Assignment 3 COMP2111 13s1
Sudoku

Jiashu Chen

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Contents

1 Introduction

The goal of the project is to develop a Sudoku solving assistant in Event-B.
The solver needs the following functionality.

Set up: The event takes an incomplete grid and put it into the Sudoku Grid.

Fill: The event takes a position on the grid and a number, and fill it into the grid.

Auto Fill: When there is only one possibility of number for a grid cell, the number will be automatically filled into the grid.

Hint: Reveal a coordinate and it's possibility. (The cell with minimal possibility).

Guess: Fill the cell with one on the hinted number

Alarm: When the solver run into problem.

Undo: Remove number from a cell in the grid.

2 Problem Statement: Entity Representation and Requirements

2.1 Sudoku Representation

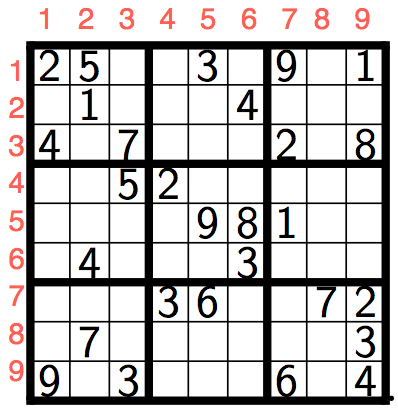

Figure 1: Sudoku Structure

As shown in the diagram the structure representation of the traffic facilities around the hotel will be the following:

Table 1: Table of Hotel Traffic Entity Representation

Type	Name	Level First Introduced	Short Description
Natural Number	ROW	Abstract Level	Non-zero natural number form 1 to 9
Natural Number	COL	Abstract Level	Non-zero natural number form 1 to 9
Natural Number	NUM	Abstract Level	Non-zero natural number form 1 to 9
RELATION	BOX	Abstract Level	Total function that maps each cell in the Sudoku to a sub-grid.
RELATION	grid	Refinement1 AutofillAndPossible	A relation that maps each row to a column in the grid
RELATION	SAMEROW	Refinement1 AutofillAndPossible	A relation maps two element in the grid together if they belongs to the same row.
RELATION	SAMECOL	Refinement1 AutofillAndPossible	A relation maps two element in the grid together if they belongs to the same col.
RELATION	SAMEBOX	Refinement1 AutofillAndPossible	A relation maps two element in the grid together if they belongs to the same box.

2.2 Abstract Level

2.2.1 Requirements

Requirements	Function
set up	The event takes an incomplete grid and put it into the Sudoku Grid.
fill	The event takes a position on the grid and a number, and fill it into the grid.

2.2.2 Implementation

In order for the ease of modeling for the system. When a change is done on the grid, instead of putting in or remove a ordered pair from the relation. The system always replace the older grid with a new one.

Event	Usage
set up	This event takes in a initial grid and put it into the Sudoku gird.
fill	The event replace the old Sudoku grid with a new grid include the new pair that is being put in.
digCell	The event replace the old Sudoku grid with a new grid include the new pair that is being removed. (This is used to avoid the EQL PO for refinement 2.)

2.3 Refinement1AutofillAndPossible

2.3.1 Requirements

Requirements	Function
Auto Fill	When there is only one possibility of number for a grid cell, the number will be automatically filled into the grid.
Hint	Reveal a coordinate and it's possibility. (The cell with minimal possibility).
Guess	Fill the cell with one on the hinted number.
Alarm	When the solver run into problem.

2.3.2 Implementation

For ease of implementation, the possibility of grid is only changed by the events upDatePossible, and upDatePossibleFullGrid. Two event that could perform a change on the grid can't happen unless the upDatePossible event is perform in between. This is ensured by the boolean value called upToDate. All cell that is already filled with a value in the Sudoku grid doesn't have any possible values.

Event	Usage
set up	This event will change the upToDate to FALSE, and change all cell in the initial grid to empty.
fill	This event will change the upToDate to FALSE, and change the cell filled in to empty.
autofill	This event will change the upToDate to FALSE, and change the cell filled in to empty. Also this event will only fire when there is only one possibility left for the cell.
digCell	This event will change the upToDate to FALSE, and possibility will be then be updated by the updatePossible event.
upDatePossible	This event updates possible values for every cells in the grid.
upDatePossibleFullGrid	This event will change possible value for all cells in the grid to empty. (can be used as a event which tells the Sudoku grid is solved).
alarm	This event is fired when a cell is not filled in yet, but it has no possible value left.
unAlarm	This event will turn the alarm off, when the grid is fixed by digCell event.
hint	this event will reveal a hint.
guess	put one of the value hinted into the grid.

2.4 Refinement2Undo

2.4.1 Requirements

Requirements	Function
Undo	take a value that is in the grid out, but this doesn't include the cells that belongs to the set up grid.

2.4.2 Implementation

A new variable called setUpGrid is introduced, which is a subset of the Sudoku grid, and it represent the set of grid that was inputted by the set up event.

Event	Usage
set up	This event will record the set up grid.
fill	Can't change the set up grid.
autofill	Can't change the set up grid.
undo	Refines digCell and it can't remove cells belongs to the setup grid
upDatePossible	No Further Change Needed.
upDatePossibleFullGrid	No Further Change Needed.
alarm	No Further Change Needed.
unAlarm	No Further Change Needed.
hint	No Further Change Needed.
guess	No Further Change Needed.

3 Comments: Undischarged POs and Development Related Issue

All POs are discharged from Abstract Machine, and Refinement2Undo

3.1 Refinement1AutofillAndPossible

3.1.1 Context: PossibleGrid

The context is too big for Rodin platform to handle, however there is a way that will shows that the context of the machine is still correct.

This can be done by either remove two of the axioms from axiom 7, 8, 9. If still having problem, it's probably because of the computer settings.

Another reason could also because the ProB animator plugin is on a broken version. ProB 2.4.0 is proved to be broken, however the animation should work on 2.3.5.

3.1.2 Machine:

Undischarged PO for set up, this is because the Rodin Platform can't prove that when a relational override is performed, the possible is still a total function.

However there are only two possible states that a cell can be in after setup, that is either belong to or not belong to the grid, therefore the relational override operation should preserve the invariants.

For upDatePossible, Rodin Platform complains about whether the event is preserve the invariant of the possibility, and whether the event will be feasible.

Feasibility of the event should be preserved, because when the cardinality of the Sudoku Grid is less than 81, then it must implies there exist such a cell, where the cell is an element of possible but not at the same time an element of the Sudoku grid.

3.1.3 Problems Encountered With Rodin Platform

Rodin is incapable of picking up all problems as the system grows bigger. For instance, when all of the context file were merged together at the start of the modeling, Rodin failed every implementation, however, after separating them into different context files, they became provable. During the development, the animator ProB was updated, and after the update it gives file exception errors, when not supposed to. this was fixed by downgrading the system.

3.2 Lessons Learnt & Further Development

- always make simple context, a lot of trouble created due to the large context.
- making one event that will update the possibility of each cell in the grid is much easier than make small updates after each step.
- don't update Rodin Platform, and it's plug-ins.

3.2.1 Further Development Strategy

Figure out a better way to represent the SAMEBOX, SAMECOL, SAMEROW, in order to allow the animation to work.

3.2.2 Issues with regard to animation

Animation on abstract level works perfectly fine, flow of the system for refinement1 and refinement2, can be done by delete the following:

- INV8
- Act2 upDatePossible(however, this will totally destroy the invariants, due to the reason of manual proofs, the situation can be changed by perform a proof replay on undischarged POs, and only setUp/inv1/INV should be left undischarged.)
- Axiom 3-9 in possible grid.

However, this animation is not capable to perform the update possible event, due to the fact that SAMEROW, SAMECOL,SAMEBOX is deleted.

A Reference

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Kai Engelhardt
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