AUP Assignment 7

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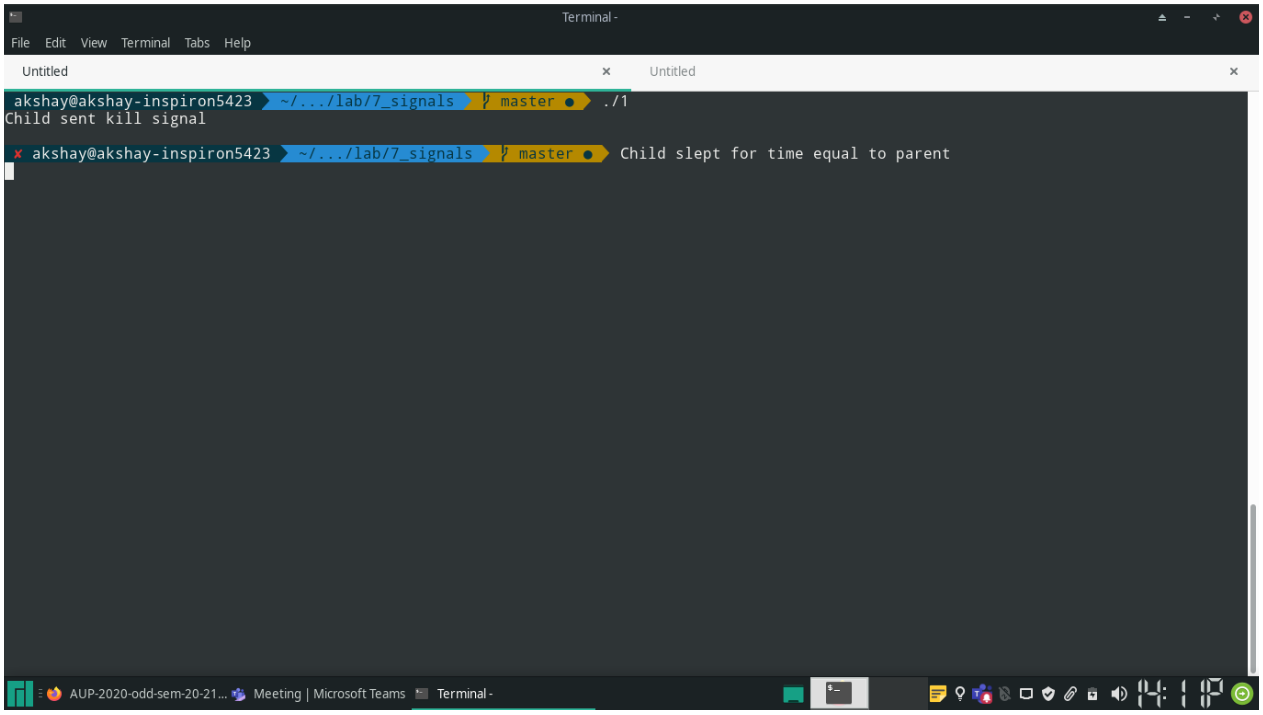
11th October 2020

Q1 Create a child process. Let the parent sleeps of 5 seconds and exits. Can the child send SIGINT to its parent if exists and kill it? Verify with a sample program.

Code

```c


#include <sys/types.h>
#include <unistd.h>
#include <signal.h>
#include <stdlib.h>
#include <stdio.h>
#include <errno.h>

int main(void) {
        int child_pid;

        if ((child_pid = fork()) == -1) {
                /* fork failed */
                perror("fork");
                return errno;
        }
        else if (child_pid) {
                /* parent */
                sleep(5);
                printf("Parent is Alive\n");
        }
        else {
                /* child */
                if (kill(getppid(), SIGINT) == -1) {
                        perror("SIGINT to parent");
                        return errno;
                }
                printf("Child sent kill signal\n");
                sleep(5);
                printf("Child slept for time equal to parent\n");
        }

        return 0;
}
```

Output



```
akshay@akshay-inspiron5423  ~/.../lab/7_signals  master ●  ./1
Child sent kill signal

✘ akshay@akshay-inspiron5423  ~/.../lab/7_signals  master ●  Child slept for time equal to parent
```

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Figure 1: Parent is alive not printed, parent killed by SIGINT sent by child

Q2:

Create a signal disposition to catch SIGCHLD and in the handler function display some message. Create a child process and let the child sleeps for some time and exits. The parent calls a wait() for the child. Display the return value of wait() to check success or failure. If failure, display the error number. Run the program:

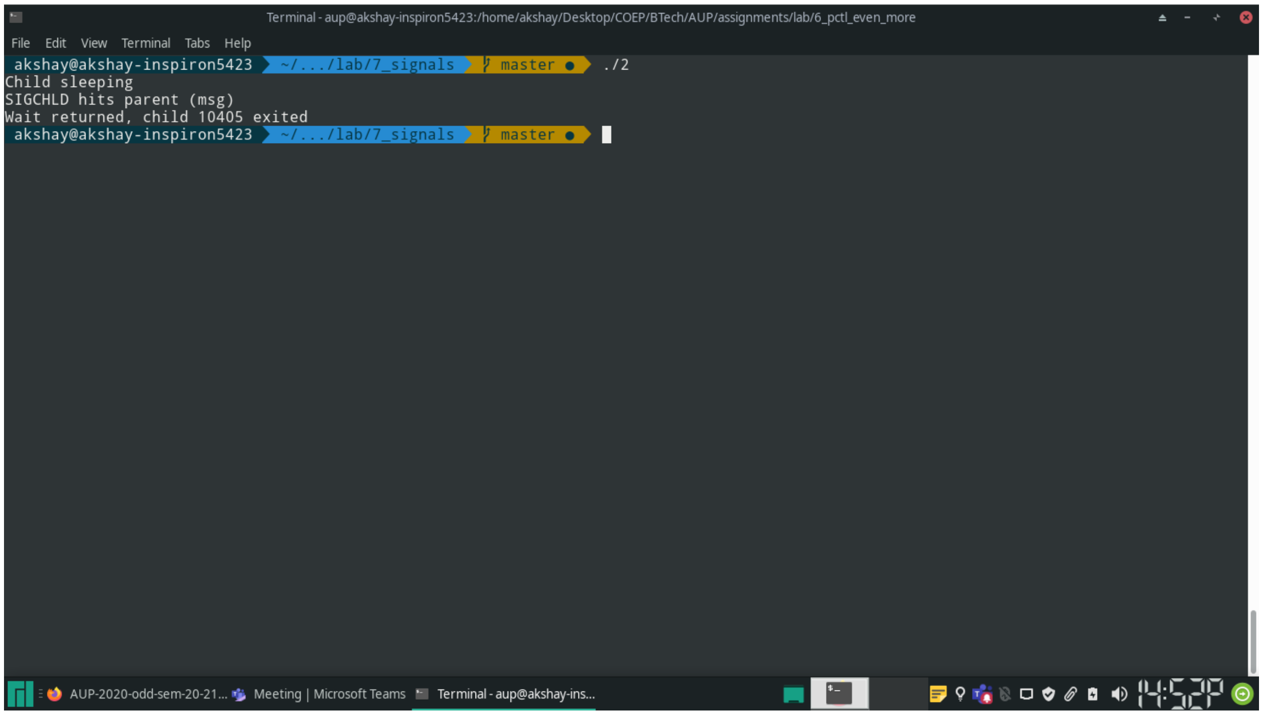
a. Normal way executing in the foreground

b. Run as a back ground process and send SIGCHLD to it from the shell

Code

```c


#include <sys/types.h>
#include <sys/wait.h>
#include <unistd.h>
#include <signal.h>
#include <errno.h>
#include <stdio.h>

void print_sigchld_msg(int sig_number) {
        printf("SIGCHLD hits parent (msg)\n");
}

int main(void) {
        pid_t child_id;

        int dead_child;
        int status;

        /* set handler for SIGCHLD */
        signal(SIGCHLD, print_sigchld_msg);

        if ((child_id = fork()) == -1) {
                perror("fork");
                return errno;
        }
        else if (child_id) {
                /* parent */

                if ((dead_child = wait(&status)) == -1) {
                        perror("wait failed");
                        return errno;
                }
                else {
                        printf("Wait returned, child %d exited\n", dead_child);
                }
        }
        else {
                /* Child */
                printf("Child sleeping\n");
                sleep(10);
        }

        return 0;
}

```

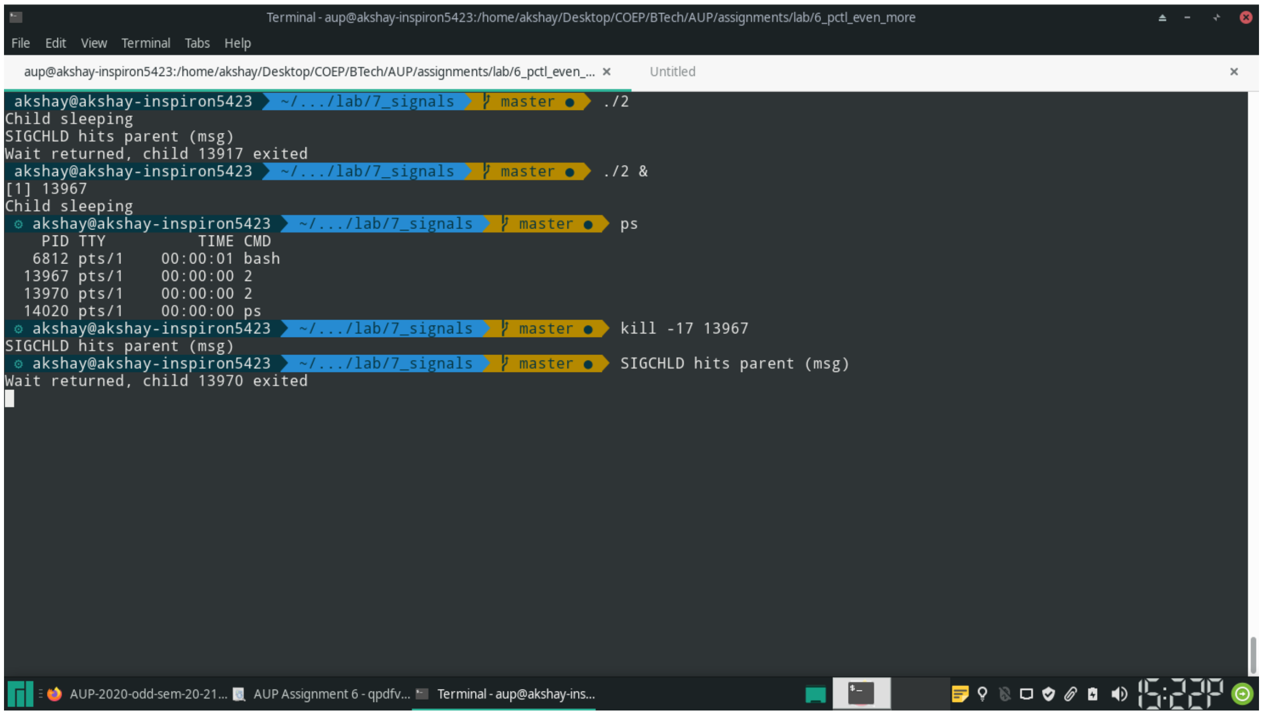
Output



Terminal - aup@akshay-inspiron5423:/home/akshay/Desktop/COEP/BTech/AUP/assignments/lab/6_pctl_even_more

```
akshay@akshay-inspiron5423  ~/.../lab/7_signals  master ●  ./2
Child sleeping
SIGCHLD hits parent (msg)
Wait returned, child 10405 exited
akshay@akshay-inspiron5423  ~/.../lab/7_signals  master ● 
```

Figure 2: Normal way of executing the program, SIGCHLD hits once



Terminal - aup@akshay-inspiron5423:/home/akshay/Desktop/COEP/BTech/AUP/assignments/lab/6_pctl_even_more

```
akshay@akshay-inspiron5423  ~/.../lab/7_signals  master ●  ./2
Child sleeping
SIGCHLD hits parent (msg)
Wait returned, child 13917 exited
akshay@akshay-inspiron5423  ~/.../lab/7_signals  master ●  ./2 &
[1] 13967
Child sleeping
⚙ akshay@akshay-inspiron5423  ~/.../lab/7_signals  master ●  ps
    PID TTY          TIME CMD
   6812 pts/1    00:00:01 bash
  13967 pts/1    00:00:00 2
  13970 pts/1    00:00:00 2
  14020 pts/1    00:00:00 ps
⚙ akshay@akshay-inspiron5423  ~/.../lab/7_signals  master ●  kill -17 13967
SIGCHLD hits parent (msg)
⚙ akshay@akshay-inspiron5423  ~/.../lab/7_signals  master ●  SIGCHLD hits parent (msg)
Wait returned, child 13970 exited
```

Figure 3: Run as a back ground process and send SIGCHLD to it from the shell, SIGCHLD hits twice

Q3 You have to create a process tree as shown below. Then you let the parent process create a process group of (3, 4, 5) so that it sends a signal to this group. Print appropriate messages.

- 1 and 2 are children of 0
- 5 is child of 1
- 3 is child of 2
- 4 is child of 3

Code

```c

#include <sys/types.h>
#include <sys/mman.h>
#include <sys/stat.h>
#include <sys/wait.h>
#include <unistd.h>
#include <fcntl.h>
#include <semaphore.h>
#include <signal.h>
#include <stdio.h>
#include <stdlib.h>
#include <errno.h>

#define SHARED_ARR "shared_array"
#define SEMAPHORE_FORKING "fork_semaphore"
#define N 6

/* to ensure that fp can be used by all processes */
static int fp;

void print_message(int signo) {
        printf("%d got hit by signal %d\n", getpid(), signo);
}

void examine_child(int pid) {
    int status;

    if (waitpid(pid, &status, 0) == -1) {
            perror("wait");
            exit(errno);
    }

    if (WIFEXITED(status)) {
            printf("%d exited with %d\n", pid, WEXITSTATUS(status));
    }
    else if (WIFSIGNALED(status)) {
            printf("%d killed by signal %d\n", pid, WTERMSIG(status));
    }
    else {
            printf("%d died in some other way\n", pid);
    }
}

void *get_shared_arr() {
        void *buf;
        /* asssert: fp is a file descriptor which points to the shared memory,
         * and is inherited by all processes */
        if ((buf = mmap(NULL, sizeof(int) * N, PROT_READ | PROT_WRITE, MAP_SHARED, fp, 0)) == MAP_FAILED) {
                perror("shared memory mmap() failed");
                exit(errno);
        }
        return buf;
}


int main(void) {

        /* process 0 */
        /* can see the pids of {1, 2} */
        sem_t *fork_sem, *pgid_sem, *exit_sem;
        int *child_pid;
        int ret;

        if (signal(SIGUSR1, print_message) == SIG_ERR) {
                perror("SIGUSR1");
                return errno;
        }

        /* link shared memory address to process- this will be visible in
         * children */
        if ((child_pid= mmap(NULL, sizeof(int) * N,
                                        PROT_READ | PROT_WRITE,
                                        MAP_SHARED | MAP_ANONYMOUS,
                                        -1, 0)) == MAP_FAILED) {

                perror("mmap");
                return errno;
        }

        /* create a shared memory map for semaphore */
        if ((fork_sem = mmap(NULL, sizeof(sem_t),
                                        PROT_READ | PROT_WRITE,
                                        MAP_SHARED | MAP_ANONYMOUS,
                                        -1, 0)) == MAP_FAILED) {

                perror("semaphore");
                return errno;
        }
        /* initialize semaphore with initial value 0- when 5 and 3 get
         * created, this is incremented by 1 each. 0 will synchronize by calling
         * down() on this twice */
        if (sem_init(fork_sem, 1, 0) == -1) {
                perror("semaphore initialization");
                return errno;
        }

        /* create a shared memory map for semaphore */
        if ((exit_sem = mmap(NULL, sizeof(sem_t),
                                        PROT_READ | PROT_WRITE,
                                        MAP_SHARED | MAP_ANONYMOUS,
                                        -1, 0)) == MAP_FAILED) {

                perror("semaphore");
                return errno;
        }

        /* initialize semaphore with initial value 0- when signals have been
         * sent, this will be incremented 5 times, wherin all processes will
         * exit */
        if (sem_init(exit_sem, 1, 0) == -1) {
                perror("semaphore initialization");
                return errno;
        }

        /* create a shared memory map for semaphore */
        if ((pgid_sem = mmap(NULL, sizeof(sem_t),
                                        PROT_READ | PROT_WRITE,
                                        MAP_SHARED | MAP_ANONYMOUS,
                                        -1, 0)) == MAP_FAILED) {

                perror("semaphore");
                return errno;
        }

        /* initialize semaphore with initial value 0- when all processes have
         * called setpgid, the parent can send signals */
        if (sem_init(pgid_sem, 1, 0) == -1) {
                perror("semaphore initialization");
                return errno;
        }

        /* assert: now each child will have access to the semaphore, unless the
         * memory region is purposely unliked */


        if ((ret = fork()) == -1) {
                perror("fork 1");
                return errno;
        }
        else if (!ret) {
                /* child 1 */
                /* can see pids of {5} */
                /* child_pid = (int *)get_shared_arr(); */

                if ((ret = fork()) == -1) {
                        perror("fork 5");
                        return errno;
                }
                else if (!ret) {
                        /* chlid 5 */
                        /* can see pids of {} */
                        /* child_pid = (int *)get_shared_arr(); */

                        /* wait for the PID of 3 to be available */
                        if (sem_wait(fork_sem) == -1) {
                                perror("P operation in 5");
                        }

                        /* set own process group to 3 */
                        if (setpgid(0, child_pid[3]) == -1) {
                                perror("setpgid(5, 3)");
                                return errno;
                        }

                        if (sem_post(pgid_sem) == -1) {
```

```
				perror("setpgid(5, 3) done synchronization");
				return errno;
			}


			/* wait for 0 to allow exiting */
			if (sem_wait(exit_sem) == -1) {
				perror("V operation in 4");
				return errno;
			}

			printf("%d is child of %d\n", getpid(), getppid());

			return 0;
		}
		child_pid[5] = ret;



		/* wait for 0 to allow exiting */
		if (sem_wait(exit_sem) == -1) {
			perror("V operation in 2");
			return errno;
		}

		printf("%d is child of %d\n", getpid(), getppid());

		examine_child(child_pid[5]);

		return 0;
	}
	child_pid[1] = ret;

	if ((ret = fork()) == -1) {
		perror("fork 2");
		return errno;
	}
	else if (!ret) {
		/* child 2 */
		/* can see pids of {3} */
		/* child_pid = (int *)get_shared_arr(); */

		if ((ret = fork()) == -1) {
			perror("fork 3");
			return errno;
		}
		else if (!ret) {
			/* child 3*/
			/* can see pids of {4} */

			child_pid[3] = getpid();

			if (setpgid(child_pid[3], child_pid[3]) == -1) {
				perror("setpgid(3, 3");
				return errno;
			}

			if (sem_post(pgid_sem) == -1) {
				perror("setpgid(3, 3) done synchronization");
```

```
                        return errno;
                }

                /* tell 5  that pid of 3 is available in shared memory,
                 * and it can call setpgid safely*/
                if (sem_post(fork_sem) == -1) {
                        perror("P operation in 3");
                        return errno;
                }


                if ((ret = fork()) == -1) {
                        perror("fork 4");
                        return errno;
                }
                else if (!ret) {
                        /* child 4*/
                        /* can see pids of {} */
                        /* child_pid = (int *)get_shared_arr(); */

                        if (setpgid(0, child_pid[3]) == -1) {
                                perror("setpgid(4, 3)");
                                return errno;
                        }

                        /* tell 0 that 4 has moved to new process group
                         * */
                        if (sem_post(pgid_sem) == -1) {
                                perror("setpgid(4, 3) done synchronization");
                                return errno;
                        }


                        /* wait for 0 to allow exiting */
                        if (sem_wait(exit_sem) == -1) {
                                perror("V operation in 4");
                                return errno;
                        }

                        printf("%d is child of %d\n", getpid(), getppid());

                        return 0;

                }

                child_pid[4] = ret;


                if (sem_wait(exit_sem) == -1) {
                        perror("V operation in 3");
                        return errno;
                }

                printf("%d is child of %d\n", getpid(), getppid());

                examine_child(child_pid[4]);

                return 0;
        }
```

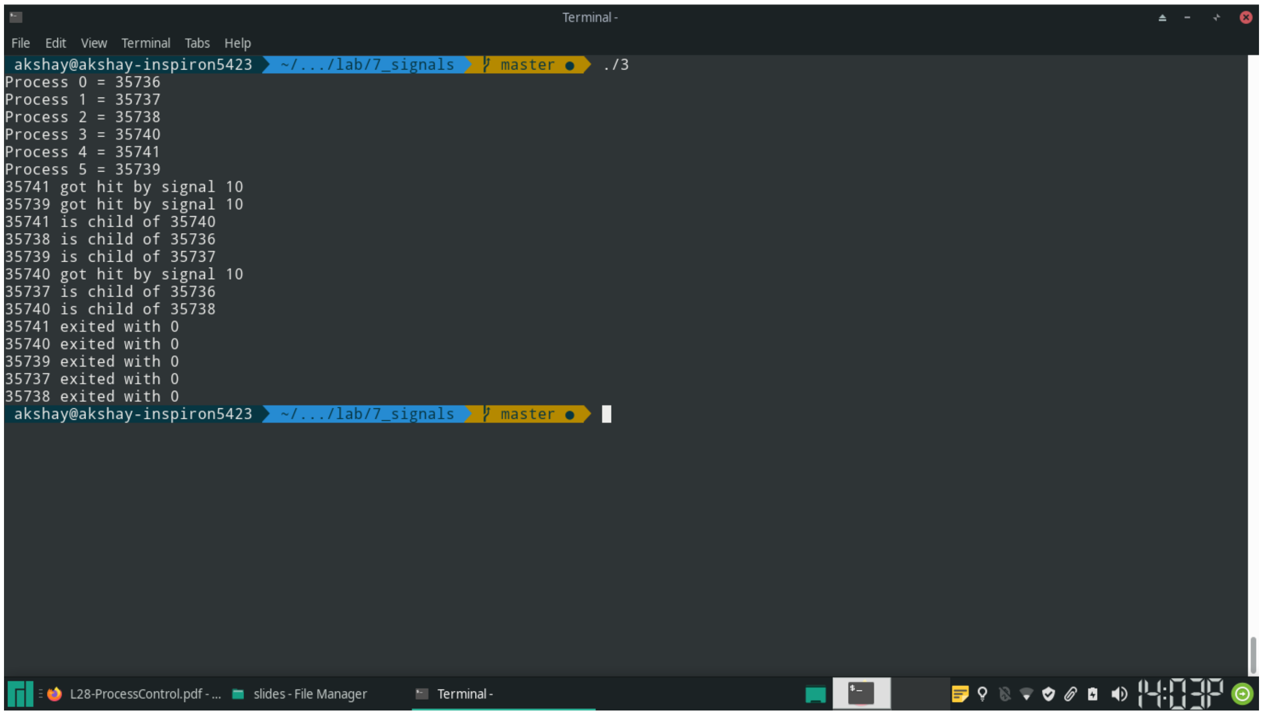
```
                child_pid[3] = ret;


                /* wait for 0 to allow exiting */
                if (sem_wait(exit_sem) == -1) {
                        perror("V operation in 2");
                        return errno;
                }

                printf("%d is child of %d\n", getpid(), getppid());

                examine_child(child_pid[3]);

                return 0;
        }
        child_pid[2] = ret;

        /* wait till all processes created, and the 3 setpgid calls finish */
        int i;
        for (i = 0; i < 3; i++) {
                if (sem_wait(pgid_sem) == -1) {
                        perror("V operation in 0");
                        return errno;
                }
        }

        child_pid[0] = getpid();

        if (kill(-child_pid[3], SIGUSR1) == -1) {
                perror("kill");
                return errno;
        }

        for (i = 0; i <= 5; i++) {
                printf("Process %d = %d\n", i, child_pid[i]);
        }


        for (i = 0; i < 5; i++) {
                if (sem_post(exit_sem) == -1) {
                        perror("P by 0");
                        return errno;
                }
        }

        examine_child(child_pid[1]);
        examine_child(child_pid[2]);

        return 0;

}
```

Explanation

- Shared memory is created for sharing pids and semaphores
- 3 semaphores are used
- *fork_sem* is used by process 3 to tell process 5 that it's pid is available in shared memory, and that it's process group has been created
- *pgid_sem* is used for telling 0 that all 3 setpgid calls are done

- *exit_sem* is used for telling 1-5 that it has called kill, and they are free to exit now

Output



```
akshay@akshay-inspiron5423 ~/.../lab/7_signals  master ● ./3
Process 0 = 35736
Process 1 = 35737
Process 2 = 35738
Process 3 = 35740
Process 4 = 35741
Process 5 = 35739
35741 got hit by signal 10
35739 got hit by signal 10
35741 is child of 35740
35738 is child of 35736
35739 is child of 35737
35740 got hit by signal 10
35737 is child of 35736
35740 is child of 35738
35741 exited with 0
35740 exited with 0
35739 exited with 0
35737 exited with 0
35738 exited with 0
akshay@akshay-inspiron5423 ~/.../lab/7_signals  master ●
```

Figure 4: Execution of 3, SIGUSR hits 3, 4, 5