

[EOPSY] LAB 5

THE BARBER PROBLEM

Ernest Pokropek

1 TABLE OF CONTENTS

2	Task description	1
3	Introduction	2
4	Implementation	2
5	Results.....	5
5.1	Simulations:.....	5
5.2	EDGE CASES:.....	11
6	Discussion.....	12

2 TASK DESCRIPTION

The analogy is based upon a hypothetical barber shop with many barbers serving women and men. In a barber shop there are N_1 barbers serving only women, N_2 barbers serving only men and N_3 barbers serving both women and men. Each barber has one barber's chair in a cutting room. In a waiting room there are M chairs. When the barber finishes cutting a customer's hair, he dismisses the customer and goes to the waiting room to see if there are others waiting. If there are, he brings one of them (but only if he is able to cut hair, i.e. the barber brings a man into the cutting room only if he can cut his hair, etc.) back to the chair and cuts hair (it lasts a random time). If there are none, he returns to the chair and sleeps in it. Each customer can be either a male client or a female client. When a client arrives, he/she checks what barbers are doing. If there is any barber sleeping (who is able to serve the client), the customer wakes him up, and sits in the cutting room chair. If all barbers (able to serve the client) are cutting hair, the customer stays in the waiting room. If there is a free chair in the waiting room, the customer sits in it and waits their turn. If there is no free chair, the customer leaves.

Implement the C language the sleeping barber problem. The program must be parameterized by N_1 , N_2 , N_3 - number of barbers, M - number of chairs in waiting room.

For synchronization use IPC semaphores (man semget, man semop) to make atomic changes on two semaphores at the same time. Print on the standard output verbose messages from customers and the barbers.

Execute the program with different N_1 , N_2 , N_3 and M values.

Describe a solution for this problem in a document (uploaded to github). Verify your program with different N_1 , N_2 , N_3 and M values.

3 INTRODUCTION

The stated in the Task Description problem is a more complex and sophisticated interpretation of the popular sleeping barber problem, working as an analogy of process synchronization.

4 IMPLEMENTATION

The implantation was done in C language using semaphores, and can be found in the **main.c** file in the same directory. The main principles are: the number of clients is fixed, and each time the client enters the barber, its gender gets randomized (however it sounds). This was implemented due to the assumption, that only sending interrupt (default Ctrl+C) can stop the program. No queue has been implanted, thus it is not a FIFO algorithm being used (although the choices are prioritized for the unisex barber). The flowcharts of the algorithms implanted are presented on the Figure 1 and 2. **Do note**, that both processes might be only stopped by sending SIGTINT (Ctrl+C).

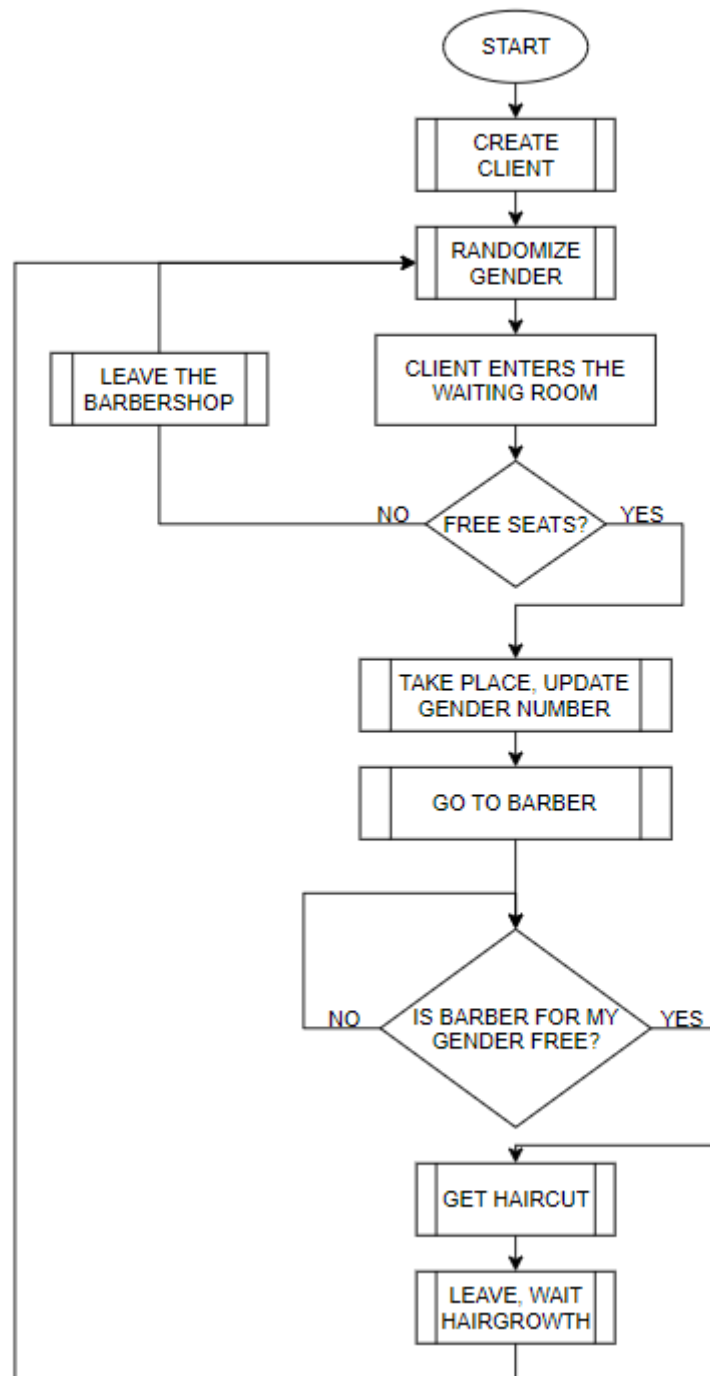


Figure 1) Client flowchart

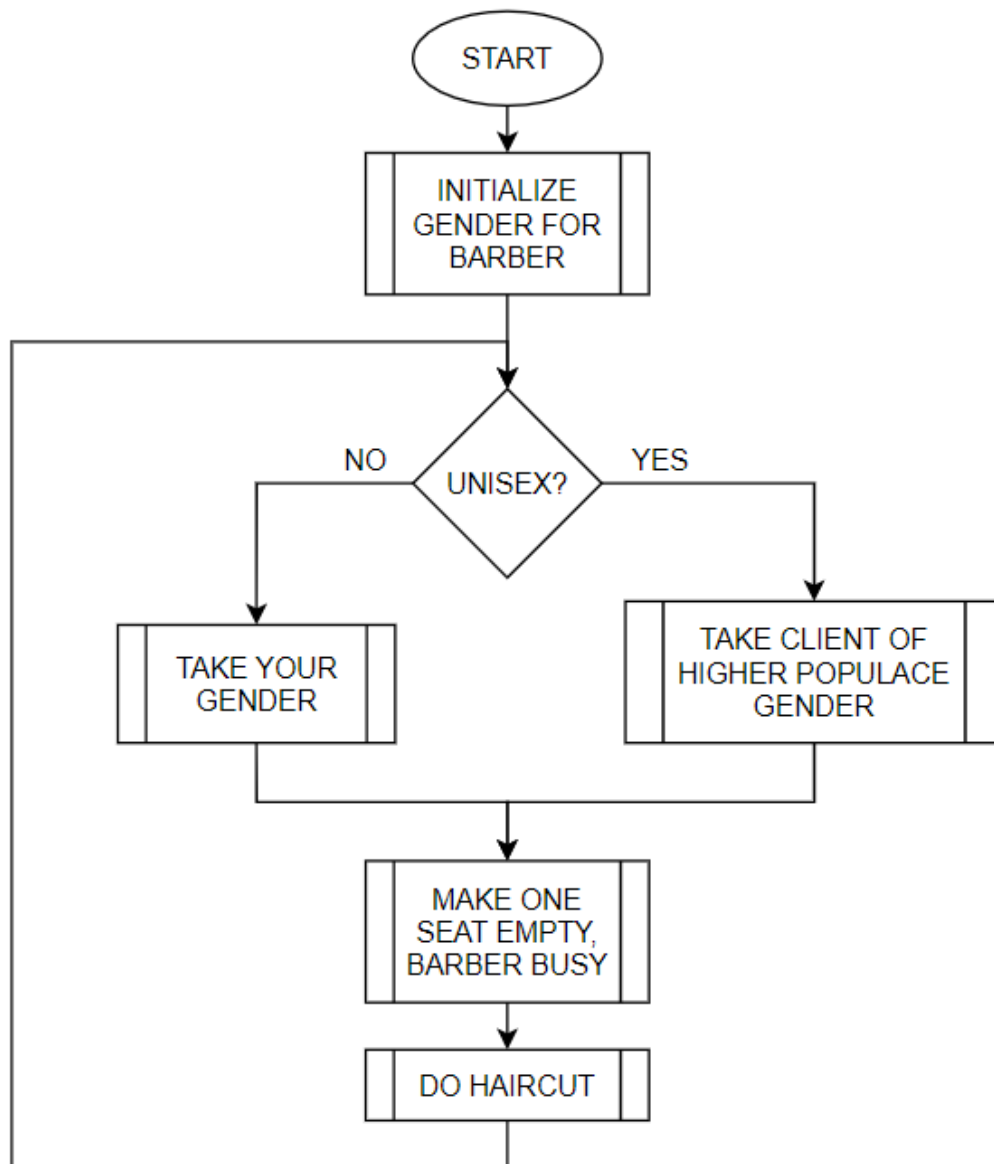


Figure 2) Barber flowchart

5 RESULTS

Simulations for various combinations were performed, as presented below.

5.1 SIMULATIONS:

Barber process started
Barber creation beginning...
female [barber] 0 created: Ready for work
female [barber] 0: Ready for new customer
female [barber] 1 created: Ready for work
female [barber] 1: Ready for new customer
male [barber] 0 created: Ready for work
male [barber] 0: Ready for new customer
male [barber] 1 created: Ready for work
male [barber] 1: Ready for new customer
unisex [barber] 0 created: Ready for work
unisex [barber] 0: Ready for new customer
female [client] 0: Entered the waiting room.
female [barber] 0: serving customer...
female [client] 0: Is to be served by a barber
female [client] 1: Entered the waiting room.
female [barber] 1: serving customer...
female [client] 1: Is to be served by a barber
female [client] 2: Entered the waiting room.
unisex [barber] 0: serving customer...
female [client] 2: Is to be served by a barber
female [client] 3: Entered the waiting room.
female [client] 4: Entered the waiting room.
female [client] 5: Entered the waiting room.
female [client] 6: Entered the waiting room.
female [client] 7: Entered the waiting room.
female [client] 7: waiting room full, exiting
female [client] 8: Entered the waiting room.
female [client] 8: waiting room full, exiting
female [barber] 0: Ready for new customer
female [barber] 0: serving customer...
female [client] 3: Is to be served by a barber
female [barber] 1: Ready for new customer
female [barber] 1: serving customer...
female [client] 4: Is to be served by a barber
unisex [barber] 0: Ready for new customer
unisex [barber] 0: serving customer...
female [client] 5: Is to be served by a barber
female [barber] 0: Ready for new customer
female [barber] 0: serving customer...
female [client] 6: Is to be served by a barber
female [barber] 1: Ready for new customer
unisex [barber] 0: Ready for new customer
female [barber] 0: Ready for new customer

Female barbers	2
Male barbers	2
Unisex barbers	1
Waiting room chairs	4
Clients	9

female [client] 0: Entered the waiting room.
female [barber] 1: serving customer...
female [client] 0: Is to be served by a barber
female [client] 1: Entered the waiting room.
unisex [barber] 0: serving customer...
female [client] 1: Is to be served by a barber
female [client] 2: Entered the waiting room.
female [barber] 0: serving customer...
female [client] 2: Is to be served by a barber
female [client] 7: Entered the waiting room.
female [client] 8: Entered the waiting room.
^CProgram was interrupted. Clearing shared memory and semaphores.
[client] id: 88 left the barbershop.
[client] id: 89 left the barbershop.
[client] id: 90 left the barbershop.
[client] id: 91 left the barbershop.
[client] id: 92 left the barbershop.
[client] id: 93 left the barbershop.
[client] id: 94 left the barbershop.
[client] id: 95 left the barbershop.
[client] id: 96 left the barbershop.
[client] id: 97 left the barbershop.
[client] id: 98 left the barbershop.
[client] id: 99 left the barbershop.
[client] id: 100 left the barbershop.
[client] id: 101 left the barbershop.

Barber process started

Barber creation beginning...

female [barber] 0 created: Ready for work
female [barber] 0: Ready for new customer
female [barber] 1 created: Ready for work
female [barber] 1: Ready for new customer
female [barber] 2 created: Ready for work
female [barber] 2: Ready for new customer
male [barber] 0 created: Ready for work
male [barber] 0: Ready for new customer
male [barber] 1 created: Ready for work
male [barber] 1: Ready for new customer
male [barber] 2 created: Ready for work
male [barber] 2: Ready for new customer
unisex [barber] 0 created: Ready for work
unisex [barber] 0: Ready for new customer
male [client] 0: Entered the waiting room.
male [barber] 1: serving customer...
male [client] 0: Is to be served by a barber
male [client] 1: Entered the waiting room.
male [client] 1: Is to be served by a barber
male [barber] 0: serving customer...
male [client] 2: Entered the waiting room.
male [client] 2: Is to be served by a barber

Female barbers	3
Male barbers	3
Unisex barbers	1
Waiting room chairs	2
Clients	20

male [barber] 2: serving customer...
male [client] 3: Entered the waiting room.
male [client] 4: Entered the waiting room.
male [client] 5: Entered the waiting room.
male [client] 5: waiting room full, exiting
male [client] 6: Entered the waiting room.
male [client] 6: waiting room full, exiting
male [client] 7: Entered the waiting room.
male [client] 7: waiting room full, exiting
male [client] 8: Entered the waiting room.
male [client] 8: waiting room full, exiting
male [client] 9: Entered the waiting room.
male [client] 9: waiting room full, exiting
male [client] 10: Entered the waiting room.
male [client] 10: waiting room full, exiting
male [client] 11: Entered the waiting room.
male [client] 11: waiting room full, exiting
male [client] 12: Entered the waiting room.
male [client] 12: waiting room full, exiting
male [client] 13: Entered the waiting room.
male [client] 13: waiting room full, exiting
male [client] 14: Entered the waiting room.
male [client] 14: waiting room full, exiting
male [client] 15: Entered the waiting room.
male [client] 15: waiting room full, exiting
male [client] 16: Entered the waiting room.
male [client] 16: waiting room full, exiting
male [client] 17: Entered the waiting room.
male [client] 17: waiting room full, exiting
male [client] 18: Entered the waiting room.
male [client] 18: waiting room full, exiting
male [client] 19: Entered the waiting room.
male [client] 19: waiting room full, exiting
male [barber] 1: Ready for new customer
male [barber] 1: serving customer...
male [client] 3: Is to be served by a barber
male [barber] 0: Ready for new customer
male [barber] 0: serving customer...
male [client] 4: Is to be served by a barber
male [barber] 2: Ready for new customer
male [barber] 1: Ready for new customer
male [barber] 0: Ready for new customer
male [client] 0: Entered the waiting room.
male [barber] 2: serving customer...
male [client] 0: Is to be served by a barber
male [client] 1: Entered the waiting room.
male [barber] 1: serving customer...
male [client] 1: Is to be served by a barber
male [client] 2: Entered the waiting room.
male [barber] 0: serving customer...
male [client] 2: Is to be served by a barber

male [client] 5: Entered the waiting room.
male [client] 6: Entered the waiting room.
male [client] 7: Entered the waiting room.
male [client] 7: waiting room full, exiting
male [client] 8: Entered the waiting room.
male [client] 8: waiting room full, exiting
male [client] 9: Entered the waiting room.
male [client] 9: waiting room full, exiting
male [client] 10: Entered the waiting room.
male [client] 10: waiting room full, exiting
male [client] 11: Entered the waiting room.
male [client] 11: waiting room full, exiting
male [client] 12: Entered the waiting room.
male [client] 12: waiting room full, exiting
male [client] 13: Entered the waiting room.
male [client] 13: waiting room full, exiting
male [client] 14: Entered the waiting room.
male [client] 14: waiting room full, exiting
male [client] 16: Entered the waiting room.
male [client] 15: Entered the waiting room.
male [client] 16: waiting room full, exiting
male [client] 15: waiting room full, exiting
male [client] 17: Entered the waiting room.
male [client] 17: waiting room full, exiting
male [client] 18: Entered the waiting room.
male [client] 18: waiting room full, exiting
male [client] 19: Entered the waiting room.
male [client] 19: waiting room full, exiting
male [barber] 2: Ready for new customer
male [client] 3: Entered the waiting room.
male [barber] 2: serving customer...
male [client] 5: Is to be served by a barber
male [client] 4: Entered the waiting room.
male [client] 4: waiting room full, exiting
male [barber] 1: Ready for new customer
male [barber] 1: serving customer...
male [client] 6: Is to be served by a barber
male [barber] 0: Ready for new customer
male [barber] 0: serving customer...
male [client] 3: Is to be served by a barber
^CProgram was interrupted. Clearing shared memory and semaphores.
[client] id: 51 left the barbershop.
[client] id: 52 left the barbershop.
[client] id: 53 left the barbershop.
[client] id: 54 left the barbershop.
[client] id: 55 left the barbershop.
[client] id: 56 left the barbershop.
[client] id: 57 left the barbershop.
[client] id: 58 left the barbershop.
[client] id: 59 left the barbershop.
[client] id: 60 left the barbershop.

[client] id: 61 left the barbershop.
 [client] id: 62 left the barbershop.
 [client] id: 63 left the barbershop.
 [client] id: 64 left the barbershop.
 [client] id: 65 left the barbershop.
 [client] id: 66 left the barbershop.
 [client] id: 67 left the barbershop.
 [client] id: 68 left the barbershop.
 [client] id: 69 left the barbershop.
 [client] id: 70 left the barbershop.
 [client] id: 71 left the barbershop.
 [client] id: 72 left the barbershop.
 [client] id: 73 left the barbershop.
 [client] id: 74 left the barbershop.
 [client] id: 75 left the barbershop.
 [client] id: 76 left the barbershop.
 [client] id: 77 left the barbershop.

Barber process started
 Barber creation beginning...
 female [barber] 0 created: Ready for work
 female [barber] 0: Ready for new customer
 male [barber] 0 created: Ready for work
 male [barber] 0: Ready for new customer
 unisex [barber] 0 created: Ready for work
 unisex [barber] 0: Ready for new customer
 unisex [barber] 1 created: Ready for work
 unisex [barber] 1: Ready for new customer
 female [client] 0: Entered the waiting room.
 female [barber] 0: serving customer...
 female [client] 0: Is to be served by a barber
 female [client] 1: Entered the waiting room.
 unisex [barber] 0: serving customer...
 female [client] 1: Is to be served by a barber
 female [client] 2: Entered the waiting room.
 female [client] 2: Is to be served by a barber
 unisex [barber] 1: serving customer...
 female [client] 3: Entered the waiting room.
 female [client] 4: Entered the waiting room.
 female [client] 4: waiting room full, exiting
 female [client] 5: Entered the waiting room.
 female [client] 5: waiting room full, exiting
 female [barber] 0: Ready for new customer
 female [barber] 0: serving customer...
 female [client] 3: Is to be served by a barber

Female barbers	1
Male barbers	1
Unisex barbers	2
Waiting room chairs	1
Clients	6

```

unisex [barber] 0: Ready for new customer
unisex [barber] 1: Ready for new customer
female [barber] 0: Ready for new customer
female [client] 0: Entered the waiting room.
female [client] 1: Entered the waiting room.
female [client] 2: Entered the waiting room.
female [client] 4: Entered the waiting room.
female [client] 5: Entered the waiting room.
female [client] 3: Entered the waiting room.
unisex [barber] 0: serving customer...
female [client] 0: Is to be served by a barber
unisex [barber] 1: serving customer...
female [client] 1: Is to be served by a barber
female [barber] 0: serving customer...
female [client] 2: Is to be served by a barber
female [client] 5: waiting room full, exiting
female [client] 3: waiting room full, exiting
unisex [barber] 0: Ready for new customer
unisex [barber] 0: serving customer...
female [client] 4: Is to be served by a barber
female [barber] 0: Ready for new customer
unisex [barber] 1: Ready for new customer
unisex [barber] 0: Ready for new customer
female [client] 0: Entered the waiting room.
female [client] 1: Entered the waiting room.
female [barber] 0: serving customer...
female [client] 0: Is to be served by a barber
unisex [barber] 1: serving customer...
female [client] 1: Is to be served by a barber
female [client] 5: Entered the waiting room.
female [client] 2: Entered the waiting room.
female [client] 3: Entered the waiting room.
unisex [barber] 0: serving customer...
female [client] 5: Is to be served by a barber
female [client] 3: waiting room full, exiting
female [client] 4: Entered the waiting room.
female [client] 4: waiting room full, exiting
female [barber] 0: Ready for new customer
female [barber] 0: serving customer...
female [client] 2: Is to be served by a barber
unisex [barber] 1: Ready for new customer
unisex [barber] 0: Ready for new customer
^CProgram was interrupted. Clearing shared memory and semaphores.
[client] id: 31 left the barbershop.
[client] id: 32 left the barbershop.
[client] id: 33 left the barbershop.
[client] id: 34 left the barbershop.
[client] id: 35 left the barbershop.
[client] id: 36 left the barbershop.
[client] id: 37 left the barbershop.
[client] id: 38 left the barbershop.

```

[client] id: 39 left the barbershop.
[client] id: 40 left the barbershop.

5.2 EDGE CASES:

Barber process started
Barber creation beginning...
male [barber] 0 created: Ready for work
male [barber] 0: Ready for new customer
male [barber] 1 created: Ready for work
male [barber] 1: Ready for new customer
female [client] 0: Entered the waiting room.
female [client] 1: Entered the waiting room.
female [client] 2: Entered the waiting room.
female [client] 3: Entered the waiting room.
female [client] 4: Entered the waiting room.
// much time passing...
^CProgram was interrupted. Clearing shared memory and semaphores.
[client] id: 159 left the barbershop.
[client] id: 160 left the barbershop.
[client] id: 161 left the barbershop.
[client] id: 162 left the barbershop.
[client] id: 163 left the barbershop.
[client] id: 164 left the barbershop.
[client] id: 165 left the barbershop.

Female barbers	0
Male barbers	2
Unisex barbers	0
Waiting room chairs	10
Clients	5

Barber process started
Barber creation beginning...
female [client] 0: Entered the waiting room.
female [client] 1: Entered the waiting room.
female [client] 1: waiting room full, exiting
female [client] 2: Entered the waiting room.
female [client] 2: waiting room full, exiting
male [client] 1: Entered the waiting room.
male [client] 1: waiting room full, exiting
male [client] 2: Entered the waiting room.
male [client] 2: waiting room full, exiting
^CProgram was interrupted. Clearing shared memory and semaphores.
[client] id: 176 left the barbershop.
[client] id: 177 left the barbershop.
[client] id: 178 left the barbershop.

Female barbers	0
Male barbers	0
Unisex barbers	0
Waiting room chairs	1
Clients	3

6 DISCUSSION

For first three cases of which the results were shown previously, the algorithm behaves as expected – the customers come to the barbershop, and take place in waiting room if it's available, otherwise they leave. Only barbers who can cut hair of given sex are doing so, and the unisex barbers can do both (although in the edge case of same number of men and women in the waiting room they will choose women). For edge cases (5.2), given only male barbers with female clients will result in infinite wait time, as there is no one to serve the clients. In case of no barbers and number of chairs smaller than customers, few of them will take a seat, and the other group would come to the barbershop and leave after they see that the waiting room is full. And all repeats for eternity (or until SIGTERM). After this, for each of the cases described previously, the processes clients are terminated, and barbers stay in their shops.