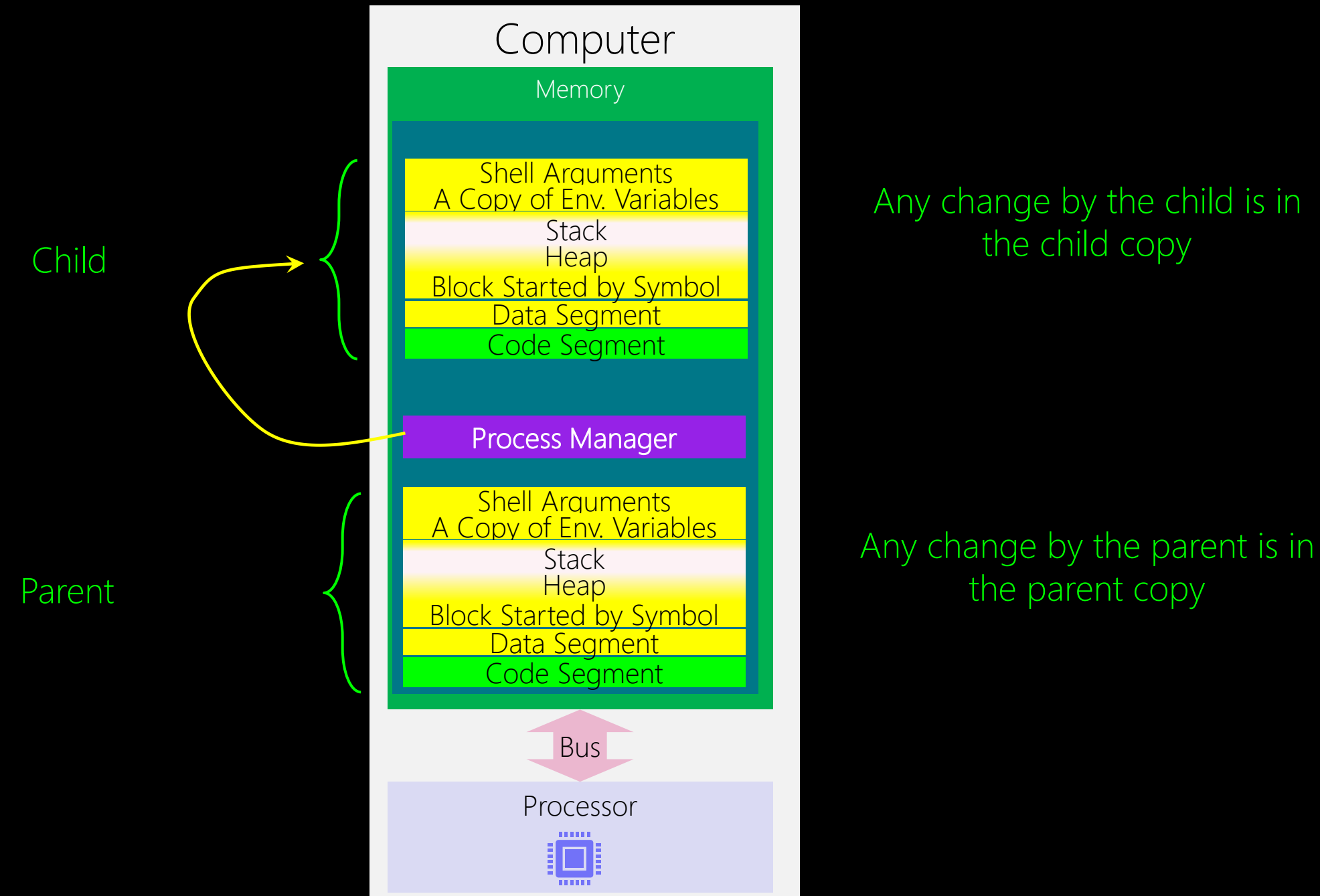
```
int child_pid = fork();
if(child_pid == -1){
        perror("impossible to have a child!");
        exit(1);
}
if(child_pid >= 0){//(child_pid != -1)
        if(child_pid > 0)
                printf("I am the parent, pid=%d\n", getpid());
        else{//(child_pid == 0)
                printf("I am the child, pid=%d\n", getpid());
                printf("My parent pid=%d\n", getppid());
                //Assign child's tasks here
                exit(0);
        }
}
//Assign parent tasks here
```

Child's Tasks

Parent's Tasks

Wait for the child

```
exit(0);
```


Computer
Memory
Shell Arguments
A Copy of Env. Variables
Stack
Heap
Block Started by Symbol
Data Segment
Code Segment
Child
Any change by the child is in the child copy
Process Manager
Shell Arguments
A Copy of Env. Variables
Stack
Heap
Block Started by Symbol
Data Segment
Code Segment
Parent
Any change by the parent is in the parent copy
Bus
Processor

Parent → Child

Passing Tasks

Passing Information

After `fork()`, any change to the variables are local to the parent and child processes.

After `fork()`, there is no conversation/communication until …

Parent

Parent → Child

13

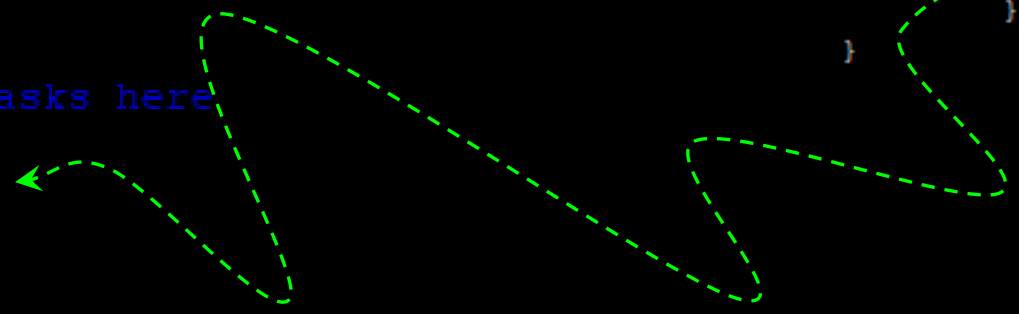
```
int child_pid = fork();
if(child_pid == -1){
        perror("impossible to have a child!");
        exit(1);
}
if(child_pid >= 0){//(child_pid != -1)
        if(child_pid > 0)
                printf("I am the parent, pid=%d\n", getpid());
        else{//(child_pid == 0)
                printf("I am the child, pid=%d\n", getpid());
                printf("My parent is pid=%d\n", getppid());
        }
}

//Assign parent tasks here
int *child_exit;
wait(child_exit);
```

Child

Parent → Child

0

```
int child_pid = fork();
if(child_pid == -1){
        perror("impossible to have a child!");
        exit(1);
}
if(child_pid >= 0){//(child_pid != -1)
        if(child_pid > 0)
                printf("I am the parent, pid=%d\n", getpid());
        else{//(child_pid == 0)
                printf("I am the child, pid=%d\n", getpid());
                printf("My parent is pid=%d\n", getppid());
        }
        exit(0);
}
```



Wait for Child Process be over

System Calls: `wait()` in `sys/wait.h`

```
#include <sys/wait.h>
pid_t wait(int *statloc);
```

Return Child's PID if OK, or −1 on error

Wait for Child Process be over

System Calls: `wait()` in `sys/wait.h`

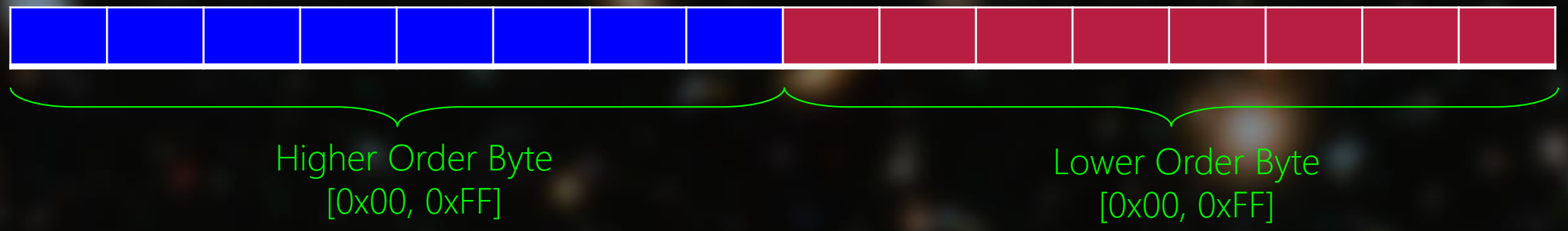
```
#include <sys/wait.h>
pid_t wait(0);
```

Parent does not care about how the child terminates!

Return Child's PID if OK, or –1 on error

Wait for Child Process be over

`int *statloc → status`



Macro	Description
`WIFEXITED(`*status*`)`	True if status was returned for a child that terminated normally. In this case, we can execute `WEXITSTATUS(`*status*`)` to fetch the low-order 8 bits of the argument that the child passed to `exit`, `_exit`, or `_Exit`.

`WIFSIGNALED(`*status*`)`	True if status was returned for a child that terminated abnormally, by receipt of a signal that it didn't catch. In this case, we can execute
	`WTERMSIG(`*status*`)`
	to fetch the signal number that caused the termination.
	Additionally, some implementations (but not the Single UNIX Specification) define the macro
	`WCOREDUMP(`*status*`)`
	that returns true if a core file of the terminated process was generated.

`WIFSTOPPED(`*status*`)`	True if status was returned for a child that is currently stopped. In this case, we can execute `WSTOPSIG(`*status*`)` to fetch the signal number that caused the child to stop.
`WIFCONTINUED(`*status*`)`	True if status was returned for a child that has been continued after a job control stop (XSI option; `waitpid` only).

Figure 8.4 Macros to examine the termination status returned by `wait` and `waitpid`

```c
#include <unistd.h>
#include <stdlib.h>
#include <stdio.h>
#include <sys/wait.h>
int main(int argc, char *argv[]){
        int a = 0;
        int b = 0;
        a = atoi(argv[1]);
        b = atoi(argv[2]);

        printf("I am a lonely process, pid=%d\n", getpid());
        int child_pid = fork();
        if(child_pid == -1){
                perror("impossible to have a child!\n");
                exit(1);
        }
        if(child_pid >= 0){//(child_pid != -1)
                if(child_pid > 0)
                        printf("I am the parent, pid=%d\n", getpid());
                else{//(child_pid == 0)
                        printf("I am the child, pid=%d\n", getpid());
                        //Assign child's tasks here
                        printf("child: %d + %d = %d\n", a, b, a - b);
                        exit(0);
                }
        }
        //Assign parent tasks here
        printf("parent: %d + %d = %d\n", a, b, a + b);
    int child_exit;
    wait(&child_exit);

    if (WIFEXITED(child_exit))
            printf("normal termination, exit status = %d\n", WEXITSTATUS(child_exit));
    else if (WIFSIGNALED(child_exit))
            printf("abnormal termination, signal number = %d\n", WTERMSIG(child_exit));
```

```
hfani@alpha:~$ ./child_exit_status 3 5
I am a lonely process, pid=1911307
I am the parent, pid=1911307
parent: 3 + 5 = 8
I am the child, pid=1911308
child: 3 + 5 = -2
normal termination, exit status = 0
```

Macro	Description
`WIFEXITED(`*status*`)`	True if status was returned for a child that terminated normally. In this case, we can execute `WEXITSTATUS(`*status*`)` to fetch the low-order 8 bits of the argument that the child passed to `exit`, `_exit`, or `_Exit`.

`WIFSIGNALED(`*status*`)`	True if status was returned for a child that terminated abnormally, by receipt of a signal that it didn't catch. In this case, we can execute
	`WTERMSIG(`*status*`)`
	to fetch the signal number that caused the termination.
	Additionally, some implementations (but not the Single UNIX Specification) define the macro
	`WCOREDUMP(`*status*`)`
	that returns true if a core file of the terminated process was generated.

`WIFSTOPPED(`*status*`)`	True if status was returned for a child that is currently stopped. In this case, we can execute `WSTOPSIG(`*status*`)` to fetch the signal number that caused the child to stop.
`WIFCONTINUED(`*status*`)`	True if status was returned for a child that has been continued after a job control stop (XSI option; `waitpid` only).

Figure 8.4 Macros to examine the termination status returned by `wait` and `waitpid`

Signaling

Like Electric Shock (IRQ) from Devices to Processor (hardware), Signals are Process Shock to Another Process (software)

Software Interrupts

Kernel Process → Other Processes
Parent → Child
Ancestor Process → Grandchildren

Name	Description	ISO C	SUS	FreeBSD 8.0	Linux 3.2.0	Mac OS X 10.6.8	Solaris 10	Default action
SIGABRT	abnormal termination (abort)	•	•	•	•	•	•	terminate+core
SIGALRM	timer expired (alarm)		•	•	•	•	•	terminate
SIGBUS	hardware fault		•	•	•	•	•	terminate+core
SIGCANCEL	threads library internal use						•	ignore
SIGCHLD	change in status of child		•	•	•	•	•	ignore
SIGCONT	continue stopped process		•	•	•	•	•	continue/ignore
SIGEMT	hardware fault			•	•	•	•	terminate+core
SIGFPE	arithmetic exception	•	•	•	•	•	•	terminate+core
SIGFREEZE	checkpoint freeze						•	ignore
SIGHUP	hangup		•	•	•	•	•	terminate
SIGILL	illegal instruction	•	•	•	•	•	•	terminate+core
SIGINFO	status request from keyboard			•		•		ignore
SIGINT	terminal interrupt character	•	•	•	•	•	•	terminate
SIGIO	asynchronous I/O			•	•	•	•	terminate/ignore
SIGIOT	hardware fault			•	•	•	•	terminate+core
SIGJVM1	Java virtual machine internal use						•	ignore
SIGJVM2	Java virtual machine internal use						•	ignore
SIGKILL	termination		•	•	•	•	•	terminate
SIGLOST	resource lost						•	terminate
SIGLWP	threads library internal use			•			•	terminate/ignore
SIGPIPE	write to pipe with no readers		•	•	•	•	•	terminate
SIGPOLL	pollable event (poll)				•		•	terminate
SIGPROF	profiling time alarm (setitimer)			•	•	•	•	terminate
SIGPWR	power fail/restart				•		•	terminate/ignore
SIGQUIT	terminal quit character		•	•	•	•	•	terminate+core
SIGSEGV	invalid memory reference	•	•	•	•	•	•	terminate+core
SIGSTKFLT	coprocessor stack fault				•			terminate
SIGSTOP	stop		•	•	•	•	•	stop process
SIGSYS	invalid system call		XSI	•	•	•	•	terminate+core
SIGTERM	termination	•	•	•	•	•	•	terminate
SIGTHAW	checkpoint thaw						•	ignore
SIGTHR	threads library internal use			•				terminate
SIGTRAP	hardware fault		XSI	•	•	•	•	terminate+core
SIGTSTP	terminal stop character		•	•	•	•	•	stop process
SIGTTIN	background read from control tty		•	•	•	•	•	stop process
SIGTTOU	background write to control tty		•	•	•	•	•	stop process
SIGURG	urgent condition (sockets)		•	•	•	•	•	ignore
SIGUSR1	user-defined signal		•	•	•	•	•	terminate
SIGUSR2	user-defined signal		•	•	•	•	•	terminate
SIGVTALRM	virtual time alarm (setitimer)		XSI	•	•	•	•	terminate
SIGWAITING	threads library internal use						•	ignore
SIGWINCH	terminal window size change			•	•	•	•	ignore
SIGXCPU	CPU limit exceeded (setrlimit)		XSI	•	•	•	•	terminate or terminate+core
SIGXFSZ	file size limit exceeded (setrlimit)		XSI	•	•	•	•	terminate or terminate+core
SIGXRES	resource control exceeded						•	ignore

Figure 10.1 UNIX System signals

Terminal/Shell → Process

SIGINT (interrupt signal), SIGTSTP (terminal stop)

When user hits `Ctrl+C` or `Ctrl+Z` keys, an IRQ (device manger, file manager) becomes a Signal (process manager)

To stop a runaway process

```
hfani@alpha:~$ vi shell_signal.c
```

```c
#include <unistd.h>
#include <stdlib.h>
#include <stdio.h>
#include <sys/wait.h>
#include <fcntl.h>
int main(int argc, char *argv[]){
        printf("I am a lonely process, pid=%d\n", getpid());
        int child_pid = fork();
        if(child_pid == -1){
                perror("impossible to have a child!\n");
                exit(1);
        }
        if(child_pid >= 0){//(child_pid != -1)
                if(child_pid > 0)
                        printf("I am the parent, pid=%d\n", getpid());
                else{//(child_pid == 0)
                        printf("I am the child, pid=%d\n", getpid());
                        while(1){};//busy waiting ...
                        exit(0);
                }
        }
        int child_exit;
        wait(&child_exit);//the child never ends! So, the parents waits forever
        if (WIFEXITED(child_exit))
                printf("normal termination, exit status = %d\n", WEXITSTATUS(child_exit));
        else if (WIFSIGNALED(child_exit))
                printf("abnormal termination, signal number = %d\n", WTERMSIG(child_exit));

        exit(0);
}
```

Busy Waiting!

```
hfani@alpha:~$ ./shell_signal
I am a lonely process, pid=1717701
I am the parent, pid=1717701
I am the child, pid=1717702
^Z
[2]+  Stopped                 ./shell_signal
hfani@alpha:~$
```

SIGTSTP (“Terminal SToP”)

The parent is stopped (terminated?) How about the child?

Try ctrl+c to send SIGINT and check the difference.

Use the ps (process status) command to see the list of processes

Processor → Kernel → Process

SIGILL (illegal Instruction)
SIGFPE (floating point exception, e.g., division by 0)
SIGSEGV (invalid memory reference)

An IRQ (device manger, file manager) becomes a Signal (process manager)
In general, any hardware can generate an error that becomes a signal to a process with the help of kernel!

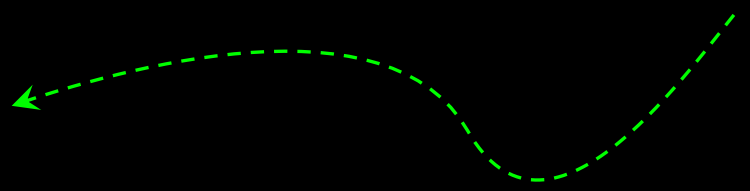
```
hfani@alpha:~$ vi processor_signal.c
```

```c
#include <unistd.h>
#include <stdlib.h>
#include <stdio.h>
#include <sys/wait.h>
#include <fcntl.h>
int main(int argc, char *argv[]){
        printf("I am a lonely process, pid=%d\n", getpid());
        int child_pid = fork();
        if(child_pid == -1){
                perror("impossible to have a child!\n");
                exit(1);
        }
        if(child_pid >= 0){//(child_pid != -1)
                if(child_pid > 0)
                        printf("I am the parent, pid=%d\n", getpid());
                else{//(child_pid == 0)
                        printf("I am the child, pid=%d\n", getpid());
                        printf("%d\n", 1/0);
                        exit(0);
                }
        }
        int child_exit;
        wait(&child_exit);
        if (WIFEXITED(child_exit))
                printf("normal termination, exit status = %d\n", WEXITSTATUS(child_exit));
        else if (WIFSIGNALED(child_exit))
                printf("abnormal termination, signal number = %d\n", WTERMSIG(child_exit));

        exit(0);
}
```

SIGFPE (floating point exception, e.g., division by 0)

```
hfani@alpha:~$ cc processor_signal.c -o processor_signal
processor_signal.c: In function ‘main’:
processor_signal.c:18:20: warning: division by zero [-Wdiv-by-zero]
   18 |     printf("%d\n", 1/0);
      |                    ^
hfani@alpha:~$ ./processor_signal
I am a lonely process, pid=1702425
I am the parent, pid=1702425
I am the child, pid=1702426
abnormal termination, signal number = 8
```

SIGFPE (floating point exception, e.g., division by 0)



Child → Kernel → Parent

SIGCHLD

We've already seen this behind the scene for `wait()` by the parent

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Parent → Child
Ancestor → Grandchildren
Powerful Process → Other Processes

SIGXXX

```
#include <signal.h>

int kill(pid_t pid, int sig);
```

0 if OK, -1 on error (signal# invalid, pid invalid, or not have permission to send the signal to any receiving process)

Signal Handling

aka disposition of a signal or action associated w/ a signal

The receiver process should do what?

Signal Handling

aka disposition of a signal or action associated w/ a signal

The receiver process should do what?

1) Ignore it! Do nothing. Sometimes it is not at your hand though (SIGKILL, SIGSTOP, SIGFPE, ...)
2) Let the default action happen (every signal has already assigned to a default action)
3) Catch the signal and handle it properly (define a function as signal handler)

Name	Description	ISO C	SUS	FreeBSD 8.0	Linux 3.2.0	Mac OS X 10.6.8	Solaris 10	Default action
SIGABRT	abnormal termination (abort)	•	•	•	•	•	•	terminate+core
SIGALRM	timer expired (alarm)		•	•	•	•	•	terminate
SIGBUS	hardware fault		•	•	•	•	•	terminate+core
SIGCANCEL	threads library internal use						•	ignore
SIGCHLD	change in status of child		•	•	•	•	•	ignore
SIGCONT	continue stopped process		•	•	•	•	•	continue/ignore
SIGEMT	hardware fault			•	•	•	•	terminate+core
SIGFPE	arithmetic exception	•	•	•	•	•	•	terminate+core
SIGFREEZE	checkpoint freeze						•	ignore
SIGHUP	hangup		•	•	•	•	•	terminate
SIGILL	illegal instruction	•	•	•	•	•	•	terminate+core
SIGINFO	status request from keyboard			•		•		ignore
SIGINT	terminal interrupt character	•	•	•	•	•	•	terminate
SIGIO	asynchronous I/O			•	•	•	•	terminate/ignore
SIGIOT	hardware fault			•	•	•	•	terminate+core
SIGJVM1	Java virtual machine internal use						•	ignore
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SIGLOST	resource lost						•	terminate
SIGLWP	threads library internal use			•			•	terminate/ignore
SIGPIPE	write to pipe with no readers		•	•	•	•	•	terminate
SIGPOLL	pollable event (poll)				•		•	terminate
SIGPROF	profiling time alarm (setitimer)			•	•	•	•	terminate
SIGPWR	power fail/restart				•		•	terminate/ignore
SIGQUIT	terminal quit character		•	•	•	•	•	terminate+core
SIGSEGV	invalid memory reference	•	•	•	•	•	•	terminate+core
SIGSTKFLT	coprocessor stack fault				•			terminate
SIGSTOP	stop		•	•	•	•	•	stop process
SIGSYS	invalid system call		XSI	•	•	•	•	terminate+core
SIGTERM	termination	•	•	•	•	•	•	terminate
SIGTHAW	checkpoint thaw						•	ignore
SIGTHR	threads library internal use			•				terminate
SIGTRAP	hardware fault		XSI	•	•	•	•	terminate+core
SIGTSTP	terminal stop character		•	•	•	•	•	stop process
SIGTTIN	background read from control tty		•	•	•	•	•	stop process
SIGTTOU	background write to control tty		•	•	•	•	•	stop process
SIGURG	urgent condition (sockets)		•	•	•	•	•	ignore
SIGUSR1	user-defined signal		•	•	•	•	•	terminate
SIGUSR2	user-defined signal		•	•	•	•	•	terminate
SIGVTALRM	virtual time alarm (setitimer)		XSI	•	•	•	•	terminate
SIGWAITING	threads library internal use						•	ignore
SIGWINCH	terminal window size change			•	•	•	•	ignore
SIGXCPU	CPU limit exceeded (setrlimit)		XSI	•	•	•	•	terminate or terminate+core
SIGXFSZ	file size limit exceeded (setrlimit)		XSI	•	•	•	•	terminate or terminate+core
SIGXRES	resource control exceeded						•	ignore

Figure 10.1 UNIX System signals

+core

Dumping the memory image of the process before termination
Into a file in the current working directory of the process
Historically, the name of the file was “core”

This file can be used with most debuggers to examine the state of the process at the time it terminated.

Not part of POSIX!

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Catch the Signal

By the receiver process

Catch the Signal

By the receiver process

Reminder from C program
We can have pointer to a function (like a pointer to a variable)
You can call the function by its address rather than by its name!

```
return_type func_name(type0 arg0, type1 arg1, ….) → return_type (*func_ptr)(type0, type1, ….)
```

```
hfani@alpha:~$ vi func_pointer.c
```

```c
#include <stdio.h>
void say_hi(int times){
        for(int i = 0; i < times; ++i)
                printf("Hi!\n");
}
int main() {

        printf("saying hi by calling the function's name:\n");
        say_hi(3);
```

```
hfani@alpha:~$ cc func_pointer.c -o func_pointer
hfani@alpha:~$ ./func_pointer
saying hi by calling the function's name:
Hi!
Hi!
Hi!
```

```
hfani@alpha:~$ vi func_pointer.c
#include <stdio.h>
void say_hi(int times){
        for(int i = 0; i < times; ++i)
                printf("Hi!\n");
}
int main() {

        printf("saying hi by calling the function's name:\n");
        say_hi(3);


        printf("saying hi by calling the function's address:\n");
        void (*func_ptr)(int);  /* function pointer declaration */
```

`func_ptr` can keep address of ANY function that has

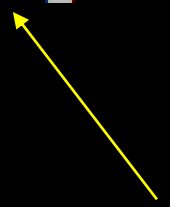
1) Single input argument of type `int`
2) output of type `void`

```
hfani@alpha:~$ vi func_pointer.c
```

```c
#include <stdio.h>
void say_hi(int times){
        for(int i = 0; i < times; ++i)
                printf("Hi!\n");
}
int main() {

        printf("saying hi by calling the function's name:\n");
        say_hi(3);


        printf("saying hi by calling the function's address:\n");
        void (*func_ptr)(int);  /* function pointer declaration */
        func_ptr = say_hi;  /* pointer assignment */
```



Pointer assignment happens just by assigning the name of the function to the pointer!

```
hfani@alpha:~$ vi func_pointer.c
```

```c
#include <stdio.h>
void say_hi(int times){
        for(int i = 0; i < times; ++i)
                printf("Hi!\n");
}
int main() {

        printf("saying hi by calling the function's name:\n");
        say_hi(3);


        printf("saying hi by calling the function's address:\n");
        void (*func_ptr)(int);  /* function pointer declaration */
        func_ptr = say_hi;  /* pointer assignment */
        func_ptr(3);  /* function call */

        return 0;
}
```

Call a function by its name is exactly the same as its pointer (address)

```
saying hi by calling the function's address:
Hi!
Hi!
Hi!
```

Catch the Signal

the receiver process subscribe a function to the kernel for one or more signals

```
#include <signal.h>

typedef void func(int);
func_ptr *signal(int, func_ptr *);
```

Returns previous signal catcher if OK, SIG_ERR on error

Example I

1) Parent send a signal to the child (harry up)
2) Child catches the signal and decides to ignore or do sth about it

```c
int main(int argc, char *argv[]){
        printf("I am a lonely process, pid=%d\n", getpid());
        int child_pid = fork();
        if(child_pid == -1){
                perror("impossible to have a child!\n");
                exit(1);
        }
        if(child_pid >= 0){//(child_pid != -1)
                if(child_pid > 0)
                        printf("I am the parent, pid=%d\n", getpid());
                else{//(child_pid == 0)
```

Child Tasks

```c
                  exit(0);
          }
  }
```

```c
printf("I sleep for 10 second and will be back with you to check on your progress, child.\n");
sleep(10);
kill(child_pid, SIGUSR1);

printf("I sleep for another 10 second. Hopefully you're done by then.\n");
sleep(10);
kill(child_pid, SIGUSR1);

printf("What's up child.\n");
sleep(10);
kill(child_pid, SIGUSR1);


int child_exit;
wait(&child_exit);
if (WIFEXITED(child_exit))
        printf("normal termination, exit status = %d\n", WEXITSTATUS(child_exit));
else if (WIFSIGNALED(child_exit))
        printf("abnormal termination, signal number = %d\n", WTERMSIG(child_exit));

exit(0);
```

Parent Tasks
Here, parent does nothing
Just does follow ups on the child
Every 10 seconds

```c
int main(int argc, char *argv[]){
        printf("I am a lonely process, pid=%d\n", getpid());
        int child_pid = fork();
        if(child_pid == -1){
                perror("impossible to have a child!\n");
                exit(1);
        }
        if(child_pid >= 0){//(child_pid != -1)
                if(child_pid > 0)
                        printf("I am the parent, pid=%d\n", getpid());
                else{//(child_pid == 0)
                        exit(0);
                }
        }
```

Child Tasks

In order to catch the signals of the parent, the child must:

1) Define a function to catch the signal
2) Subscribe the function to the kernel
3) Does her other tasks till the parent sends the signal

```c
int signal_counter = 2;
void child_signal_handler(int signal){
        printf("I received a signal from my parrent %d\n", getppid());
        printf("The signal is %d\n", signal);
        if(signal_counter <= 0){
                printf("Sorry ma! I couldn't finish it. It's not my fault. Kernel does not give me the processor. I quit!\n");
                exit(1);
        }
        else{
                printf("I still have %d chances. Let's finish it soon.\n", signal_counter);
                --signal_counter;
        }

}
```

In order to catch the signals of the parent, the child must:

1) Define a function to catch the signal → this function can handle any signal (why?)

```c
int main(int argc, char *argv[]){
        printf("I am a lonely process, pid=%d\n", getpid());
        int child_pid = fork();
        if(child_pid == -1){
                perror("impossible to have a child!\n");
                exit(1);
        }
        if(child_pid >= 0){//(child_pid != -1)
                if(child_pid > 0)
                        printf("I am the parent, pid=%d\n", getpid());
                else{//(child_pid == 0)
                        printf("I am the child, pid=%d\n", getpid());
                        //subscribe a signal handler to the kernel
                        void *res = signal(SIGUSR1, child_signal_handler);
                        if(res == SIG_ERR)
                                printf("subscription for SIGUSR1 was not successful!\n");

                        while(1){}//busy waiting
                        exit(0);
                }
        }
```

In order to catch the signals of the parent, the child must:

1) Define a function to catch the signal
2) Subscribe the function to the kernel → the child only subscribe the function for SIGUSR1 signal

```c
int main(int argc, char *argv[]){
        printf("I am a lonely process, pid=%d\n", getpid());
        int child_pid = fork();
        if(child_pid == -1){
                perror("impossible to have a child!\n");
                exit(1);
        }
        if(child_pid >= 0){//(child_pid != -1)
                if(child_pid > 0)
                        printf("I am the parent, pid=%d\n", getpid());
                else{//(child_pid == 0)
                        printf("I am the child, pid=%d\n", getpid());
                        //subscribe a signal handler to the kernel
                        void *res = signal(SIGUSR1, child_signal_handler);
                        if(res == SIG_ERR)
                                printf("subscription for SIGUSR1 was not successful!\n");

                        while(1){}//busy waiting
                        exit(0);
                }
        }
```

In order to catch the signals of the parent, the child must:

1) Define a function to catch the signal
2) Subscribe the function to the kernel
3) Does her other tasks till the parent sends the signal → busy waiting, not doing anything :D

```
hfani@alpha:~$ cc parent_child_signal.c -o parent_child_signal
hfani@alpha:~$ ./parent_child_signal
I am a lonely process, pid=1886308
I am the parent, pid=1886308
I sleep for 10 second and will be back with you to check on your progress, child.
I am the child, pid=1886309
I sleep for another 10 second. Hopefully you're done by then.
I received a signal from my parrent 1886308
The signal is 10
I still have 2 chances. Let's finish it soon.
What's up child.
I received a signal from my parrent 1886308
The signal is 10
I still have 1 chances. Let's finish it soon.
I received a signal from my parrent 1886308
The signal is 10
Sorry ma! I couldn't finish it. It's not my fault. Kernel does not give me the processor. I quit!
normal termination, exit status = 1
hfani@alpha:~$
```

Build and run the program to feel the conversation between the parent and her child.

Example I

1) Parent send a signal to the child (harry up)
2) Child catches the signal and decides to ignore or do sth about it

If the child finishes sooner, what happens to the signals of the parent?

Example I

1) Parent send a signal to the child (harry up)
2) Child catches the signal and decides to ignore or do sth about it

What if the child wants to subscribe the same signal handler for another signal, e.g., SIGUSR2?

SIGKILL, SIGSTOP

1) Cannot be Ignored
2) Cannot be caught

Kill Bill (2003) - Quentin Tarantino

Example II

Child ignores all the parent's signals

```c
void child_signal_handler(int signal){
        printf("I received a signal from my parrent %d\n", getppid());
        printf("The signal is %d\n", signal);
        printf("I don't care about your signal, ma! I simply ignore it");
}
```

The signal handler does nothing, just printing out messages.

```c
printf("I sleep for 10 second and will be back with you to check on your progress, child.\n");
sleep(10);
kill(child_pid, SIGUSR1);

printf("I sleep for another 10 second. Hopefully you're done by then.\n");
sleep(10);
kill(child_pid, SIGUSR1);

printf("What's up child.\n");
sleep(10);
kill(child_pid, SIGUSR1);

printf("Seems you don't care. I'll kill you!");
kill(child_pid, SIGINT);

int child_exit;
wait(&child_exit);
if (WIFEXITED(child_exit))
        printf("normal termination, exit status = %d\n", WEXITSTATUS(child_exit));
else if (WIFSIGNALED(child_exit))
        printf("abnormal termination, signal number = %d\n", WTERMSIG(child_exit));

exit(0);
```

The parent send a signal that cannot be ignored or caught.

```
hfani@alpha:~$ vi parent_child_ignore.c

hfani@alpha:~$ ./parent_child_ignore
I am a lonely process, pid=1978948
I am the parent, pid=1978948
I sleep for 10 second and will be back with you to check on your progress, child.
I am the child, pid=1978949
I sleep for another 10 second. Hopefully you're done by then.
I received a signal from my parrent 1978948
The signal is 10
I don't care about your signal, ma! I simply ignore it
What's up child.
I received a signal from my parrent 1978948
The signal is 10
I don't care about your signal, ma! I simply ignore it
Seems you don't care. I'll kill you
I received a signal from my parrent 1978948
!abnormal termination, signal number = 2
```

What if the child catches & ignores SIGINT?

What if a process catches & ignores CTRL+C or CTRL+Z?

Signals

Software Shocks: Urgent Communications

I'll send you a signal, if you don't do anything about it, I'll kill you!

Inter-Process Communication (IPC)

Normal Communication

Can you do this for me? Yes, here is it. Anything else?

Single Processor ~~Multiprocessor~~