

# Generating all states in a Qualitative Reasoning project

Gongze Cao  
12161381

Jonathan Mitnik  
10911197

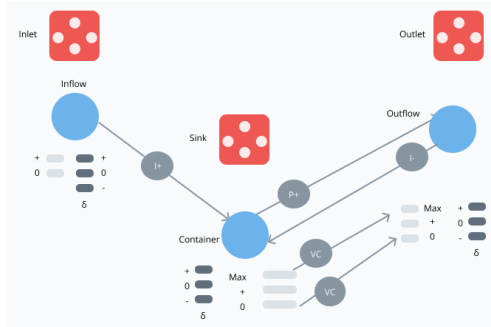


Figure 1: Causal model of the sink

[1]

## 1 Introduction

## 2 The Domain: Causal Model

The constraints as presented within the frame of this assignment consist of the the following:

- A P+ (positive proportional) relationship from Container to Outflow. This insinuates that whenever the Container's derivative, the outflow goes through a proportional change for its derivative.
- A I+ (influential positive) from Inflow to Container. Whenever the inflow is active, which is understood as having a magnitude greater than zero, the container will be influenced to increase (thus setting the derivative above zero).
- An I- relation from Outflow to Container. The existence of the outflow means that there water in the container is decreasing.
- A VC (value correspondence) from the containers max value to the outflow's max. If the container reaches the top, the outflow will also be at its strongest.

- A VC relation from the containers empty value to the outflow's empty. With no water in the container, there is no water to be flowing out.

Figure 1 captures this relationship.

## 3 Methodology

### 3.1 Assumptions and decisions

Within the frame of this assignment, a number of assumptions were made when implementing a set of rules for the generation of the state graph. The level of

Aside from the given constraints regarding the domain's relations, a number of additional constraints were set as inferred by the existing ones. The exogenous variable, the inflow, has been set to be a binary variable, which means that either the sink is on in an instant, or it is off: this is to simplify the unnecessary amount of states which may not add much to the model itself. Furthermore, the exogenous variable will be modeled based off a negative parabola. The reason a negative parabola is chosen, is twofold: a real interaction with a sink would go in the way off washing hands (on), then turning it off, and turning it on yet again after some time went by. As such, a negative parabola starts this pattern immediately, and can represent the inactivity (drainage) of a sink as well as the reactivation.

Furthermore, the representation to a real sink is taken further to the landmark states of our container. If the container, and by proxy the outflow, reaches a maximum or minimum, then the derivatives are instantly set within the same state to zero. This way, the state will instantly achieve maximum without insinuating that there is more to come, or less to come on a minimum state.

### 3.2 Generating a state-graph

*Representing the state-graph.* A state-graph is initialized with an empty node. This node contains a collection of the different magnitudes and derivatives of a quantity, which is referred to as a state. By turning these values of the entities into a string, it is possible to hash a state by the string representation of all these values. This will be important when storing each state in a global variable ‘visitedStates’, which keeps track of new encountered variables.

*Generating new states.* Upon entering a state, the main goal is to apply a number of functions on the value of the entities, and to generate as many possible children as possible. This is done in three stages: first apply the current derivatives on the children. If the magnitude value of an entity’s quantity is on a landmark (such as zero and maximum), this will produce a single state. However, due to the nature of intervals as explained in [1], the values could either transition to another value in the interval or to the next state in the quantity space: as such, these possible ambiguity leads to an additional child being generated to account for this chance. The second stage is to apply the current relations to the states. This can be intra-state and immediately (e.g. apply when no ambiguities are present), or the examined state is split into multiple states with different outcomes. First, any influence relations are applied, and then the

### References

- [1] Bert Bredeweg, Anders Bouwer, Jelmer Jellema, Dirk Bertels, Floris Linnebank, and Jochem Liem. Garp3 - a new workbench for qualitative reasoning and modelling. In *20th International Workshop on Qualitative Reasoning (QR-06)*, C. Bailey-Kellogg and B. Kuipers (eds), pages 21–28, 2006.