МГТУ им. Баумана

Лабораторная работа №5

По курсу: "Операционные системы"

Взаимодействие параллельных процессов

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На листингах 1,...,4 представлена первая программа, демонстрирующая реализацию задачи «Производство-потребление» по алгоритму Э. Дейкстры.

Листинг 1: Начальные установки

```
#define N 24 //buffer size
#define LETTERS "abcdefghijklmnopqrstuvwxyz"
#define OBJECT_QTY 1
#define PROC_COUNT 3

#define BS 0 //bin_sem
#define BF 1 //buffer_full
#define BE 2 //buffer_empty

#define P -1
#define V 1

struct sembuf producerStart[2] = {{BE, P, 0}, {BS, P, 0}};
struct sembuf producerStop [2] = {{BS, V, 0}, {BF, V, 0}};
struct sembuf consumerStart[2] = {{BF, P, 0}, {BS, P, 0}};
struct sembuf consumerStop [2] = {{BS, V, 0}, {BE, V, 0}};

int *prod_pos = NULL;
int *cons_pos = NULL;
char *buff_pos = NULL;

const int size = sizeof(int) * 2 + sizeof(char) * N;
```

Листинг 2: Код подпрограммы main()

```
int main()
{
    srand(time(NULL));

    printf("Parent: PID = %d\n", getpid());

    int shm_perms = S_IRUSR | S_IWUSR | S_IRGRP | S_IROTH;
    int fd = shmget(IPC_PRIVATE, size, shm_perms);
    if (fd == -1)
    {
        perror("New shared memory segment could not be created\n");
        return 1;
    }

    int *addr = shmat(fd, NULL, 0);
    if ((char *)addr == (char*) -1)
    {
        perror("Shared memory segment could not be attached to the address space of the calling process\n");
        return 1;
    }

    prod_pos = addr;
    cons_pos = addr + sizeof(int);
    buff_pos = (char *)(addr + sizeof(int) * 2);

    *prod_pos = 0;
    *cons_pos = 0;

    int sem_perms = S_IRUSR | S_IWUSR | S_IRGRP | S_IROTH;
    int semid = semget(IPC_PRIVATE, 3, IPC_CREAT | IPC_EXCL | sem_perms);
    if (semid == -1)
    {
        perror("New semaphore set could not be created\n");
        return 1;
    }

    int init_BS = semctl(semid, BS, SETVAL, 1);
    if (init_BS == -1)
    {
        perror("SETVAL command could not be applied to semaphore BS\n");
        return 1;
    }

    int init_BF = semctl(semid, BF, SETVAL, 0);
    if (init_BF == -1)
    {
        perror("SETVAL command could not be applied to semaphore BF\n");
        return 1;
    }

    int init_BE = semctl(semid, BE, SETVAL, N);
    if (init_BE == -1)
    {
        perror("SETVAL command could not be applied to semaphore BE\n");
        return 1;
    }

    for (int i = 0; i < PROC_COUNT; i++)
    {
        ProducerCreation(semid, i);
        ConsumerCreation(semid, i);
    }

    int status;
    for (int i = 0; i < PROC_COUNT * 2; i++)
        wait(&status);

    if (shmdt(addr) == -1)
        perror("Shared memory segment could not be detached from the address space of the calling process\n");
    return 0;
}
```

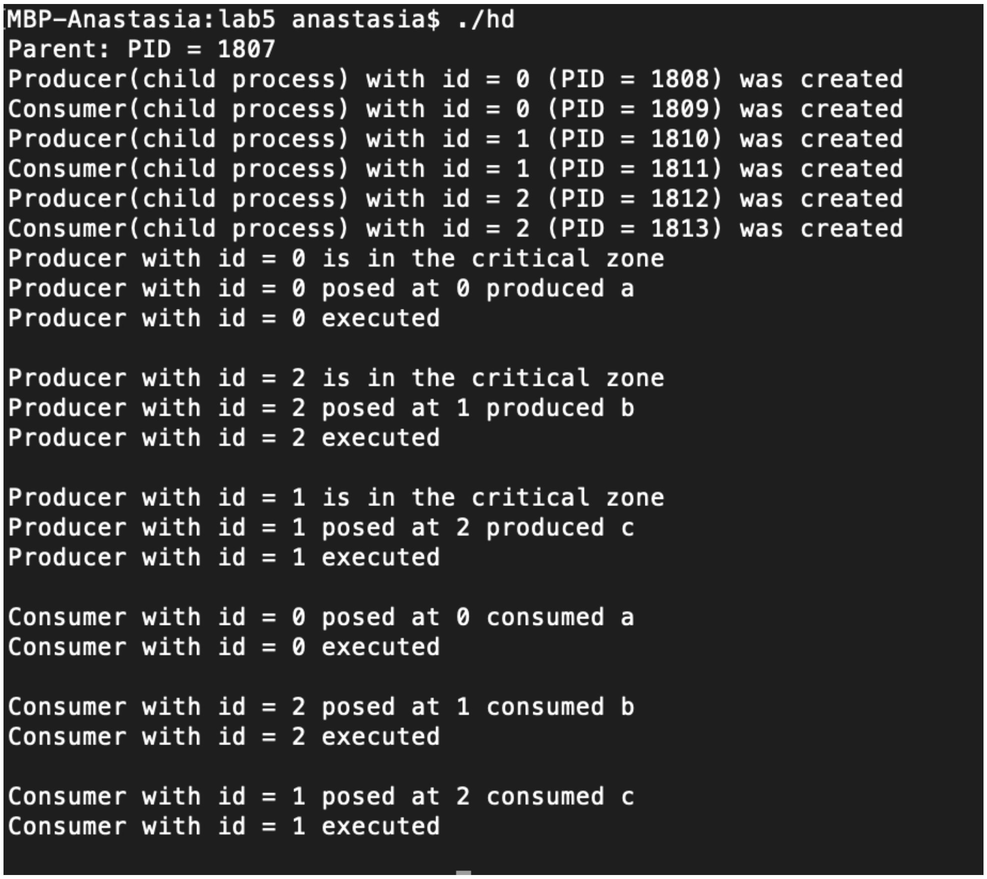
Листинг 3: Код подпрограмм создания и работы производителя

```
void ProducerRoutine(const int semid, const int prod_id)
{
    //Random delays
    sleep(rand() % 2);

    if (semop(semid, producerStart, 2) == -1)
    {
        perror("Producer's semop failed (couldn't enter the
            critical zone)\n");
        exit(1);
    }
    printf("Producer with id = %d is in the critical zone\n", prod_id);

    buff_pos[*prod_pos] = LETTERS[*prod_pos];

    printf("Producer with id = %d posed at %d produced %c\n", prod_id, *prod_pos, buff_pos[*prod_pos]);
    (*prod_pos)++;

    if (semop(semid, producerStop, 2) == -1)
    {
        perror("Producer's semop failed (couldn't escape the critical zone)\n");
        exit(1);
    }
}

void ProducerCreation(const int semid, const int id)
{
    int process;
    if ((process = fork()) == -1)
    {
        perror("Can\'t fork.\n");
        exit(1);
    }

    else if (process == 0)
    {
        printf("Producer(child process) with id = %d (PID = %d) was created\n", id, getpid());

        ProducerRoutine(semid, id);

        printf("Producer with id = %d executed\n\n", id);
        exit(0);
    }
}
```

Листинг 4: Код подпрограмм создания и работы потребителя

```
void ConsumerRoutine(const int semid, const int cons_id)
{
    //Random delays
    sleep(rand() % 5);

    if (semop(semid, consumerStart, 2) == -1)
    {
        perror("Consumer's semop failed (couldn't enter the critical zone)\n");
        exit(1);
    }

    printf("Consumer with id = %d posed at %d consumed %c\n", cons_id, *cons_pos, buff_pos[*cons_pos]);
    (*cons_pos)++;

    if (semop(semid, consumerStop, 2) == -1)
    {
        perror("Consumer's semop failed (couldn't escape the critical zone)\n");
        exit(1);
    }
}

void ConsumerCreation(const int semid, const int id)
{
    int process;
    if ((process = fork()) == -1)
    {
        perror("Can\'t fork.\n");
        exit(1);
    }

    else if (process == 0)
    {
        printf("Consumer(child process) with id = %d (PID = %d) was created\n", id, getpid());

        ConsumerRoutine(semid, id);

        printf("Consumer with id = %d executed\n\n", id);
        exit(0);
    }
}
```

На рисунке 1 приведен результат работы программы, в случае когда диапазон задержек выполнения потребителей больше диапазона задержек выполнения производителей. При этом задержки потребителей случайным образом принимают следующие значения: 0, 1, 2, 3, 4, - а задержки производителей - 0, 1. Следовательно, производство осуществляется быстрее потребления.



```
MBP-Anastasia:lab5 anastasia$ ./hd
Parent: PID = 1807
Producer(child process) with id = 0 (PID = 1808) was created
Consumer(child process) with id = 0 (PID = 1809) was created
Producer(child process) with id = 1 (PID = 1810) was created
Consumer(child process) with id = 1 (PID = 1811) was created
Producer(child process) with id = 2 (PID = 1812) was created
Consumer(child process) with id = 2 (PID = 1813) was created
Producer with id = 0 is in the critical zone
Producer with id = 0 posed at 0 produced a
Producer with id = 0 executed

Producer with id = 2 is in the critical zone
Producer with id = 2 posed at 1 produced b
Producer with id = 2 executed

Producer with id = 1 is in the critical zone
Producer with id = 1 posed at 2 produced c
Producer with id = 1 executed

Consumer with id = 0 posed at 0 consumed a
Consumer with id = 0 executed

Consumer with id = 2 posed at 1 consumed b
Consumer with id = 2 executed

Consumer with id = 1 posed at 2 consumed c
Consumer with id = 1 executed
```

Рис 1: Результат работы программы (задержки потребителей больше)

На листингах 5,...,8 представлена вторая программа, демонстрирующая реализацию задачи «Читатели – писатели» по монитору Хоара с четырьмя функциями: Начать_чтение, Закончить_чтение, Начать_запись, Закончить_запись.

Листинг 5: Начальные установки

```
#include <sys/types.h>
#include <sys/ipc.h>
#include <sys/sem.h>
#include <sys/stat.h>
#include <sys/shm.h>
#include <stdlib.h>
#include <unistd.h>

#include <pthread.h>
#include <stdio.h>

#define WHITE "\033[0m"
#define GREEN "\033[0;32m"

#define WRITERS 5
#define READERS 3
#define FLG 0

#define AW 0 //active_writer (logical)
#define AR 1 //active_readers
#define QW 2 //writers_queue
#define QR 3 //readers_queue

#define D -1 //decrement
#define I 1 //increment
#define W 0 //wait (sleep()) while semaphore is not 0

struct sembuf start_read[5] = {
    {QR, I, FLG},    //readers_queue + 1
    {QW, W, FLG},    //wait until writers_queue = 0
    {AW, W, FLG},    //wait until active_writer = 0
    {QR, D, FLG},    //readers_queue - 1
    {AR, I, FLG}};   //active_readers + 1
struct sembuf stop_read[1] = {{AR, D, FLG}};
struct sembuf start_write[5] = {
    {QW, I, FLG},  //writers_queue + 1
    {AR, W, FLG},  //wait until active_readers = 0
    {AW, W, FLG},  //wait until active_writer = 0
    {AW, I, FLG},  //active_writer = 1
    {QW, D, FLG}   //writers_queue - 1
};
struct sembuf stop_write[1] = {{AW, D, FLG}}; // active_writer = 0

int *addr = NULL;
```

Листинг 6: Код подпрограммы main()

```
int main()
{
    printf("Parent: PID = %d\n", getpid());

    int shm_perms = S_IRUSR | S_IWUSR | S_IRGRP | S_IROTH;
    int fd = shmget(IPC_PRIVATE, sizeof(int), shm_perms);
    if (fd == -1)
    {
        perror("New shared memory segment could not be created\n");
        return 1;
    }

    addr = shmat(fd, NULL, 0);
    if ((char *)addr == (char*) -1)
    {
        perror("Shared memory segment could not be attached to the address space of the calling process\n");
        return 1;
    }

    *addr = 0;

    int sem_perms = S_IRUSR | S_IWUSR | S_IRGRP | S_IROTH;
    int semid = semget(IPC_PRIVATE, 4, IPC_CREAT | IPC_EXCL | sem_perms);
    if (semid == -1)
    {
        perror("New semaphore set could not be created\n");
        return 1;
    }

    for (int i = 0; i < WRITERS; i++)
        Writer(semid, i);

    for (int i = 0; i < READERS; i++)
        Reader(semid, i);

    int status;

    for (int i = 0; i < WRITERS + READERS; i++)
        wait(&status);

    if (shmdt(addr) == -1)
        perror("Shared memory segment could not be detached from the address space of the calling process\n");
    return 0;
}
```

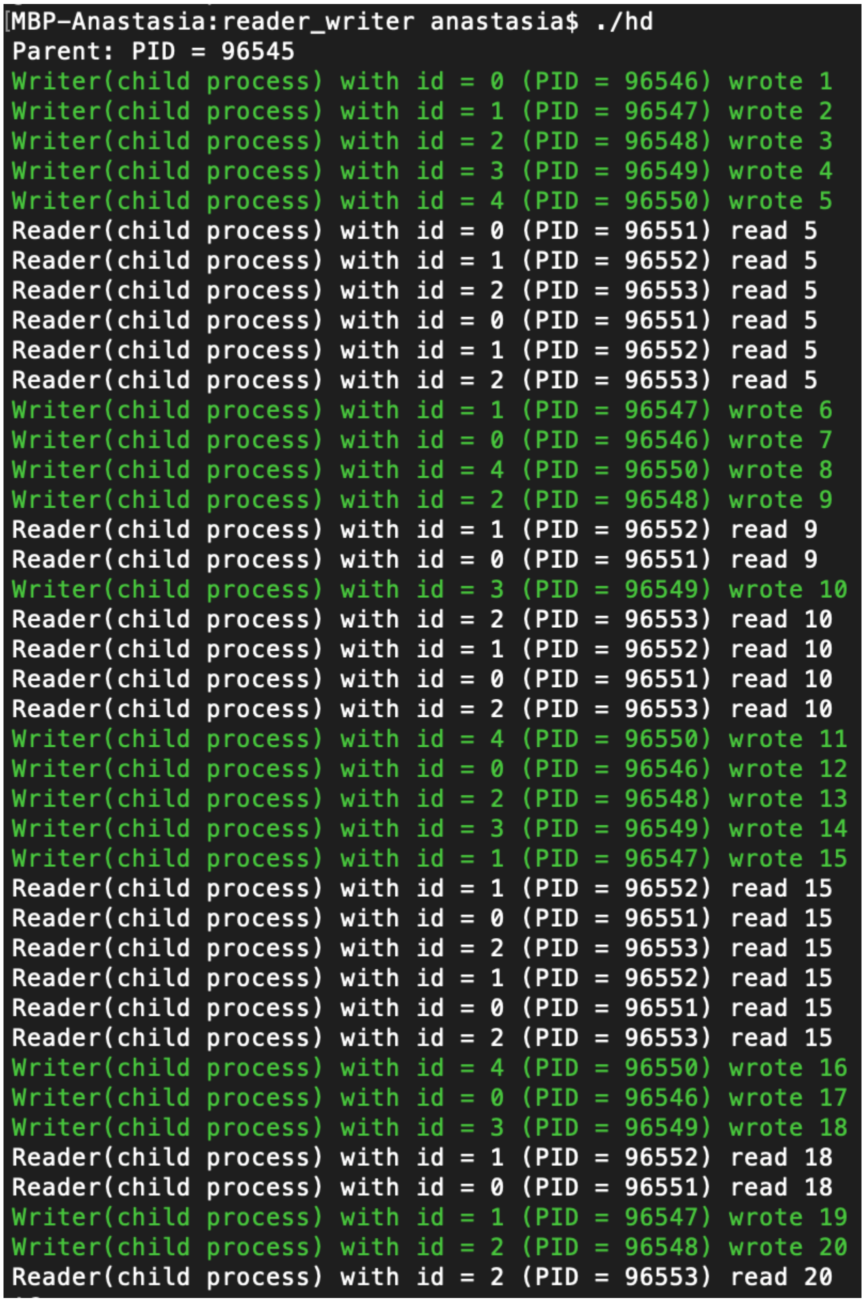
Листинг 7: Код подпрограммы Writer() - процесс писатель

```
void Writer(const int semid, const int id)
{
    int process;
    if ((process = fork()) == -1)
    {
        perror("Can\'t fork.\n");
        exit(1);
    }

    else if (process == 0)
    {
        while(1)
        {
            if (semop(semid, start_write, 5) == -1)
            {
                perror("Writer's semop failed (couldn't enter the critical zone)\n");
                exit(1);
            }

            (*addr)++;
            printf("%sWriter(child process) with id = %d (PID = %d) wrote %d\n", GREEN, id, getpid(), *addr);

            if (semop(semid, stop_write, 1) == -1)
            {
                perror("Writer's semop failed (couldn't escape the critical zone)\n");
                exit(1);
            }
            sleep(2);
        }
        exit(0);
    }
}
```

Листинг 8: Код подпрограммы Reader() - процесс читатель

```
void Reader(const int semid, const int id)
{
    int process;
    if ((process = fork()) == -1)
    {
        perror("Can\'t fork.\n");
        exit(1);
    }

    else if (process == 0)
    {
        while(1)
        {
            if (semop(semid, start_read, 5) == -1)
            {
                perror("Reader's semop failed (couldn't enter the critical zone)\n");
                exit(1);
            }

            printf("%sReader(child process) with id = %d (PID = %d) read %d\n", WHITE, id, getpid(), *addr);

            if (semop(semid, stop_read,1) == -1)
            {
                perror("Reader's semop failed (couldn't escape the critical zone)\n");
                exit(1);
            }
            sleep(1);
        }
        exit(0);
    }
}
```

На рисунке 2 приведен результат работы второй программы.



```
[MBP-Anastasia:reader_writer anastasia$ ./hd
Parent: PID = 96545
Writer(child process) with id = 0 (PID = 96546) wrote 1
Writer(child process) with id = 1 (PID = 96547) wrote 2
Writer(child process) with id = 2 (PID = 96548) wrote 3
Writer(child process) with id = 3 (PID = 96549) wrote 4
Writer(child process) with id = 4 (PID = 96550) wrote 5
Reader(child process) with id = 0 (PID = 96551) read 5
Reader(child process) with id = 1 (PID = 96552) read 5
Reader(child process) with id = 2 (PID = 96553) read 5
Reader(child process) with id = 0 (PID = 96551) read 5
Reader(child process) with id = 1 (PID = 96552) read 5
Reader(child process) with id = 2 (PID = 96553) read 5
Writer(child process) with id = 1 (PID = 96547) wrote 6
Writer(child process) with id = 0 (PID = 96546) wrote 7
Writer(child process) with id = 4 (PID = 96550) wrote 8
Writer(child process) with id = 2 (PID = 96548) wrote 9
Reader(child process) with id = 1 (PID = 96552) read 9
Reader(child process) with id = 0 (PID = 96551) read 9
Writer(child process) with id = 3 (PID = 96549) wrote 10
Reader(child process) with id = 2 (PID = 96553) read 10
Reader(child process) with id = 1 (PID = 96552) read 10
Reader(child process) with id = 0 (PID = 96551) read 10
Reader(child process) with id = 2 (PID = 96553) read 10
Writer(child process) with id = 4 (PID = 96550) wrote 11
Writer(child process) with id = 0 (PID = 96546) wrote 12
Writer(child process) with id = 2 (PID = 96548) wrote 13
Writer(child process) with id = 3 (PID = 96549) wrote 14
Writer(child process) with id = 1 (PID = 96547) wrote 15
Reader(child process) with id = 1 (PID = 96552) read 15
Reader(child process) with id = 0 (PID = 96551) read 15
Reader(child process) with id = 2 (PID = 96553) read 15
Reader(child process) with id = 1 (PID = 96552) read 15
Reader(child process) with id = 0 (PID = 96551) read 15
Reader(child process) with id = 2 (PID = 96553) read 15
Writer(child process) with id = 4 (PID = 96550) wrote 16
Writer(child process) with id = 0 (PID = 96546) wrote 17
Writer(child process) with id = 3 (PID = 96549) wrote 18
Reader(child process) with id = 1 (PID = 96552) read 18
Reader(child process) with id = 0 (PID = 96551) read 18
Writer(child process) with id = 1 (PID = 96547) wrote 19
Writer(child process) with id = 2 (PID = 96548) wrote 20
Reader(child process) with id = 2 (PID = 96553) read 20
```

Рис 2.: Результат работы программы