Concurrent Programming

Exercise Booklet 5: Semaphores (cont)

1. On Fridays the bar is usually full of men, therefore the owners would like to implement an access control mechanism in which one man can enter for every two women.

   a) Implement such a mechanism, assuming that men will have to wait indefinitely if no women arrive.

   b) Modify the solution assuming that, after a certain hour, all men are allowed to enter (those that are waiting outside and those that arrive). For that there is a thread that will invoke, when the time comes, the operation `itGotLate`. You may assume that the code for this thread is already given for you, the only thing that you must do is define the behavior of `itGotLate` and modify the threads that model the men and women.

2. In the office there is a unisex restroom with n toilets. The restroom can be used by both men and women, but cannot be used by men and women at the same time. Provide a solution using semaphores. The solution should be free from deadlock but not necessarily from starvation.

3. Model a ferry between two coasts using semaphores. The ferry has capacity for N passengers and works in the following way. It waits in one coast until it fills up and then automatically switches to the other coast. When it arrives at a coast, all the passengers get off and, only after all the passengers have gotten off, all those that are waiting to board do so. The ferry and each passenger has to be implemented as a thread.

4. In a gym there are four apparatus, each involving a different muscle group. The apparatus are loaded with weight discs (all of the same size). Each gym client has a routine that indicates what apparatus she must use, in what order and with what weight (the routine could include repeating the use of an apparatus). The gym requires that each client, when finished using an apparatus, unloads all weight discs and places them in their storage area (this includes consecutive uses of the same apparatus).

   a) Write code that simulates the gym's workings, guaranteeing mutual exclusion in the access of the shared resources and freedom of deadlock.

   b) Indicate whether your solution is free of starvation. If it's not, indicate how you could obtain it.

5. We wish to model and industrial oil refinement plant where autonomous vehicles transport products with different levels of processing. The plant consists of:

   - a platform where it receives raw material (`RawMaterialPlatform`),
   - a platform where it deposits the finished product (`EndProductPlatform`),
   - 8 processing machines, and
   - 4 vehicles.

   Each machine unloads the contents of a vehicle, processes the contents and then loads the refined product into a vehicle. The processed product is not necessarily loaded into the same vehicle from which it unloaded the unprocessed product.

   Each vehicle has an ordered list of loading and unloading tasks to be performed in different machines or platforms. Vehicles are autonomous and hence their movement between machines and platforms need not be modelled. While a vehicle is loading/unloading, it should not proceed to the next machine/platform until the operation has completed.

   Model this scenario using semaphores.

6. Blood donations are received in a hemotherapy center. Extraction takes place in one of 4 beds and takes a random amount of time. People that arrive to donate are received in the order in which they arrive, but if there are no free beds they wait in the waiting room. In the waiting room there are 10 outdated magazines that people read while they wait for their turn. While waiting donors continuously pick up a magazine, read it, put it down. When a bed is freed, the next donor is called from the waiting room, who leaves the magazine she was reading. As soon as a magazine has been freed, the donors that are waiting compete to take it.

   Provide a solution using semaphores that models this scenario. Hint: have the process of acquiring a magazine and that of acquiring a bed be the concurrent threads that are spawned for each donor.

7. Consider the following simplified version of "The Settlers" game. It consists in managing a village by means of villagers and numerous resources.

   The player has 8 villagers to whom she assigns a list of tasks that are executed indefinitely. The tasks that may be executed are:

   - extract a resource from a site
   - deposit a resource in a site
   - Move from one site to another – this takes a villager 10 seconds

   In this version of the game the village has the following sites:

   - Lake, where water can be extracted
   - Farm, where 10 seconds after watering a parcel of land, food can be extracted
   - Warehouse, where water and food can be stored for future extraction

   Bear in mind that the extraction task requires that the villager wait until the resources are available. If there are none available, the villager must wait: in the case of the farm for 10 seconds after she has watered the parcel, in the case of the warehouse until there is a resource to extract.

   Model this scenario using semaphores, assuming that the warehouse has infinite space and there are an infinite number of parcels in the farm.