Experiment Report

— Producer-Consumer Problem

Name:Wang Xingyi StudentID:5140309531

December 22, 2016

1 Introduction

In this project, we will design a programming solution to the bounded-buffer problem using producer and consumer process. The solution uses three semaphores: **empty** and **full**, which count the number of empty and full slots in the buffer, and **mutex**, which is a binary(or mutual exclusion) semaphore that protects the actual insertion or removal of items in the buffer. For this project, standard counting semaphores will be used for **empty** and **full**, and, rather than a binary semaphore, a mutex lock will be used to represent **mutex**. The producer and consumer - running as separate threads - will move items to and from a buffer that is synchronized with these **empty**, **full**, and **mutex** structure. We will solve this problem using Pthread.

2 Running environment

⟶ Ubuntu 16.04

3 Experimental procedure

3.1 The buffer

The buffer is defined in 'buffer.h' and its size is initially designed as 5.

```
/* buffer.h */
typedef int buffer_item
#define BUFFER_SIZE 5
```

This buffer will be manipulated with two functions, **insert_item()** and **remove_item()**.

```c
#include "buffer.h"

/* the buffer */
buffer_item buffer[BUFFER_SIZE];

int insert_item(buffer_item item) {
    /* insert item into buffer
     * return 0 if successful, otherwise
     * return -1 indicating an error condition */
    if (cnt < BUFFER_SIZE) {
        buffer[cnt++] = item;
        return 0;
    }
    else
        return -1;
}

int remove_item(buffer_item *item) {
    /* remove an object from buffer
     * placing it in item
     * return 0 if successful, otherwise
     * return -1 indicating an error condition */
    if (cnt > 0) {
        *item = buffer[--cnt];
        return 0;
    }
    else
        return -1;
}
```

3.2 Producer and Consumer Threads

We use Pthread to implement **producer** and **consumer** in different threads. Producer first sleeps for a couple of seconds and generate a random number to present that is has produced an item, and insert it into the buffer if the buffer is still available. Similarly, consumer also sleeps for a couple of seconds and consumes the remaining items in the buffer.

```c
void *producer(void *param) {
    buffer_item item;

    while (1) {
        /* sleep for a random period of time */
```

```c
        sleep(rand() % 5);
        /* generate a random number */
        item = rand();

        sem_wait(&empty);
        pthread_mutex_lock(&mutex);
        if (insert_item(item))
            fprintf(stderr, "report error condition\n");
        else
            printf("producer produced %d\n", item);
        pthread_mutex_unlock(&mutex);
        sem_post(&full);
    }
}

void *consumer(void *param) {
    buffer_item item;

    while (1) {
        /* sleep for a random period of time */
        sleep(rand() % 5);

        sem_wait(&full);
        pthread_mutex_lock(&mutex);
        if (remove_item(&item))
            fprintf(stderr, "report error condition\n");
        else
            printf("consumer consumed %d\n", item);
        pthread_mutex_unlock(&mutex);
        sem_post(&empty);
    }
}
```

3.3 Mutex Locks

Mutex locks are available in the Pthread API and can be used to protect a critical section.

```c
#include <pthread.h>
pthread_mutex_t mutex;

pthread_mutex_init(&mutex, NULL);
```

```

pthread_mutex_lock(&mutex);
/* critical section */
pthread_mutex_unlock(&mutex);
```

3.4 Semaphores

We use unnamed semaphores provided by Pthread.

```
#include <semaphore.h>
sem_t empty, full;

sem_init(&empty, 0, BUFFER_SIZE);
sem_init(&full, 0, 0);
```

And the classical **wait()** and **signal()** semaphore operatons are named as **sem_wait()** and **sem_post()** respectively.

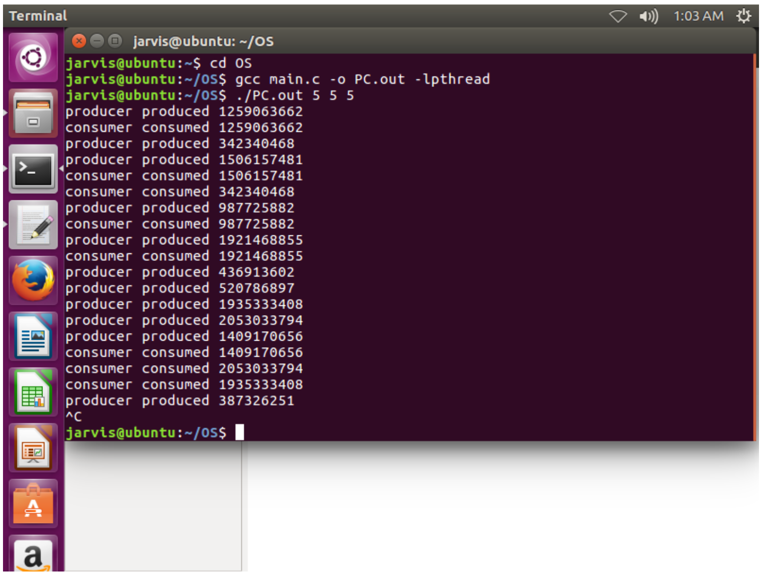
3.5 main()

The **main()** function will initialize the buffer and create the separate producer and consumer threads. Once it has created the producer and consumer threads, the main() function will sleep for a period of time and, upon awakening, will terminate the application. The **main()** function will be passed three parameters on the command line.

4 Conclusion and Discussion

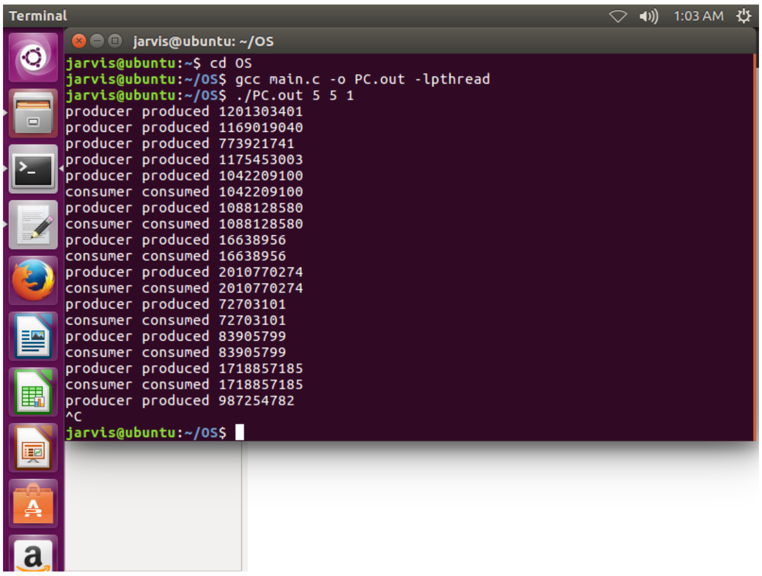
We will demonstrate this producer-consumer system in three different situations.

4.1 Producers are as many as Consumers



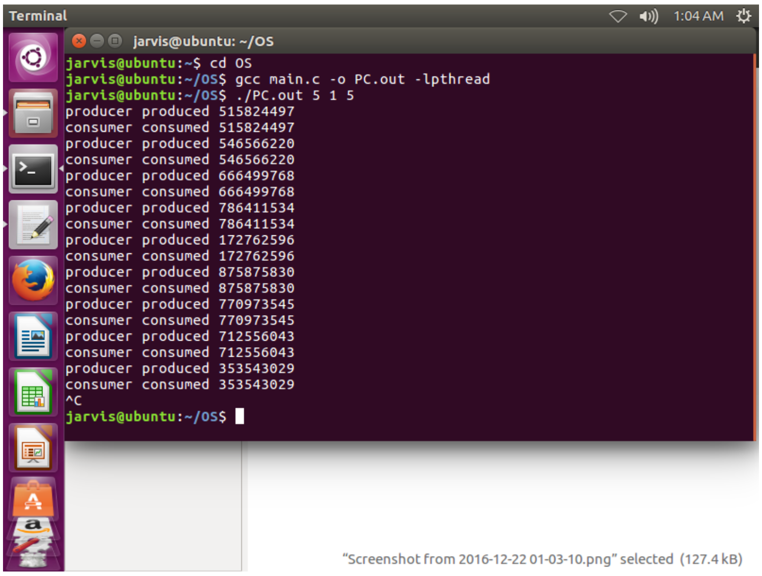
In this situation, we allocate 5 producers and 5 consumers. The result shows that producer and consumer randomly produce or consume items. But an item must be consumed after being produced(of course!).

4.2 Producers are more than Consumers



In this situation, we allocate 5 producers and 1 consumer. The result shows that 5 items are produced first, and the buffer is full. Once an item is consumed, another new item will be produced immediately. So the first 4 items will remains in the bounded buffer.

4.3 Producers are less that Consumers



In this situation, we allocate 1 producers and 5 consumer. An item that is produced will be consumed immediately.