2. Controlling Cars on a Bridge

Jean-Raymond Abrial

2009

A Requirements Document (1)

- The system we are going to build is a piece of software connected to some equipment.

- There are two kinds of requirements:
  - those concerned with the equipment, labeled EQP,
  - those concerned with the function of the system, labeled FUN.

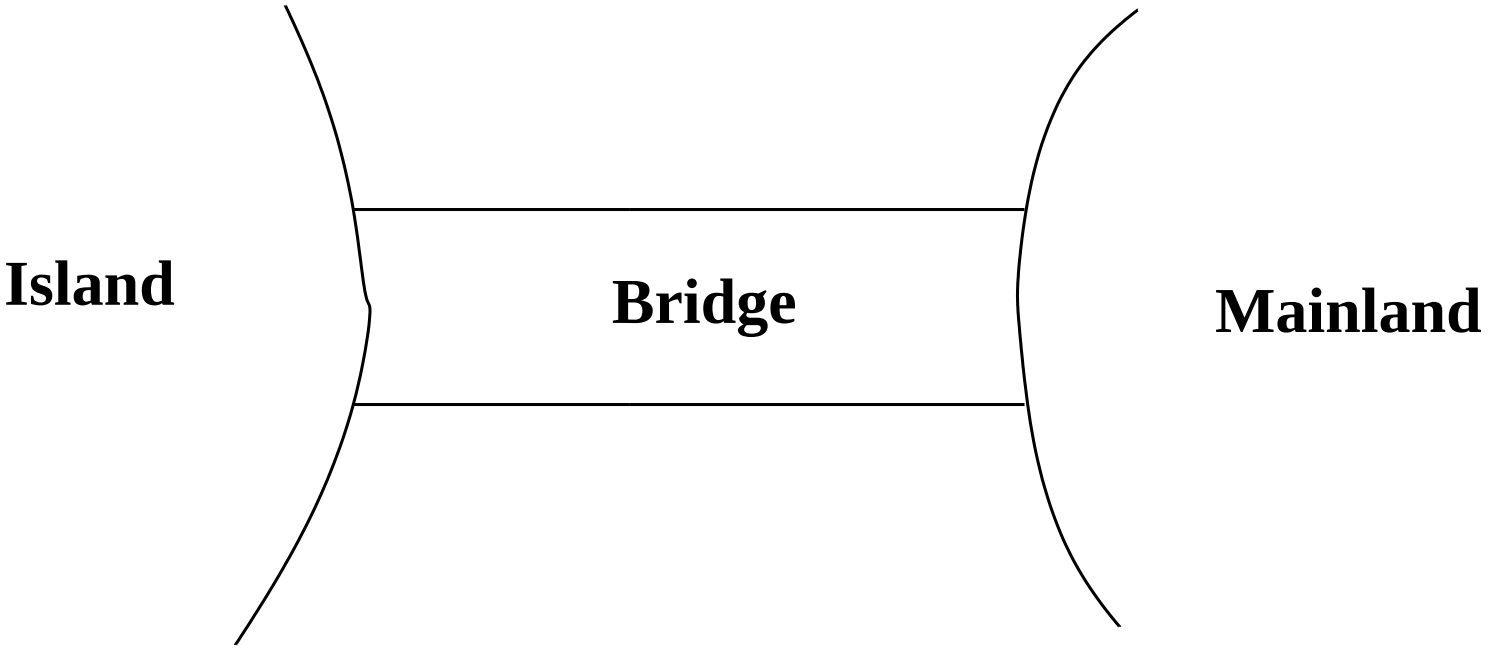
- The function of this system is to control cars on a narrow bridge.

- This bridge is supposed to link the mainland to a small island.

A Requirements Document (2)

The system is controlling cars on a bridge between the mainland and an island	FUN-1

- This can be illustrated as follows



A Requirements Document (3)

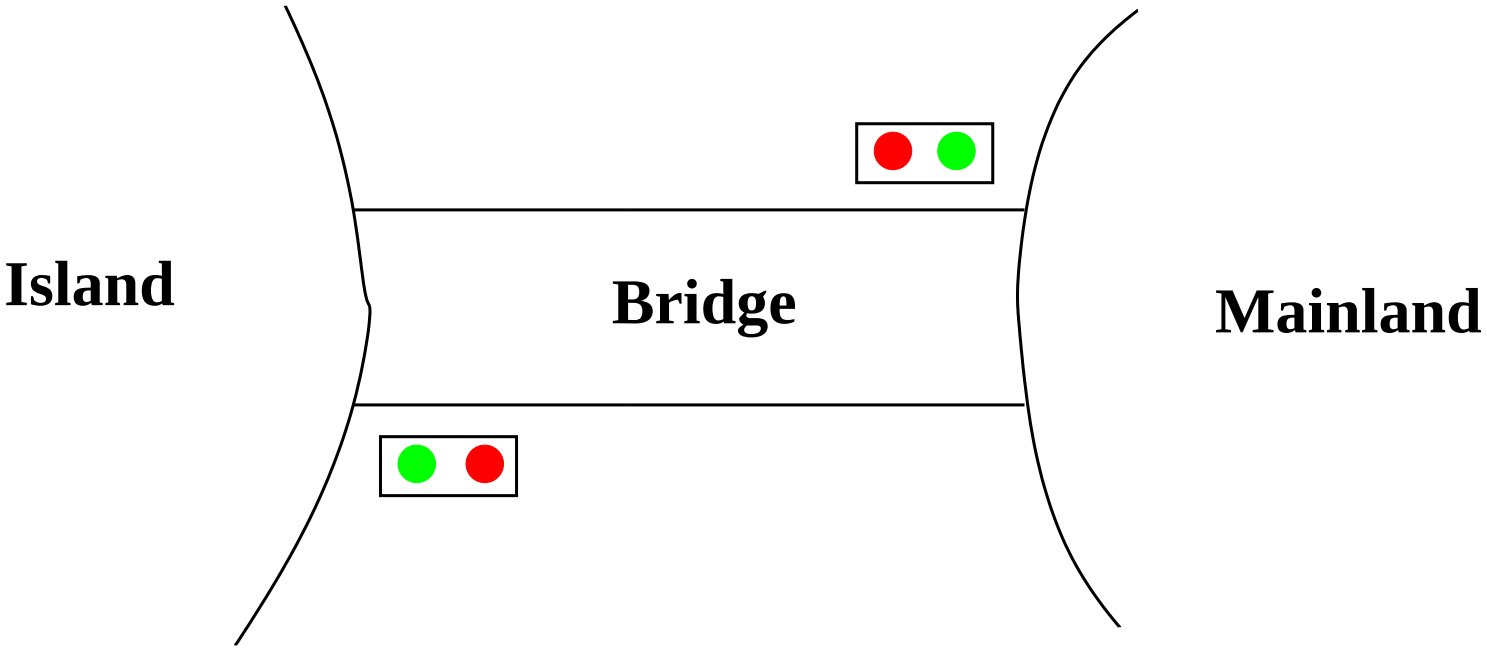
- The controller is equipped with two traffic lights with two colors.

The system has two traffic lights with two colors: green and red	EQP-1

A Requirements Document (4)

- One of the traffic lights is situated on the mainland and the other one on the island. Both are close to the bridge.

- This can be illustrated as follows



A Requirements Document (5)

The traffic lights control the entrance to the bridge at both ends of it	EQP-2

- Drivers are supposed to obey the traffic light by not passing when a traffic light is red.

Cars are not supposed to pass on a red traffic light, only on a green one	EQP-3

A Requirements Document (6)

- There are also some car sensors situated at both ends of the bridge.

- These sensors are supposed to detect the presence of cars intending to enter or leave the bridge.

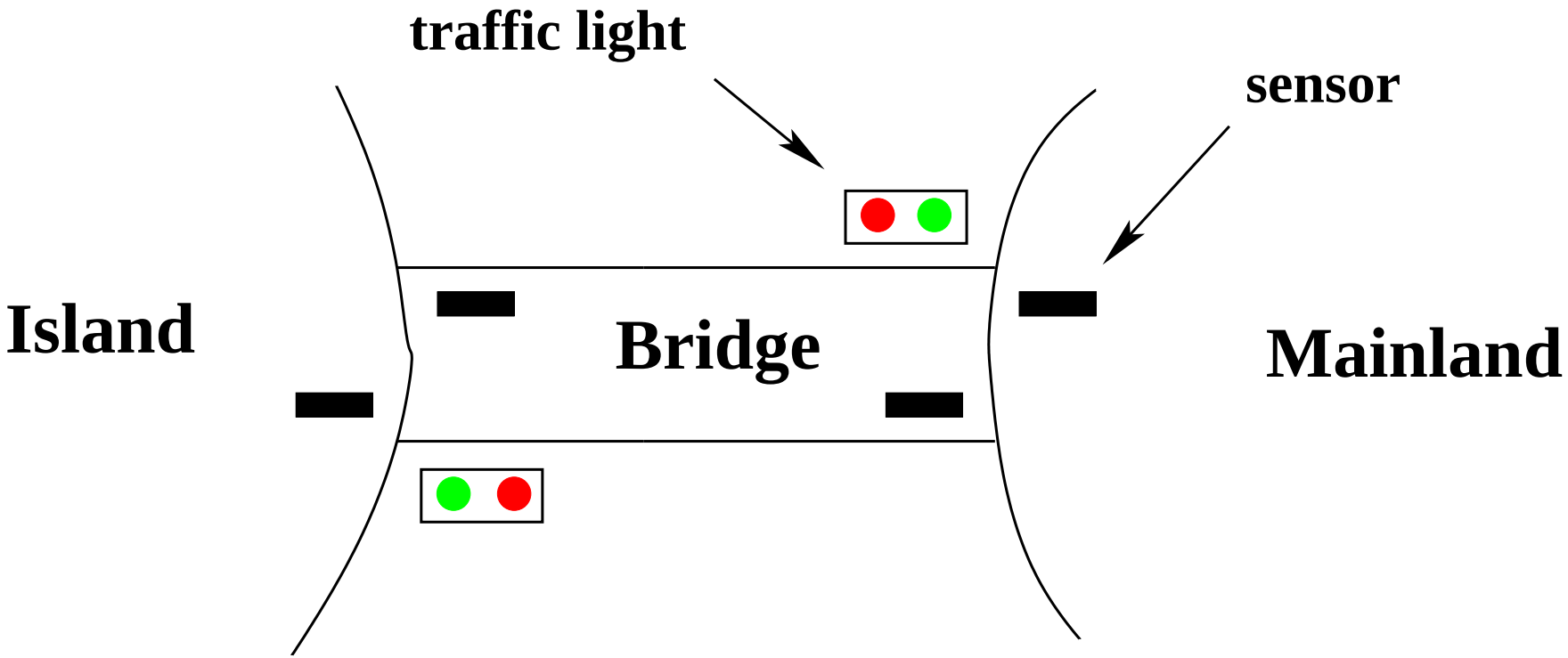
- There are four such sensors. Two of them are situated on the bridge and the other two are situated on the mainland and on the island.

The system is equipped with four car sensors each with two states: on or off	EQP-4

A Requirements Document (7)

The sensors are used to detect the presence of cars entering or leaving the bridge	EQP-5

- The pieces of equipment can be illustrated as follows:



A Requirements Document (8)

- This system has two main constraints: the number of cars on the bridge and the island is limited and the bridge is one way.

The number of cars on the bridge and the island is limited	FUN-2

The bridge is one way or the other, not both at the same time	FUN-3

The Reference Document (1)

The system is controlling cars on a bridge between the mainland and an island	FUN-1
The number of cars on the bridge and the island is limited	FUN-2
The bridge is one way or the other, not both at the same time	FUN-3

The Reference Document (2)

The system has two traffic lights with two colors: green and red	EQP-1
The traffic lights control the entrance to the bridge at both ends of it	EQP-2
Cars are not supposed to pass on a red traffic light, only on a green one	EQP-3

The Reference Document (3)

The system is equipped with four car sensors each with two states: on or off	EQP-4

The sensors are used to detect the presence of cars entering or leaving the bridge	EQP-5

Our Refinement Strategy

- Initial model: Limiting the number of cars (FUN-2)

- First refinement: Introducing the one way bridge (FUN-3)

- Second refinement: Introducing the traffic lights (EQP-1,2,3)

- Third refinement: Introducing the sensors (EQP-4,5)

Our Refinement Strategy

- Initial model: Limiting the number of cars (FUN-2)

- First refinement: Introducing the one-way bridge (FUN-3)

- Second refinement: Introducing the traffic lights (EQP-1,2,3)

- Third refinement: Introducing the sensors (EQP-4,5)

Initial Model

- It is very simple

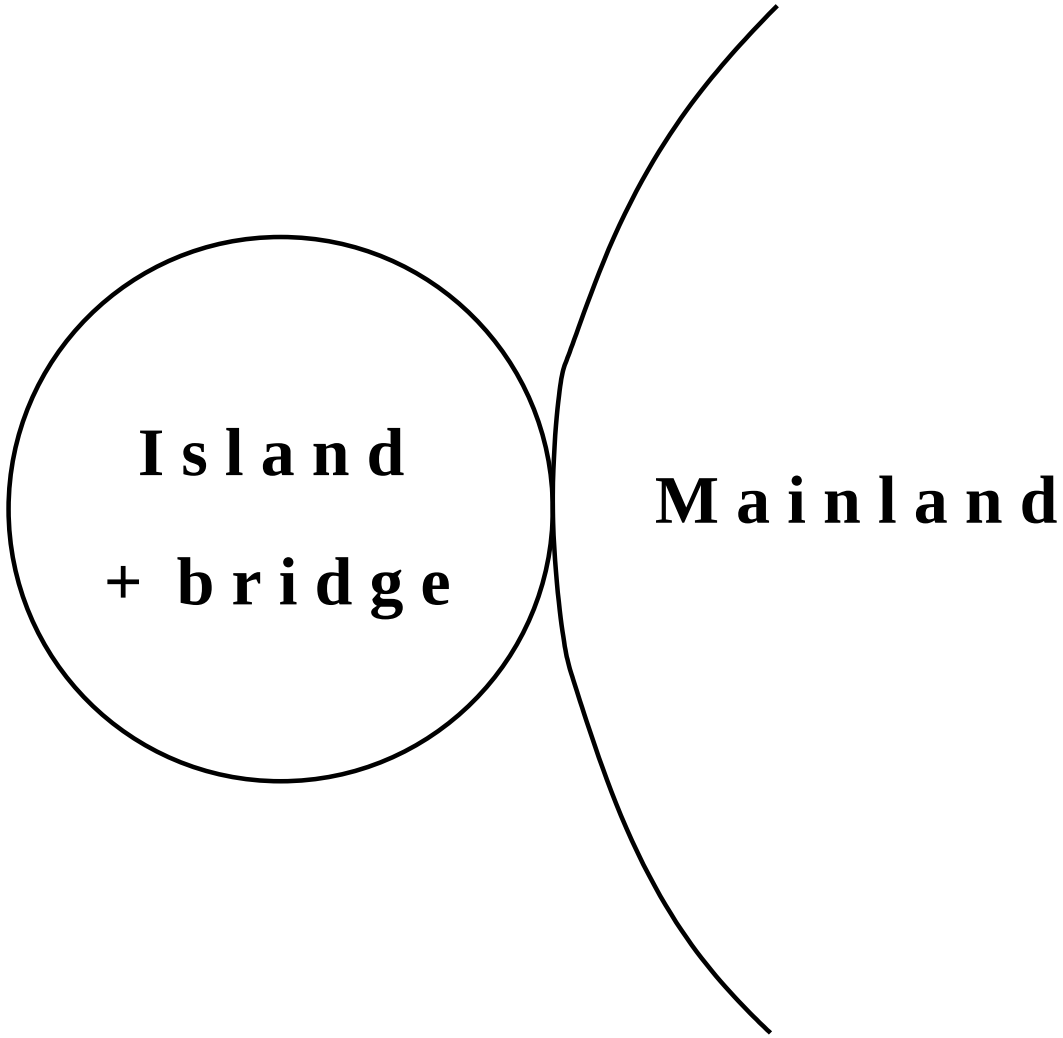
- We completely ignore the equipment: traffic lights and sensors

- We do not even consider the bridge

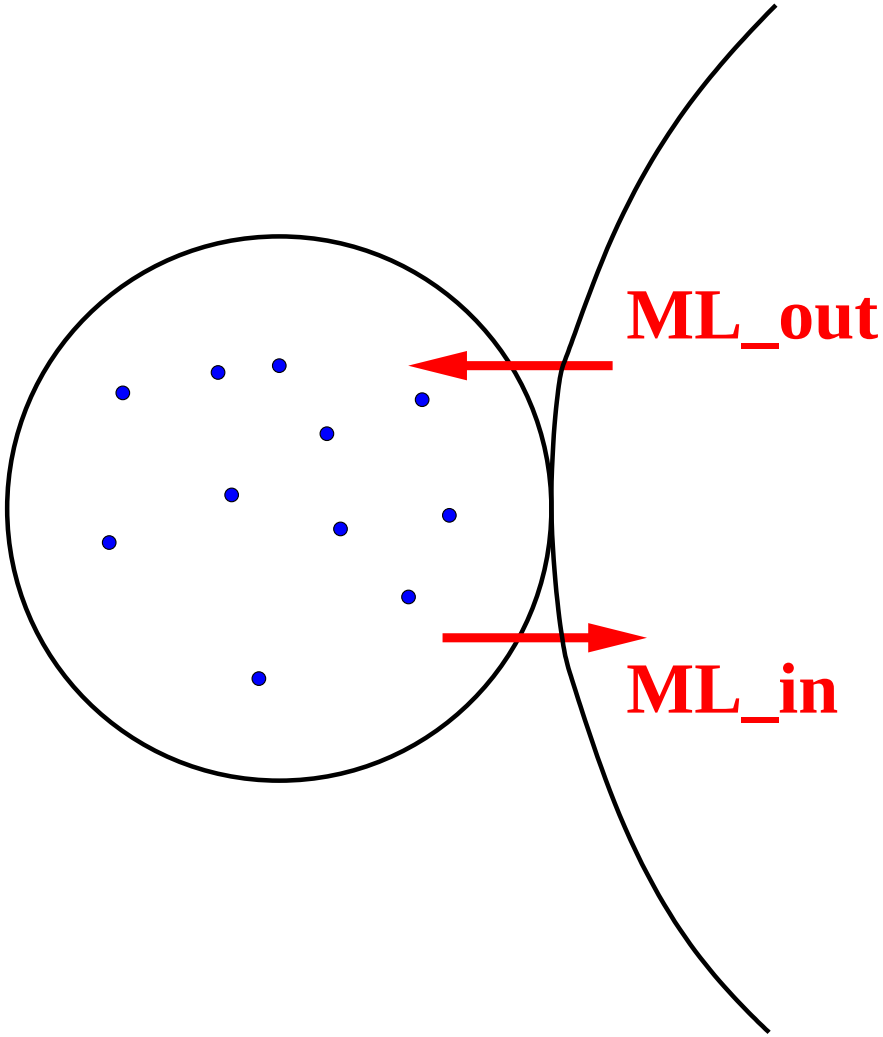
- We are just interested in the pair “island-bridge”

- We are focusing FUN-2: limited number of cars on island-bridge

A Situation as Seen from the Sky



Two Events that may be Observed



Event ML_out

- This is the first transition (or event) that can be observed

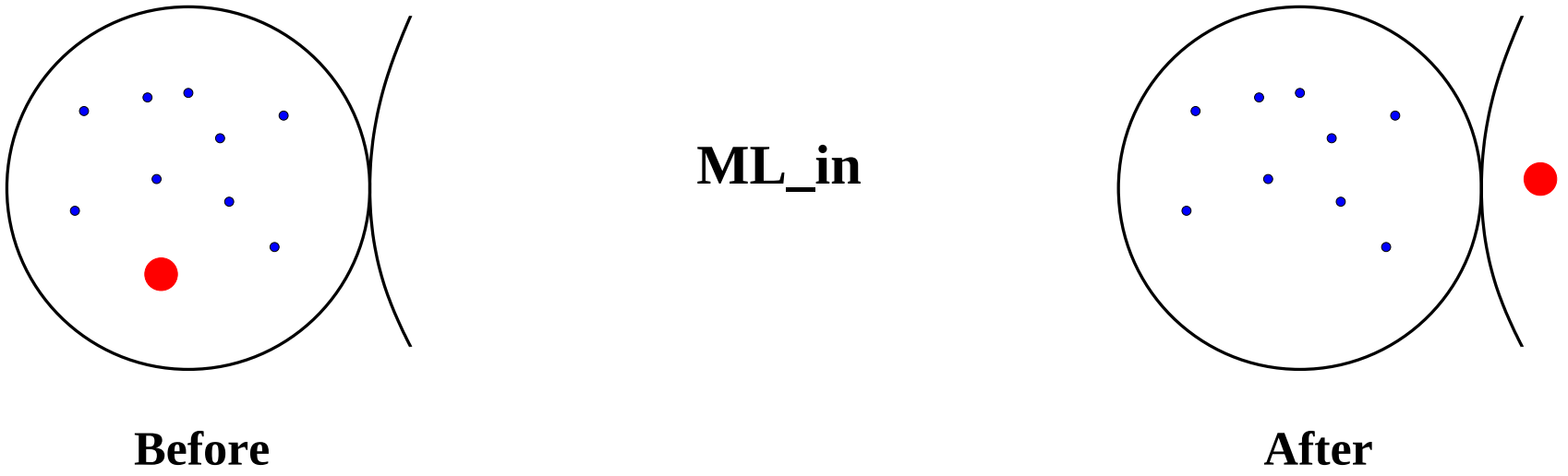
- A car is leaving the mainland and entering the Island-Bridge

- The number of cars in the Island-Bridge is incremented

Event ML_in

- We can also observe a second transition (or event)

- A car leaving the Island-Bridge and re-entering the mainland



- The number of cars in the Island-Bridge is decremented

Our Refinement Strategy

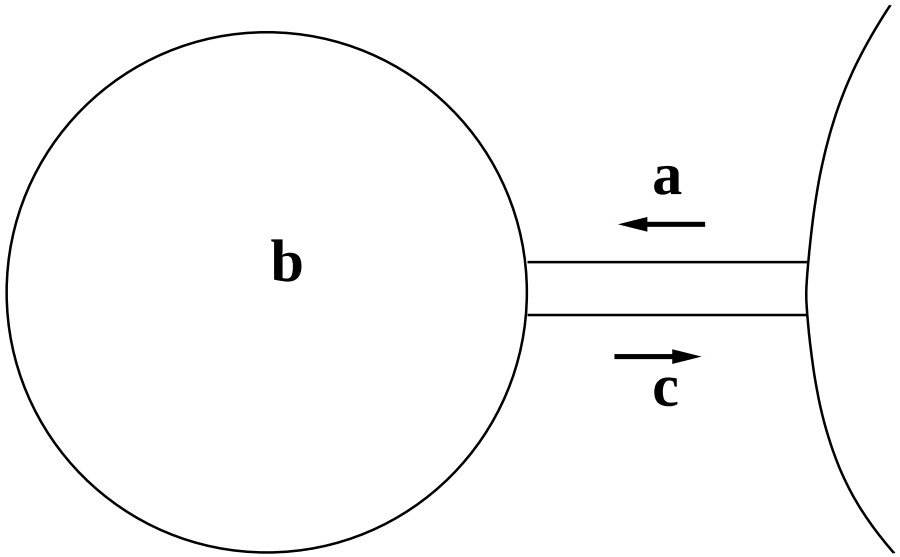
- Initial model: Limiting the number of cars (FUN-2)

- First refinement: Introducing the one way bridge (FUN-3)

- Second refinement: Introducing the traffic lights (EQP-1,2,3)

- Third refinement: Introducing the sensors (EQP-4,5)

Introducing Three New Variables: a, b, and c



- a denotes the number of cars on bridge going to island
- b denotes the number of cars on island
- c denotes the number of cars on bridge going to mainland
- a, b, and c are the concrete variables
- They replace the abstract variable n