CSE344 - System Programming - Midterm

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1   Design Explanation

1.1   Children processes

The parent process will fork into 3 types of children:

1.1.1   Nurses

Nurses are the producers. Just like any other producer & consumer problem they will wait for empty space when the buffer is full. However posting the semaphore to notify consumer is a little bit different. The value of semaphore must be the minimum of 2 vaccines. In order to satisfy this, semaphore should be posted only if the type of the vaccine added to buffer is less than or equal to the other type of vaccine:

```
if (!mem->eof && novacc_this <= novacc_other)
  sem_post(&mem->vaccines_available);
```

Nurses will continue until, one of them reach the end of the file, and return value of `read()` is goint to be 0. In this case nurse will be terminated. But before terminaton, it will perform `sem_post(&mem->empty)` to make sure that the other nurses won't stuck in `sem_wait(&mem->empty)`, and they will also terminate.

1.1.2   Vaccinators

Vaccinators are the consumers. They will wait for the semaphore: `vaccines_available`, and post `empty`. In the critical section:

1. remove vaccines from the buffer

2. selct the next citizen to invite

3. set the information to print

After critical section, the vaccinator is going to inform the citizen by writing to its pipe. And print the log.

Note: Since printing is out of the critical section, the order of the lines are not guaranteed. I have added both on the Running & Test Cases section.

1.1.3   Citizens

Citizens should wait for get vaccinated. Thus, a citizen will read its pipe `t` times (number of shots) in total. The write end of the pipes are located in the shared memory, and they are accesed by vaccinators.

1.2   Number of Semaphores

3 unnamed POSIX semaphores are used, and they are located in shared memory.

- sem: to protect access to shared memory
- empty: nurses (producers) will wait on this semaphore, when the buffer is full
- vaccines_available: vaccinators (consumers) will wait on this semaphore, until there are enough amount of vaccines in the buffer

1.3   Shared Memory

Multiple unnamed shared memories is used for interprocess communication. mmap system call is used with MAP_SHARED | MAP_ANONYMOUS flags, therefore the mapping is not backed by any file.

1.4   Handling SIGINT

In case of receiving SIGINT, handler function is going to call exit(EXIT_SUCCESS). An exit handler is registered, therefore it will terminated gracefully.

2   Running & Test Cases

Program tested with different cases and also with the valgrind to check memory leaks. According the output of the valgrind, "All heap blocks were freed – no leaks are possible".

```
valgrind --leak-check=full \
        --show-leak-kinds=all \
        --track-origins=yes \
        --verbose \
        --log-file=valgrind-out.txt \
        ...
```

When log functions are inside of the critical section:

```
./program  -n 3 -v 3 -c 3 -b 11 -t 3 -i input
```

```
Welcome to GTU344 clinic. Number of citizens to vaccinate c=3 with t=3 doeses.
Nurse 1 (pid=861723) has brought vaccine 1: the clinic has 1 vaccine1 and 0 vaccine2.
Nurse 1 (pid=861723) has brought vaccine 2: the clinic has 1 vaccine1 and 1 vaccine2.
Nurse 1 (pid=861723) has brought vaccine 1: the clinic has 2 vaccine1 and 1 vaccine2.
Nurse 1 (pid=861723) has brought vaccine 2: the clinic has 2 vaccine1 and 2 vaccine2.
Nurse 1 (pid=861723) has brought vaccine 1: the clinic has 3 vaccine1 and 2 vaccine2.
Nurse 1 (pid=861723) has brought vaccine 2: the clinic has 3 vaccine1 and 3 vaccine2.
Nurse 1 (pid=861723) has brought vaccine 1: the clinic has 4 vaccine1 and 3 vaccine2.
Nurse 1 (pid=861723) has brought vaccine 2: the clinic has 4 vaccine1 and 4 vaccine2.
Nurse 1 (pid=861723) has brought vaccine 1: the clinic has 5 vaccine1 and 4 vaccine2.
Nurse 1 (pid=861723) has brought vaccine 2: the clinic has 5 vaccine1 and 5 vaccine2.
Nurse 2 (pid=861724) has brought vaccine 1: the clinic has 6 vaccine1 and 5 vaccine2.
Vaccinator 1 (pid=861729) is inviting citizen pid=861726 to the clinic.
Citizen 1 (pid=861726) is vaccinated for the 1st time: the clinic has 5 vaccine1 and 4 vaccine2.
Vaccinator 2 (pid=861730) is inviting citizen pid=861727 to the clinic.
Citizen 2 (pid=861727) is vaccinated for the 1st time: the clinic has 4 vaccine1 and 3 vaccine2.
Nurse 3 (pid=861725) has brought vaccine 2: the clinic has 4 vaccine1 and 4 vaccine2.
Vaccinator 3 (pid=861731) is inviting citizen pid=861728 to the clinic.
Citizen 3 (pid=861728) is vaccinated for the 1st time: the clinic has 3 vaccine1 and 3 vaccine2.
Vaccinator 3 (pid=861731) is inviting citizen pid=861726 to the clinic.
Citizen 1 (pid=861726) is vaccinated for the 2nd time: the clinic has 2 vaccine1 and 2 vaccine2.
Vaccinator 2 (pid=861730) is inviting citizen pid=861727 to the clinic.
Citizen 2 (pid=861727) is vaccinated for the 2nd time: the clinic has 1 vaccine1 and 1 vaccine2.
Nurse 1 (pid=861723) has brought vaccine 1: the clinic has 2 vaccine1 and 1 vaccine2.
Nurse 1 (pid=861723) has brought vaccine 2: the clinic has 2 vaccine1 and 2 vaccine2.
Nurse 3 (pid=861725) has brought vaccine 1: the clinic has 3 vaccine1 and 2 vaccine2.
Vaccinator 1 (pid=861729) is inviting citizen pid=861728 to the clinic.
Citizen 3 (pid=861728) is vaccinated for the 2nd time: the clinic has 2 vaccine1 and 1 vaccine2.
Nurse 2 (pid=861724) has brought vaccine 2: the clinic has 2 vaccine1 and 2 vaccine2.
Vaccinator 3 (pid=861731) is inviting citizen pid=861726 to the clinic.
Citizen 1 (pid=861726) is vaccinated for the 3rd time: the clinic has 1 vaccine1 and 1 vaccine2.
↪  The citizen is leaving. Remaining citizens to vaccinate: 2
Nurse 1 (pid=861723) has brought vaccine 1: the clinic has 2 vaccine1 and 1 vaccine2.
Nurse 3 (pid=861725) has brought vaccine 2: the clinic has 2 vaccine1 and 2 vaccine2.
Vaccinator 2 (pid=861730) is inviting citizen pid=861727 to the clinic.
Citizen 2 (pid=861727) is vaccinated for the 3rd time: the clinic has 1 vaccine1 and 1 vaccine2.
↪  The citizen is leaving. Remaining citizens to vaccinate: 1
Vaccinator 1 (pid=861729) is inviting citizen pid=861728 to the clinic.
Citizen 3 (pid=861728) is vaccinated for the 3rd time: the clinic has 0 vaccine1 and 0 vaccine2.
↪  The citizen is leaving. Remaining citizens to vaccinate: 0
Nurses have carried all vaccines to the buffer, terminating.
All citizens have been vacinated.
Vaccinator 1 (pid=861729) vaccinated 3 doses. Vaccinator 2 (pid=861730) vaccinated 3 doses.
↪  Vaccinator 3 (pid=861731) vaccinated 3 doses. The clinic is now close. Stay healthy.
```

When log functions are out of the critical section:

```
./program  -n 3 -v 3 -c 3 -b 11 -t 3 -i input
```

```
Welcome to GTU344 clinic. Number of citizens to vaccinate c=3 with t=3 doeses.
Nurse 1 (pid=866625) has brought vaccine 1: the clinic has 1 vaccine1 and 0 vaccine2.
Nurse 1 (pid=866625) has brought vaccine 1: the clinic has 1 vaccine1 and 1 vaccine2.
Nurse 1 (pid=866625) has brought vaccine 1: the clinic has 2 vaccine1 and 1 vaccine2.
Nurse 1 (pid=866625) has brought vaccine 2: the clinic has 2 vaccine1 and 2 vaccine2.
Nurse 1 (pid=866625) has brought vaccine 1: the clinic has 3 vaccine1 and 2 vaccine2.
Nurse 1 (pid=866625) has brought vaccine 2: the clinic has 3 vaccine1 and 3 vaccine2.
Nurse 1 (pid=866625) has brought vaccine 1: the clinic has 4 vaccine1 and 3 vaccine2.
Nurse 1 (pid=866625) has brought vaccine 2: the clinic has 4 vaccine1 and 4 vaccine2.
Nurse 1 (pid=866625) has brought vaccine 1: the clinic has 5 vaccine1 and 4 vaccine2.
Nurse 1 (pid=866625) has brought vaccine 2: the clinic has 5 vaccine1 and 5 vaccine2.
Nurse 1 (pid=866625) has brought vaccine 1: the clinic has 5 vaccine1 and 4 vaccine2.
Vaccinator 1 (pid=866631) is inviting citizen pid=866628 to the clinic.
Citizen 1 (pid=866628) is vaccinated for the 1st time: the clinic has 4 vaccine1 and 4 vaccine2.
Vaccinator 1 (pid=866631) is inviting citizen pid=866630 to the clinic.
Citizen 3 (pid=866630) is vaccinated for the 1st time: the clinic has 3 vaccine1 and 2 vaccine2.
Nurse 1 (pid=866625) has brought vaccine 2: the clinic has 3 vaccine1 and 3 vaccine2.
Vaccinator 2 (pid=866632) is inviting citizen pid=866629 to the clinic.
Citizen 2 (pid=866629) is vaccinated for the 1st time: the clinic has 4 vaccine1 and 3 vaccine2.
Nurse 3 (pid=866627) has brought vaccine 1: the clinic has 4 vaccine1 and 3 vaccine2.
Vaccinator 1 (pid=866631) is inviting citizen pid=866628 to the clinic.
Nurse 1 (pid=866625) has brought vaccine 2: the clinic has 3 vaccine1 and 3 vaccine2.
Citizen 1 (pid=866628) is vaccinated for the 2nd time: the clinic has 3 vaccine1 and 2 vaccine2.
Vaccinator 2 (pid=866632) is inviting citizen pid=866629 to the clinic.
Vaccinator 1 (pid=866631) is inviting citizen pid=866630 to the clinic.
Citizen 3 (pid=866630) is vaccinated for the 2nd time: the clinic has 1 vaccine1 and 1 vaccine2.
Citizen 2 (pid=866629) is vaccinated for the 2nd time: the clinic has 2 vaccine1 and 2 vaccine2.
Nurse 3 (pid=866627) has brought vaccine 1: the clinic has 1 vaccine1 and 0 vaccine2.
Nurse 3 (pid=866627) has brought vaccine 2: the clinic has 1 vaccine1 and 1 vaccine2.
Nurse 1 (pid=866625) has brought vaccine 1: the clinic has 2 vaccine1 and 1 vaccine2.
Vaccinator 3 (pid=866633) is inviting citizen pid=866628 to the clinic.
Vaccinator 2 (pid=866632) is inviting citizen pid=866629 to the clinic.
Nurse 3 (pid=866627) has brought vaccine 2: the clinic has 2 vaccine1 and 1 vaccine2.
Citizen 1 (pid=866628) is vaccinated for the 3rd time: the clinic has 0 vaccine1 and 0 vaccine2.
↪  The citizen is leaving. Remaining citizens to vaccinate: 2
Citizen 2 (pid=866629) is vaccinated for the 3rd time: the clinic has 1 vaccine1 and 0 vaccine2.
↪  The citizen is leaving. Remaining citizens to vaccinate: 1
Vaccinator 2 (pid=866632) is inviting citizen pid=866630 to the clinic.
Citizen 3 (pid=866630) is vaccinated for the 3rd time: the clinic has 0 vaccine1 and 0 vaccine2.
↪  The citizen is leaving. Remaining citizens to vaccinate: 0
All citizens have been vacinated.
Nurses have carried all vaccines to the buffer, terminating.
Vaccinator 1 (pid=866631) vaccinated 4 doses. Vaccinator 2 (pid=866632) vaccinated 4 doses.
↪  Vaccinator 3 (pid=866633) vaccinated 1 doses. The clinic is now close. Stay healthy.
```