AUP : Assignment - 10 [IPC]

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Q1

A pipe setup is given below that involves three processes. P is the parent process, and C1 and C2 are child processes, spawned from P. The pipes are named p1, p2, p3, and p4. Write a program that establishes the necessary pipe connections, setups, and carries out the reading/writing of the text in the indicated directions.

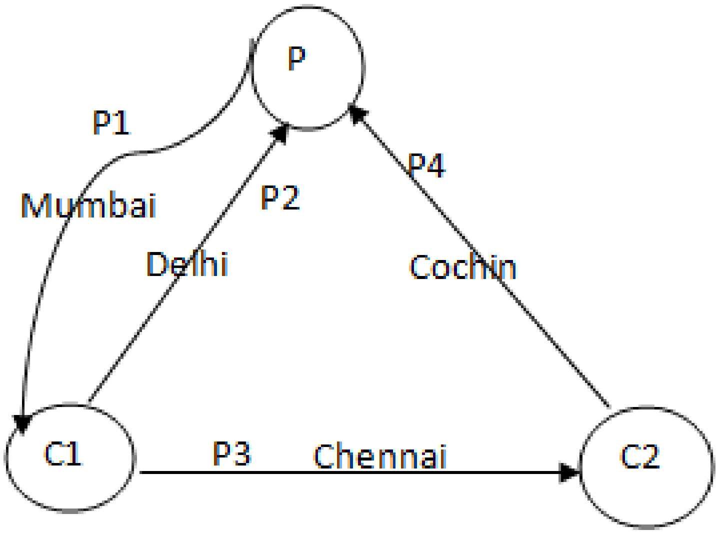


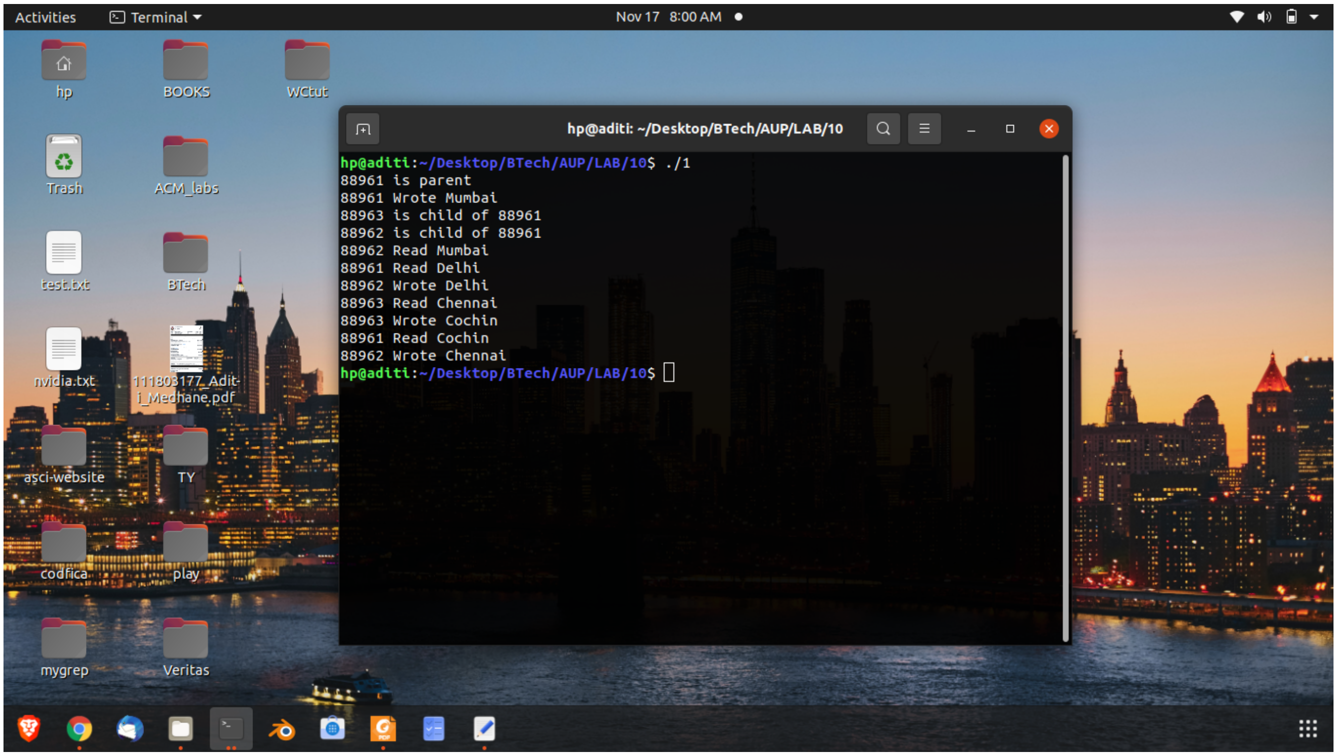
Figure 1: Pipe Setup

Code

```
#include <sys/types.h>
#include <fcntl.h>
#include <unistd.h>
#include <errno.h>
#include <stdio.h>
#include <string.h>

#define M1 "Mumbai"
#define M2 "Delhi"
#define M3 "Chennai"
#define M4 "Cochin"

#define BUFLEN 10

int main(void) {

        int pid, ppid;

        int pipes[5][2];

        int n;
        char buf[BUFLEN];

        int i;

        /* open 4 pipes */
        for (i = 1; i <= 4; i++) {
                if (pipe(pipes[i]) == -1) {
                        perror("pipe");
                        return errno;
                }
        }

        if ((pid = fork()) == -1) {
                perror("fork 1 failed");
                return errno;
        }
        else if (!pid) {
                /* C1 */

                /* 1 W */
                close(pipes[1][1]);

                /* 2 R */
                close(pipes[2][0]);

                /* 3 R */
                close(pipes[3][0]);

                /* 4 RW */
                close(pipes[4][0]);
                close(pipes[4][1]);

                pid = getpid();
                ppid = getppid();

                printf("%d is child of %d\n", pid, ppid);

                if ((n = read(pipes[1][0], buf, BUFLEN)) == -1) {
                        perror("read 1");
                        return errno;
                }
                printf("%d Read %s\n", pid, buf);
                close(pipes[1][0]);

                if (write(pipes[2][1], M2, strlen(M2) + 1) == -1) {
                        perror("write 2");
                        return errno;
                }
                printf("%d Wrote %s\n", pid, M2);
                close(pipes[2][1]);

                if (write(pipes[3][1], M3, strlen(M3) + 1) == -1) {
                        perror("write 3");
                        return errno;
                }
                printf("%d Wrote %s\n", pid, M3);
                close(pipes[3][1]);

                return 0;
        }

        if ((pid = fork()) == -1) {
                perror("fork 2 failed");
                return errno;
        }
        else if (!pid) {
                /* C2 */

                /* 1 RW */
                close(pipes[1][0]);
                close(pipes[1][1]);

                /* 2 RW */
                close(pipes[2][0]);
                close(pipes[2][1]);

                /* 3 W */
                close(pipes[3][1]);

                /* 4 R */
                close(pipes[4][0]);

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

                if ((n = read(pipes[3][0], buf, BUFLEN)) == -1) {
                        perror("read 3");
                        return errno;
                }
                printf("%d Read %s\n", pid, buf);
                close(pipes[3][0]);

                if (write(pipes[4][1], M4, strlen(M4) + 1) == -1) {
                        perror("write 4");
                        return errno;
                }
                printf("%d Wrote %s\n", pid, M4);
                close(pipes[4][1]);

                return 0;
        }

        /* P */

        /* close read end of 1 */
        close(pipes[1][0]);

        /* close write end of 2 */
        close(pipes[2][1]);

        /* close write end of 4 */
        close(pipes[4][1]);

        /* close both ends of 3 */
        close(pipes[3][0]);
        close(pipes[3][1]);

        pid = getpid();
        printf("%d is parent\n", pid);


        if (write(pipes[1][1], M1, strlen(M1) + 1) == -1) {
                perror("write 1");
                return errno;
        }
        printf("%d Wrote %s\n", pid, M1);
        close(pipes[1][1]);

        if ((n = read(pipes[2][0], buf, BUFLEN)) == -1) {
                perror("read 2");
                return errno;
        }
        printf("%d Read %s\n", pid, buf);
        close(pipes[2][0]);
```

```c
        if ((n = read(pipes[4][0], buf, BUFLEN)) == -1) {
                perror("read 4");
                return errno;
        }
        printf("%d Read %s\n", pid, buf);
        close(pipes[4][0]);

        return 0;
}

```

Output



```
hp@aditi:~/Desktop/BTech/AUP/LAB/10$ ./1
88961 is parent
88961 Wrote Mumbai
88963 is child of 88961
88962 is child of 88961
88962 Read Mumbai
88961 Read Delhi
88962 Wrote Delhi
88963 Read Chennai
88963 Wrote Cochin
88961 Read Cochin
88962 Wrote Chennai
hp@aditi:~/Desktop/BTech/AUP/LAB/10$ 
```

Figure 2: Messages read and written by processes

Q2

Let P1 and P2 be two processes alternatively writing numbers from 1 to 100 to a file. Let P1 write odd numbers and p2, even. Implement the synchronization between the processes using FIFO.

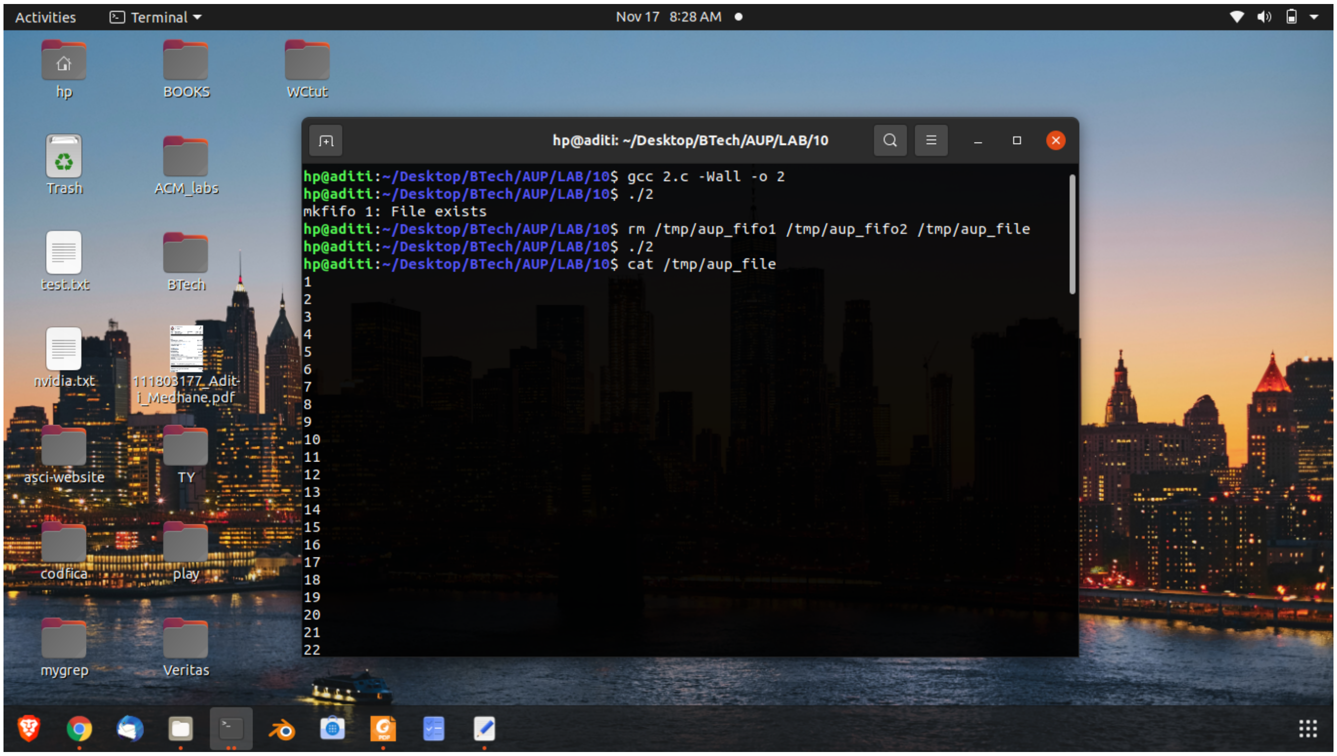
Code

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


#define FIFO1 "/tmp/aup_fifo1"
#define FIFO2 "/tmp/aup_fifo2"
#define FILENAME "/tmp/aup_file"
#define BUFLEN 10

int main(void) {

        int pid;
        int fr, fw, fp;
        int i;
        char buf[BUFLEN];

        if (mkfifo(FIFO1, S_IRUSR | S_IWUSR) == -1) {
                perror("mkfifo 1");
                return errno;
        }

        if (mkfifo(FIFO2, S_IRUSR | S_IWUSR) == -1) {
                perror("mkfifo 2");
                return errno;
        }

        if ((fp = open(FILENAME, O_WRONLY | O_CREAT,
                       S_IRUSR | S_IWUSR)) == -1) {
                perror("file");
                return errno;
        }

        if ((pid = fork()) == -1) {
                perror("fork");
                return errno;
        }
        else if (pid) {
                /* P1 */

                if ((fw = open(FIFO1, O_WRONLY)) == -1) {
                        perror("write 1");
                        return errno;
                }

                if ((fr = open(FIFO2, O_RDONLY)) == -1) {
                        perror("read 2");
                        return errno;
                }

                i = 1;
                while (i <= 100) {
                        sprintf(buf, "%d\n", i);

                        if (write(fp, buf, strlen(buf)) == -1) {
                                perror("odd write");
                                return errno;
                        }

                        if (write(fw, "*", 1) == -1) {
                                perror("sync write odd");
                                return errno;
                        }

                        if (read(fr, buf, 1) == -1) {
                                perror("sync read odd");
                                return errno;
                        }

                        i += 2;
                }

                close(fp);
                close(fw);
                close(fr);

                return 0;
        }
        else {
                /* P1 */

                if ((fr = open(FIFO1, O_RDONLY)) == -1) {
                        perror("read 1");
                        return errno;
                }

                if ((fw = open(FIFO2, O_WRONLY)) == -1) {
                        perror("write 2");
                        return errno;
                }

                i = 2;
                while (i <= 100) {
                        if (read(fr, buf, 1) == -1) {
                                perror("sync read even");
                                return errno;
                        }

                        sprintf(buf, "%d\n", i);

                        if (write(fp, buf, strlen(buf)) == -1) {
                                perror("odd write");
                                return errno;
                        }

                        if (write(fw, "*", 1) == -1) {
                                perror("sync write even");
                                return errno;
                        }

                        i += 2;
                }

                close(fp);
                close(fw);
                close(fr);

                return 0;
        }
}
```

Explanation

The program uses two FIFOs, **/tmp/aup__fifo1** and **/tmp/aup__fifo2**. The file which is used for writing the numbers is **/tmp/aup__file**.

Output



```
hp@aditi:~/Desktop/BTech/AUP/LAB/10$ gcc 2.c -Wall -o 2
hp@aditi:~/Desktop/BTech/AUP/LAB/10$ ./2
mkfifo 1: File exists
hp@aditi:~/Desktop/BTech/AUP/LAB/10$ rm /tmp/aup_fifo1 /tmp/aup_fifo2 /tmp/aup_file
hp@aditi:~/Desktop/BTech/AUP/LAB/10$ ./2
hp@aditi:~/Desktop/BTech/AUP/LAB/10$ cat /tmp/aup_file
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
```

Figure 3: Synchronized writes to shared file

Q3

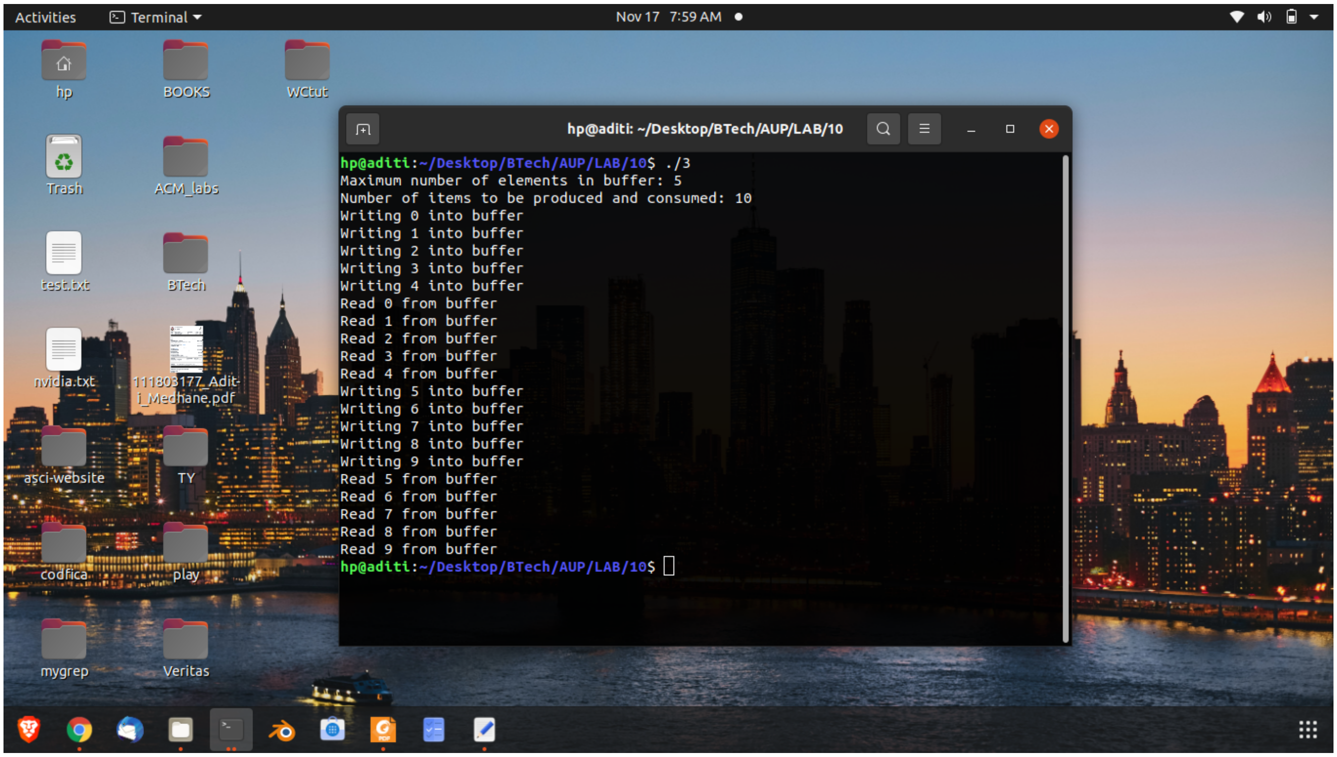
Implement a producer-consumer setup using shared memory and semaphore. Ensure that data doesn't get over-written by the producer before the consumer reads and displays on the screen. Also ensure that the consumer doesn't read the same data twice.

Code

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

#define BUF_SIZE 5
#define N_ITEMS 10

int main(void) {

        int *buf;
        sem_t *sem_fill;
        sem_t *sem_empty;
        int pid;
        int i;

        printf("Maximum number of elements in buffer: %d\n", BUF_SIZE);
        printf("Number of items to be produced and consumed: %d\n", N_ITEMS);

        if ((buf = (int *)mmap(NULL,
                        BUF_SIZE * sizeof(int),
                        PROT_READ | PROT_WRITE,
                        MAP_SHARED | MAP_ANONYMOUS,
                        -1,
                        0)) == (void *)-1) {
                perror("mmap 1");
                return errno;
        }

        if ((sem_fill = (sem_t *)mmap(NULL,
                        sizeof(sem_t),
                        PROT_READ | PROT_WRITE,
                        MAP_SHARED | MAP_ANONYMOUS,
                        -1,
                        0)) == (void *)-1) {
                perror("mmap fill");
                return errno;
        }

        if (sem_init(sem_fill, 1, 0) == -1) {
                perror("init fill");
                return errno;
        }

        if ((sem_empty = (sem_t *)mmap(NULL,
                        sizeof(sem_t),
                        PROT_READ | PROT_WRITE,
                        MAP_SHARED | MAP_ANONYMOUS,
                        -1,
                        0)) == (void *)-1) {
                perror("mmap 2");
                return errno;
        }

        if (sem_init(sem_empty, 1, BUF_SIZE) == -1) {
                perror("init empty");
                return errno;
        }

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

                for (i = 0; i < N_ITEMS; i++) {
                        if (sem_wait(sem_empty) == -1) {
                                perror("wait in producer");
                                return errno;
                        }

                        buf[i % BUF_SIZE] = i;
                        printf("Writing %d into buffer\n", i);

                        if (sem_post(sem_fill) == -1) {
                                perror("post in producer");
                                return errno;
                        }
                }
        }
        else {
                /* child, consumer */

                for (i = 0; i < N_ITEMS; i++) {

                        if (sem_wait(sem_fill) == -1) {
                                perror("wait in consumer");
                                return errno;
                        }

                        printf("Read %d from buffer\n", buf[i % BUF_SIZE]);

                        if (sem_post(sem_empty) == -1) {
                                perror("post in consumer");
                                        return errno;
                        }
                }
        }

        return 0;
}
```

Explanation

There is 1 producer and 1 consumer, 10 items are sent through the shared memory in total, capacity of the shared memory is 5 items. ### Output



```
hp@aditi:~/Desktop/BTech/AUP/LAB/10$ ./3
Maximum number of elements in buffer: 5
Number of items to be produced and consumed: 10
Writing 0 into buffer
Writing 1 into buffer
Writing 2 into buffer
Writing 3 into buffer
Writing 4 into buffer
Read 0 from buffer
Read 1 from buffer
Read 2 from buffer
Read 3 from buffer
Read 4 from buffer
Writing 5 into buffer
Writing 6 into buffer
Writing 7 into buffer
Writing 8 into buffer
Writing 9 into buffer
Read 5 from buffer
Read 6 from buffer
Read 7 from buffer
Read 8 from buffer
Read 9 from buffer
hp@aditi:~/Desktop/BTech/AUP/LAB/10$
```

Figure 4: Items written and read without deadlock