Modeling of a Level Crossing System

Below there is an excerpt from a case study [1] describing a level crossing system based on radio communication between trains and the controlled crossing.

Introduction

The problem chosen for the case study is a distributed control system of a level crossing, the intersection of a single-track railway line and a road. The area of the intersection is called the danger zone, since trains and road vehicles must not enter it at the same time to avoid a collision. The level crossing is equipped with barriers and traffic lights. The traffic lights come in two colors: red and yellow. When the yellow light is on, road users (motorists, cyclists, pedestrians, etc.) are alerted to an approaching train. The red light means that the level is dangerous and therefore prohibited for road traffic. The yellow and red lights should never be lit together. When both lights are off, road users can cross.

Entities present in the system

- Signal lights and barriers are controlled by the Level Crossing Controller.
- Another control system is on board the train (Train Controller).
- These two entities can communicate with each other by means of mobile radio communication.
**Passage scenario of a train**

Each time a train approaches the level crossing, the latter's control system is activated, and performs a series of actions, each of them at a specific time, allowing the crossing to be closed safely:

1. The yellow light is on.
2. 3 seconds later, the lights turn red.
3. After additional 9 seconds, the barriers will begin to drop.
4. If the barriers have been fully lowered within a maximum of 6 seconds, the level crossing controller signals the safe state of the level crossing, allowing the train to cross the danger zone.

When the train has finished crossing the level crossing, the level crossing controller goes into deactivated mode, and the crossing can be re-opened to traffic.

**Additional details on the behavior of the system**

The train detects that it is approaching the level crossing by ground devices positioned so that the level crossing can be closed in time to allow the train to pass. Also, when the train's controller detects that it is approaching a level crossing, it sends a radio message to the level crossing controller to turn on the traffic lights and lower the barriers. This message must be acknowledged by the level crossing controller. Furthermore, the train controller will apply a braking operation to the train which is programmed so that the train slows down and eventually comes to a stop just before the danger zone. This braking is maintained until the train has received the appropriate signal. After a certain delay from the detection of the approach, the train controller sends a status request to the level crossing controller. If the level crossing is in a safe condition, the train cancels the braking operation and continues its journey and crosses the level crossing. A zone exit detector allows the level crossing controller to take into account that a train has left the zone. It will be admitted that several trains can be simultaneously approaching. The barriers can only be lifted if all the trains engaged have left the danger zone. The level crossing controller detects the failure of the barriers by not receiving a signal from the "barriers down" or "barriers up" sensor before a certain delay.

**Objectives**

1) Make a schematic representation of the system explaining the signals exchanged.
2) Model the system using a class diagram.
3) Give a state machine of the train controller.
4) Give a state machine of the level crossing controller.