AUP : Assignment - 5 [Process Control Advanced]

Aditi Rajendra Medhane 111803177

27th September 2021

Q1

Implement a program in which parent sorts an integer array. Then it creates a child process. The child accepts a number to be searched in the array, performs a binary search in the array and display the result. Appropriately modify the program to create scenarios to demonstrate that zombie and orphan states of the child can be formed.

Code

```c
#include <stdio.h> //fflush defined
#include <stdlib.h>
#include <pwd.h>
#include <sys/types.h>
#include <sys/stat.h>
#include <unistd.h>
#include <fcntl.h>
#include <errno.h>
#include <dirent.h>

#include <string.h> //for memcpy
#define BUF_SIZE 100
#define N 10
#define MOD 1000

#define ZOMBIE 1
#define ORPHAN 2

static int buf[BUF_SIZE];
static int arr[BUF_SIZE];

//Generate Random Integer Array
void rand_arr(int *arr, int n, int limit){
    int i;
    for(i = 0; i < n; i++){
        arr[i] = rand() % limit;
    }
}

//Binary Search Algo
int binary_search(int *arr, int n, int x){
    int left, right, mid;
    int mid_element;

    left = 0;
    right = n-1;

    while(left <= right){
        mid = (left + right) / 2;
        mid_element = arr[mid];

        if(x < mid_element)
            right = mid + 1;
        else if(x > mid_element)
```

```
            left = mid + 1;
        else
            return mid;
    }
    return -1;
}

//MERGES a[left:mid], a[mid:right], using temp
void merge(int *a, int left, int right, int *buf){
    int mid;
    int size = left;
    int lp, rp;

    mid = (left + right) / 2;

    lp = left;
    rp = mid;

    while(lp < mid && rp < right){
        if(a[lp] <= a[rp]){
            buf[size++] = a[lp++];
        }
        else{
            buf[size++] = a[rp++];
        }
    }

    int start, end;
    if (lp == mid){
        start = rp;
        end = right;
    }
    else{
        start = lp;
        end = mid;
    }

    while(start < end){
        buf[size++] = a[start++];
    }

    memcpy(a + left, buf + left, sizeof(int) * (right - left));
}

void serial_MergeSort(int *a, int left, int right, int *buf){
    int mid = (left + right) / 2;

    //Already sorted
    if((right - left) <= 1)
        return;

    serial_MergeSort(a, left, mid, buf);
    serial_MergeSort(a, mid, right, buf);

    merge(a, left, right, buf);
}

void arr_print(int *arr, int n){
    int i;
    for(i = 0; i < n; i++)
        printf("%d ", arr[i]);
    printf("\n");
}

int main(int argc, char *argv[]){
    int elem, index;
    int n = N;
```

```
    rand_arr(arr, n, MOD);

    serial_MergeSort(arr, 0, n, buf);

    //PARENT
    if(fork()) {
#if SCENARIO == ZOMBIE
        sleep(10);
        exit(0);
#elif SCENARIO == ORPHAN
        exit(0);
#endif
    }
    //CHILD
    else{
        arr_print(arr, n);
        printf("\nElement :");

        //Usage of fflush : flush a stream
        //fflush()  forces  a  write  of  all user-space
        //buffered data for the given output or update stream via the  stream's
            // underlying write function.
        fflush(stdin);

        scanf("%d", &elem);
        index = binary_search(arr, n, elem);

        if(index >= 0){
            printf("Element %d found @ %d\n", elem, index);
        }
        else{
            printf("Element %d not found\n", elem);
        }
#if SCENARIO == ORPHAN
        printf("CHILD = %d\tPARENT = %d\n",getpid(), getppid());
#endif
    }

}
```

Explanation

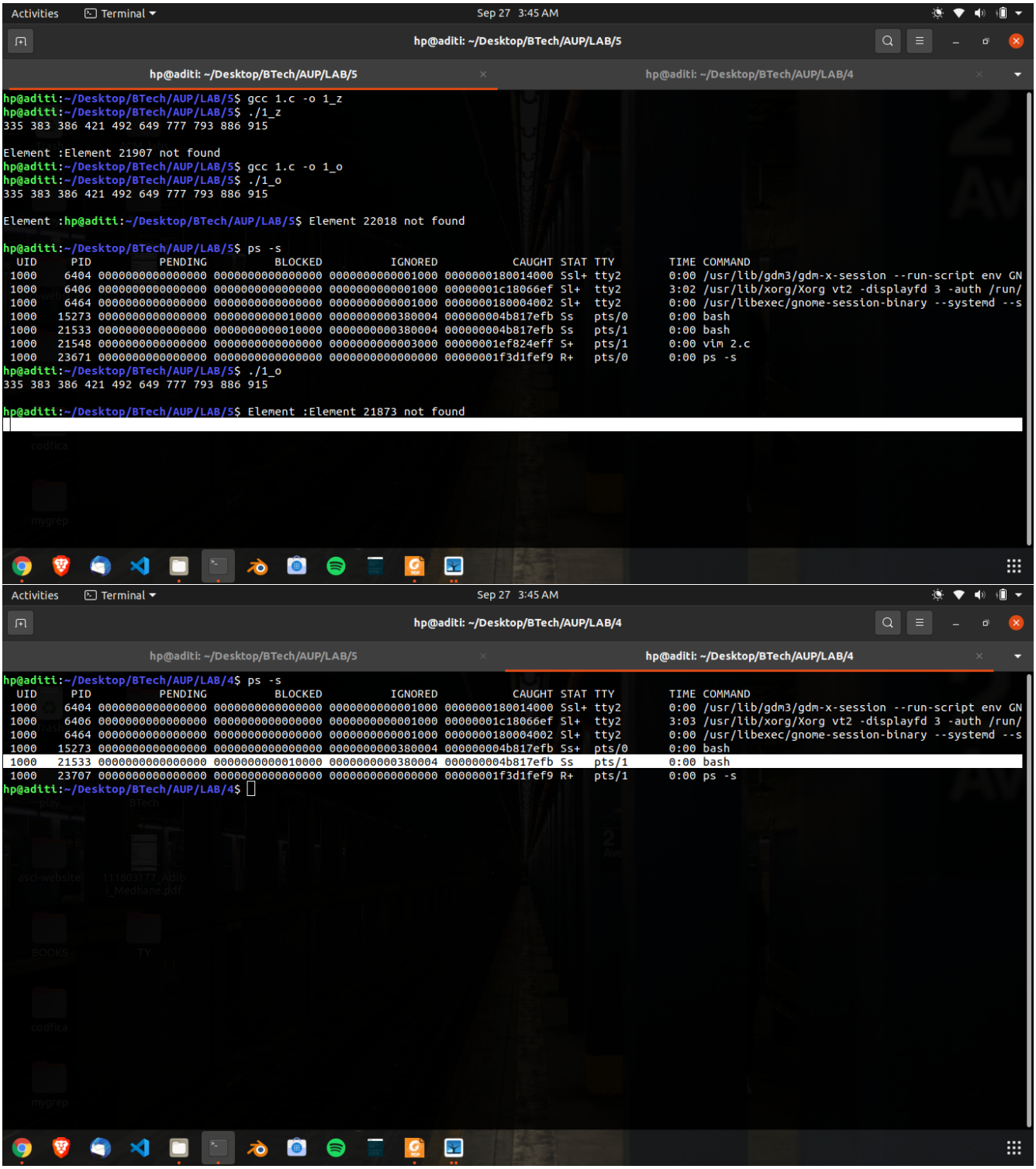
1. **Zombie process**:

- The parent is made to sleep for 10 second. Then, the child process accepts an input, searches it, displays the result, and exits.
- When this happens, Ctrl+Z is used to stop the parent process, and *ps -s* is run.
- The output shows that the child process has zombied.

2. **Orphan process**:

- The parent process is made to exit immediately without sleeping. Then the child process **tries to** access an input, searches, displays the result and leaves.
- The child however **fails to execute scanf, and scanf returns -1, failing**. This is because when the parent exited, the child was adopted by *init*. Due to this it relenquishes control of *stdin*, causing scanf to fail.
- The child then calls getppid(), and prints it's and the parent's PID. The ppid is **1**, which means the parent is *init*. This indicates that the child was *orphaned*.

Output


Activities
Terminal
Sep 27 3:45 AM
hp@aditi: ~/Desktop/BTech/AUP/LAB/5
hp@aditi: ~/Desktop/BTech/AUP/LAB/5
hp@aditi: ~/Desktop/BTech/AUP/LAB/4
hp@aditi:~/Desktop/BTech/AUP/LAB/5$ gcc 1.c -o 1_z
hp@aditi:~/Desktop/BTech/AUP/LAB/5$ ./1_z
335 383 386 421 492 649 777 793 886 915
Element :Element 21907 not found
hp@aditi:~/Desktop/BTech/AUP/LAB/5$ gcc 1.c -o 1_o
hp@aditi:~/Desktop/BTech/AUP/LAB/5$ ./1_o
335 383 386 421 492 649 777 793 886 915
Element :hp@aditi:~/Desktop/BTech/AUP/LAB/5$ Element 22018 not found
hp@aditi:~/Desktop/BTech/AUP/LAB/5$ ps -s
UID PID PENDING BLOCKED IGNORED CAUGHT STAT TTY TIME COMMAND
1000 6404 0000000000000000 0000000000000000 0000000000001000 0000000180014000 Ssl+ tty2 0:00 /usr/lib/gdm3/gdm-x-session --run-script env GN
1000 6406 0000000000000000 0000000000000000 0000000000001000 00000001c18066ef Sl+ tty2 3:02 /usr/lib/xorg/Xorg vt2 -displayfd 3 -auth /run/
1000 6464 0000000000000000 0000000000000000 0000000000001000 0000000180004002 Sl+ tty2 0:00 /usr/libexec/gnome-session-binary --systemd --s
1000 15273 0000000000000000 0000000000010000 0000000000380004 000000004b817efb Ss pts/0 0:00 bash
1000 21533 0000000000000000 0000000000010000 0000000000380004 000000004b817efb Ss pts/1 0:00 bash
1000 21548 0000000000000000 0000000000000000 0000000000003000 00000001ef824eff S+ pts/1 0:00 vim 2.c
1000 23671 0000000000000000 0000000000000000 0000000000000000 00000001f3d1fef9 R+ pts/0 0:00 ps -s
hp@aditi:~/Desktop/BTech/AUP/LAB/5$ ./1_o
335 383 386 421 492 649 777 793 886 915
hp@aditi:~/Desktop/BTech/AUP/LAB/5$ Element :Element 21873 not found
Activities
Terminal
Sep 27 3:45 AM
hp@aditi: ~/Desktop/BTech/AUP/LAB/4
hp@aditi: ~/Desktop/BTech/AUP/LAB/5
hp@aditi: ~/Desktop/BTech/AUP/LAB/4
hp@aditi:~/Desktop/BTech/AUP/LAB/4$ ps -s
UID PID PENDING BLOCKED IGNORED CAUGHT STAT TTY TIME COMMAND
1000 6404 0000000000000000 0000000000000000 0000000000001000 0000000180014000 Ssl+ tty2 0:00 /usr/lib/gdm3/gdm-x-session --run-script env GN
1000 6406 0000000000000000 0000000000000000 0000000000001000 00000001c18066ef Sl+ tty2 3:03 /usr/lib/xorg/Xorg vt2 -displayfd 3 -auth /run/
1000 6464 0000000000000000 0000000000000000 0000000000001000 0000000180004002 Sl+ tty2 0:00 /usr/libexec/gnome-session-binary --systemd --s
1000 15273 0000000000000000 0000000000000000 0000000000380004 000000004b817efb Ss+ pts/0 0:00 bash
1000 21533 0000000000000000 0000000000010000 0000000000380004 000000004b817efb Ss pts/1 0:00 bash
1000 23707 0000000000000000 0000000000000000 0000000000000000 00000001f3d1fef9 R+ pts/1 0:00 ps -s
hp@aditi:~/Desktop/BTech/AUP/LAB/4$

Q2

The parent starts as many child processes as to the value of its integer command line argument. The child processes simply sleep for the time specified by the argument, then exit. After starting all the children, the parent process does not wait for them immediately, but after a time specified by command line argument, checks the status of all terminated children, print the list of non terminated children and then terminates itself.

Code

```c
#include <stdio.h>
#include <stdlib.h>
#include <pwd.h>
#include <sys/types.h>
#include <sys/stat.h>
#include <unistd.h>
#include <fcntl.h>
#include <errno.h>
#include <dirent.h>

#include <sys/wait.h>

#define SIZE 100

static pid_t children[SIZE];
static int child_sleep_time[SIZE];

int main(int argc, char *argv[]){
    if(argc < 3){
        fprintf(stderr, "USAGE : ./2 <NO_of_CHILDERN> <PARENT_SLEEP_TIME>\
                [<child1_sleeptime> ...]\n");
        return EINVAL;
    }

    int n_child, n_parent_sleep;

    n_child = atoi(argv[1]);

    if(n_child > SIZE){
        fprintf(stderr, "Maximum number of Children is %d\n", SIZE);
        return EINVAL;
    }

    if(argc != (n_child + 3)){
        fprintf(stderr, "Specify Sleep Time for Each Child\n");
        return EINVAL;
    }

    n_parent_sleep = atoi(argv[2]);

    int i;
    int status;
    int pid_ret;

    for(i = 0; i < n_child; i++){
        child_sleep_time[i] = atoi(argv[3 + i]);
    }

    for(i = 0; i < n_child; i++){
        if ((children[i] = fork()) == -1){
            perror("fork");
            return errno;
        }
        else if (!children[i]){
            sleep(child_sleep_time[i]);
            exit(0);
        }
    }
```

```
59
60      sleep(n_parent_sleep);
61
62      for(i = 0; i < n_child; i++){
63          printf("CHILD : %d\t", children[i]);
64          //Child Process has not changed state, is still running
65          if ((pid_ret = waitpid(children[i], &status, WNOHANG)) == 0){
66              printf("RUNNING\n");
67          }
68          else if (pid_ret != -1){
69              printf("EXITED\n");
70          }
71          else{
72              printf("ERROR\n");
73          }
74      }
75      return 0;
76
77  }
```

Output

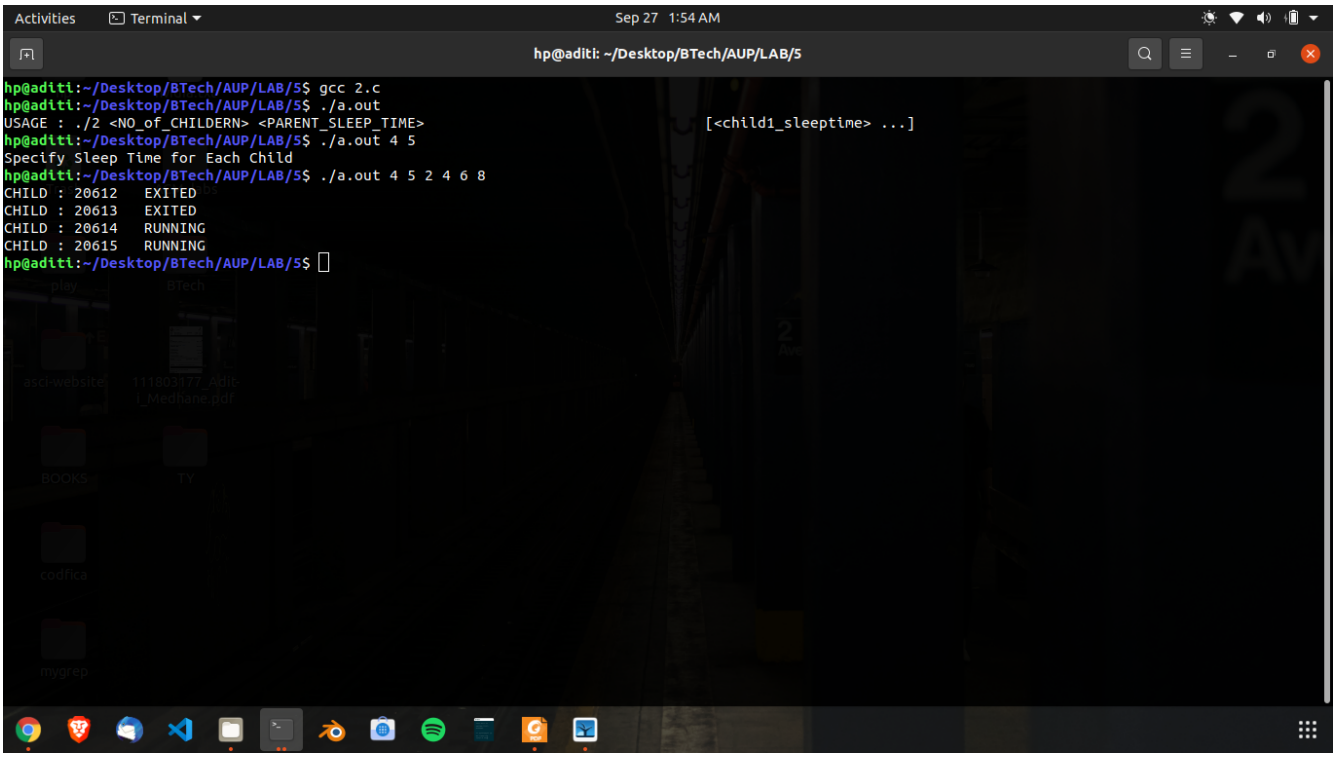


Figure 1: Output

Q3

Write a program to create 2 child processes that ultimately become zombie processes. The first child displays some message and immediately terminates. The 2nd child sleeps for 100 and then terminates. Inside the parent program using "system" display the all the process stats and the program exits. Immediately on the command prompt display the all the process stats. What happened to the Zombie processes?

Code

```c
#include <stdio.h>
#include <stdlib.h>
#include <sys/types.h>
#include <sys/stat.h>
#include <unistd.h>
#include <fcntl.h>
#include <errno.h>
#include <dirent.h>

void child_1_States(void){
    printf("I am the first-born: %d\n", getpid());
    exit(0);
}

void child_2_States(void){
    sleep(100);
    exit(0);s
}

int main(int argc, char*argv[]){
    int child_pid, i;

    void(*child_States[])(void) = {child_1_States, child_2_States};

    for(i = 0; i < 2; i++) {
        if ((child_pid = fork()) == -1) {
            perror("fork");
            return errno;
        }
        else if (!child_pid){
            //IN CHILD
            child_States[i]();
            //WILL NEVER RETURN HERE ....LOL....
            //FUNCTION HAS exit() in it
        }

    }

    if(system("ps -o command,pid,ppid,state") == -1)
        perror("ps -o command, pid, ppid, state");

    return 0;
}
```

Explanation

- It has not been specified that the parent should wait. If the parent does not sleep for more than 100 second, then the child which sleeps **will become orphan, not zombie**.
- The child which exits immediately is zombied. This can be seen by first calling *ps* using system *inside* the program, and immediately calling *ps* after the main program exists on the command prompt.
- The first *ps* (in the program) shows that one of the process is Zombie(Z), and the other is Sleeping(S).
- The second *ps* shows that the other process is Sleeping(S), and it's parent is init, indicated by the ppid printed.

What happens to the zombie process?

The child which exits is zombied. When the parent exits, it effectively becomes like an **orphan** gets attached to *init*. Because it has terminated, it gets **reaped** by init.

On the other hand, the child which is sleeping gets orphaned, as the parent exits before it.

Output

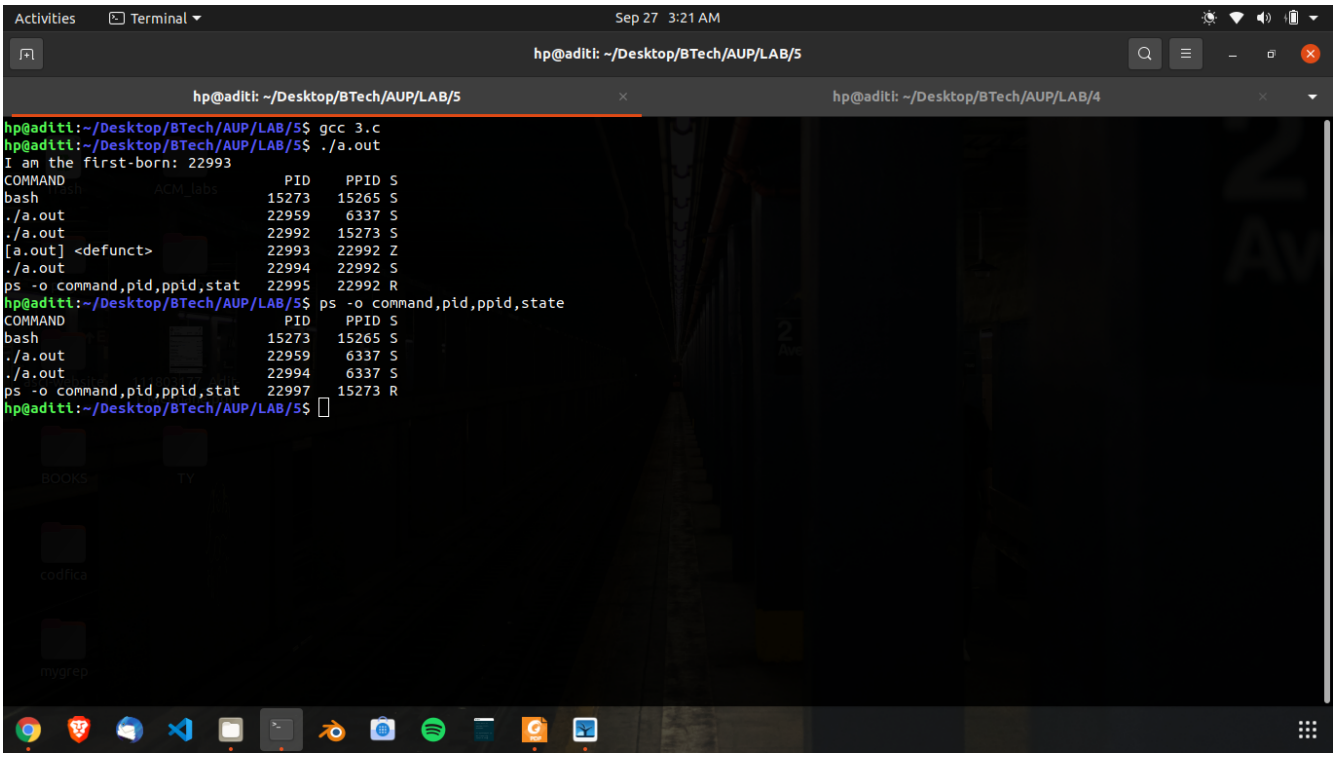


Figure 2: OUTPUT