UML Modeling: Requirement Analysis
Modeling a Motorway Toll Station

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We consider a motorway toll station (in fact half of it since we are interested only in one way of traffic).

The toll station belongs to some motorway company, which has a central office somewhere (possibly very far from the toll station). It is composed of several toll lanes and of a supervision office controlling all the lanes. The lanes are installed across the traffic stream (Figure 1).

Each toll lane allows the passage of one vehicle at a time. It is composed of the following elements (Figure 2):

- an upstream light which indicates whether the lane is open, and what are the payment means available for the lane (see below);
- an upstream barrier, which is manually operated, to enforce the closing of the lane;
- a downstream barrier, which is opened automatically by the system, to let the vehicle pass, and which is closed, automatically too, after the vehicle has left the lane;
- a downstream (traffic) light which is red when the downstream barrier is closed, and which turns green when this barrier is open;
- a first (magnetic) loop, placed just before the upstream barrier, which detects the presence of a vehicle in the lane;
- a second (magnetic) loop, placed just after the upstream barrier, which detects that a vehicle has left the lane;
- a paying device, placed just before the upstream barrier, owing to which the driver may pay the toll.

They are several sorts of lanes, differing by the means of payment they support:

- the manual lanes, where the payment is received by a lane operator; all kinds of vehicles can use these lanes; the operator establishes the price, receives the payment (cash or card), and is responsible for opening the upstream barrier to let the vehicle go;
- the automatic lanes, where the payment is automatic.

There are several sort of automatic payment devices:

- automatic cash payment where the driver pays with coins; the change is given back automatically as well; if the machine cannot return the exact change, it tries to return a reasonable approximation of it; if this is impossible, an alarm is sent to the supervision office, and manual intervention will be performed;
- motorway company card payment: the driver must be a subscriber to this service, he/she should have an account with the motorway company; the card is read by the device, and the customer's account is automatically updated in the motorway company central system;
- express lane payment: the driver must be a subscriber to this service, he/she should have an account with the motorway company; the vehicle is equipped with a badge (placed behind the windscreen); the lane payment device has a scanner which detects the presence of the badge, reads infor-

mation from it, and updates automatically the customer's account in the motorway company central system. In the most sophisticated of these express lanes, the detection of the badge takes place well ahead the barrier, so that the lane can be opened in advance: the driver does not even stop.

A given automatic lane can support several payment devices of different kinds. Only regular cars can use the automatic lanes. They all pay the same price. But the subscribers of the motorway company are given a discount which depends on their monthly use of the motorway. This discount is computed by the motorway company central system.

Each lane is controlled by a microprocessor system which is in charge of handling the traffic lights, the operations on the (downstream) barrier, and the payment. The supervision office attached to the toll station has a computer system which registers the information about the passage and the payment of all vehicles. This computer is linked to the lane microprocessors through a reasonably fast network; it is also linked with the motorway company through a specialized network

The station supervision computer makes it possible to display information to supervisors and handle requests from the supervisors to the lanes such as opening or closing a lane, or alarms from the lane microprocessors (such as system breakdowns, payment device out of cash, vehicle stuck in a lane, etc.).

The supervision computer gathers statistics about the toll station passages, and suggests to the supervisors that it may be useful to open some more lanes, or close some of them. The decision of opening or closing a lane remains to the supervisors (remember that these operations involve a manual intervention on the upstream barrier).

The manual interventions are under the responsibility of a group of employees. They help in opening/closing the lanes, assist vehicles stuck in a lane, collect the cash in the payment devices or feed the payment devices with new cash, or perform any maintenance work that may be needed.

The purpose of the study is to elaborate a Requirement Analysis model of the software for the toll station. This software is deployed on the lane microprocessor systems as well as on the supervision computer (you may propose a deployment diagram for it, since this structure is part of the non-functional requirements of the system).

The model should consist of

- a top level Use Case Diagram expressing the main use cases of the system;
- the first levels of decomposition of these use cases into subordinate use cases;
- some meaningful scenarios for the most interesting use cases, expressed informally, but also using Sequence, Collaboration, or Activity Diagrams;
- one or several class diagram(s) showing the high level classes together with their relationships, that will help in realizing the (most interesting) use cases;
- several State-Transition Diagrams for those classes with an interesting reactive behavior.

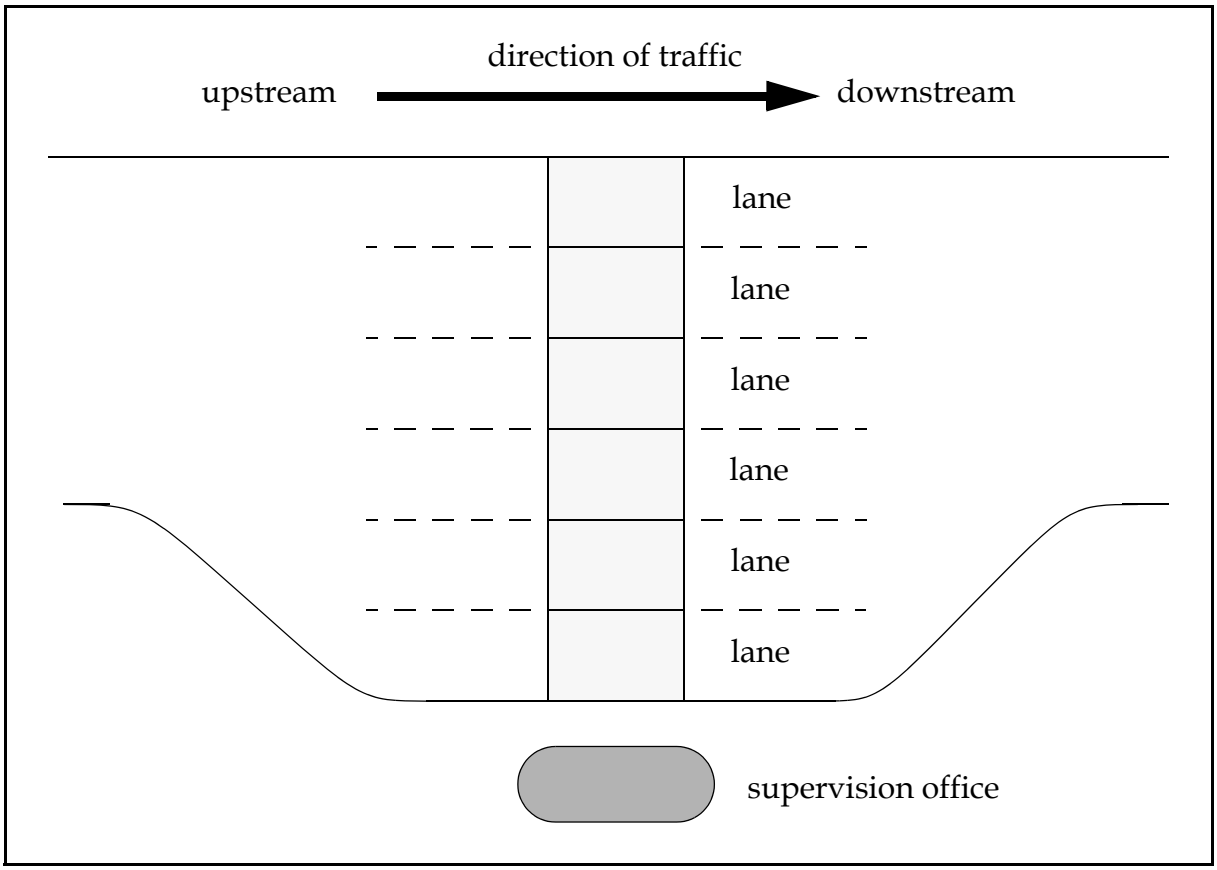

Figure 1: The toll station (half of it!)

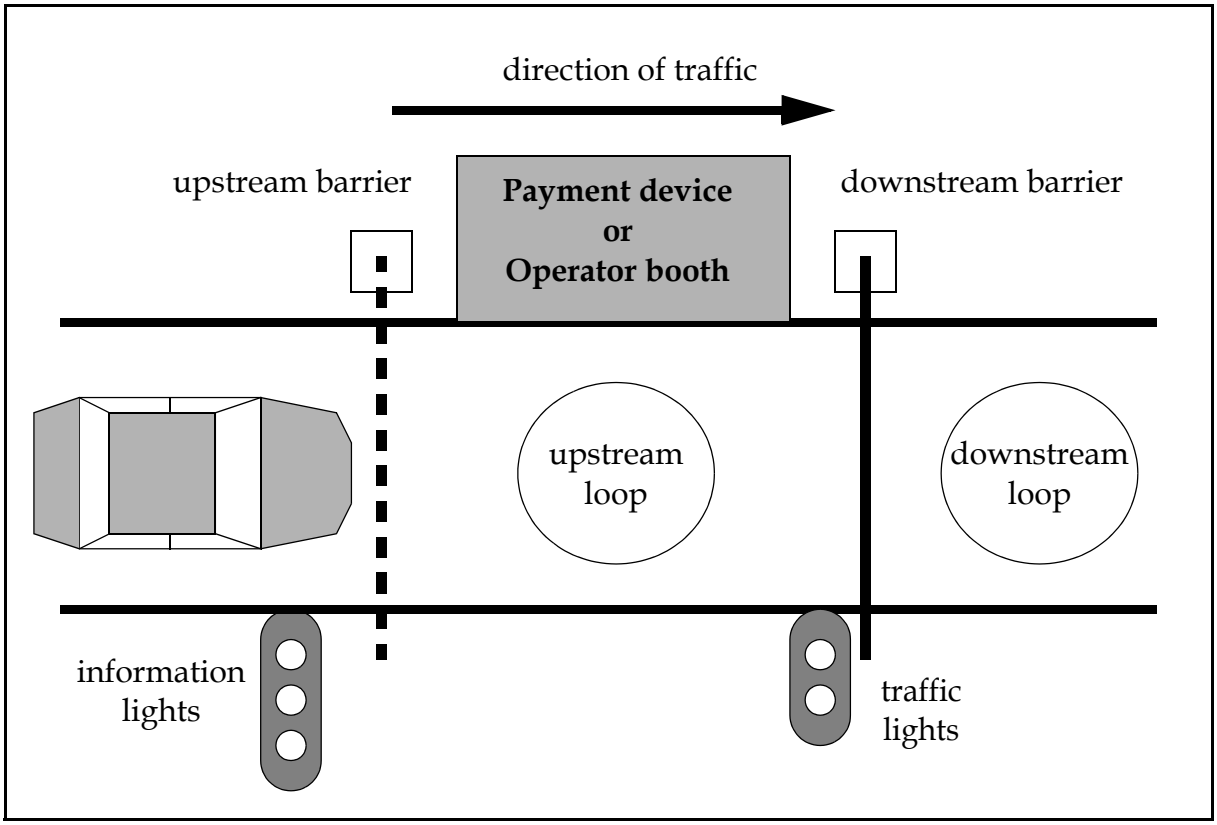

Figure 2: A toll lane