1. Consider the simplified firefly model below based on the model presented in the lecture (and in figure 10.4, page 154 of [1]), but with discrete time cycles. In this model, the sensitive (charging) period takes 7 units of time and a cycle is composed of 10 units of time. Considering that the first time step of a cycle is 0, a firefly achieves the threshold level at the time step 6 of the cycle. The flashing occurs after 3 units of time from the threshold level, meaning that a firefly flashes at the time step 9 of a cycle. If a firefly is in its sensitive period when a neighbour firefly flashes, it is reset to the time step 0 of its cycle. However, if a firefly is in the non-sensitive period, it keeps its behaviour as if nothing happened.

So, if a firefly is by itself, it will progress in the following way:

\[0 \ 1 \ 2 \ 3 \ 4 \ 5 \ 6 \ 7 \ 8 \ [9] \ 0 \ 1 \ 2 \ 3 \ 4 \ 5 \ 6 \ 7 \ 8 \ [9] \ 0 \ ...\]

where “[9]” represents a flash at the time step 9 of a cycle and each number in the sequence corresponds to a level of charge.

However, if there was a single flash from a neighbour firefly at the time step 1 of the first cycle, the following behaviour would occur:

\[0 \ 1 \ 0 \ 1 \ 2 \ 3 \ 4 \ 5 \ 6 \ 7 \ 8 \ [9] \ 0 \ 1 \ 2 \ 3 \ 4 \ 5 \ 6 \ 7 \ 8 \ [9] \ 0 \ ...\]
If there was a flashing in the time step 7, on the other hand, the firefly wouldn’t change its behaviour because it is in the non-sensitive period:

0 1 2 3 4 5 6 7 8 [9] 0 1 2 3 4 5 6 7 8 [9] 0 ...

Now, consider that there are two neighbour fireflies A and B. Initially, A is at the time step 7 and B is at the time step 6. Simulate their behaviour by hand as in the examples above until synchronization is achieved (1%).

2. Consider the following assignment problem:

- There are three nurses \( n_1, n_2 \) and \( n_3 \) and three tasks \( t_1, t_2 \) and \( t_3 \) to be performed.
- There is a cost associated to a nurse \( i \) performing a task \( j \): \( c(n_i, t_j) \).
- We need to assign nurses to tasks in such a way as to minimize the total cost.
- Each task must have one and only one nurse assigned to them.
- A nurse can be assigned to more than one task

Construct a graph such that a path taken by an artificial ant from a source node to a destination node can be interpreted as an assignment for this problem. Explain how the assignment can be read with an example. (1%)

Hint: Think about how the decision of which edge to take can be cast as a decision of which assignment to make. If you want, you can use directed edges, i.e., edges that can only be traversed in one direction in your graph (use arrow tips for edges to indicate this). Alternatively, you can specify mechanisms such as memories of nodes visited so far in order to determine which nodes are feasible or infeasible.

References