INFORMATICS INSTITUTE OF TECHNOLOGY

UNIVERSITY OF WESTMINSTER

Informatics Institute of Technology

In collaboration with

University of Westminster

BEng. (Hons) in Software Engineering

MODULE: 6SENG003C.1 Reasoning about Programs

Coursework Report

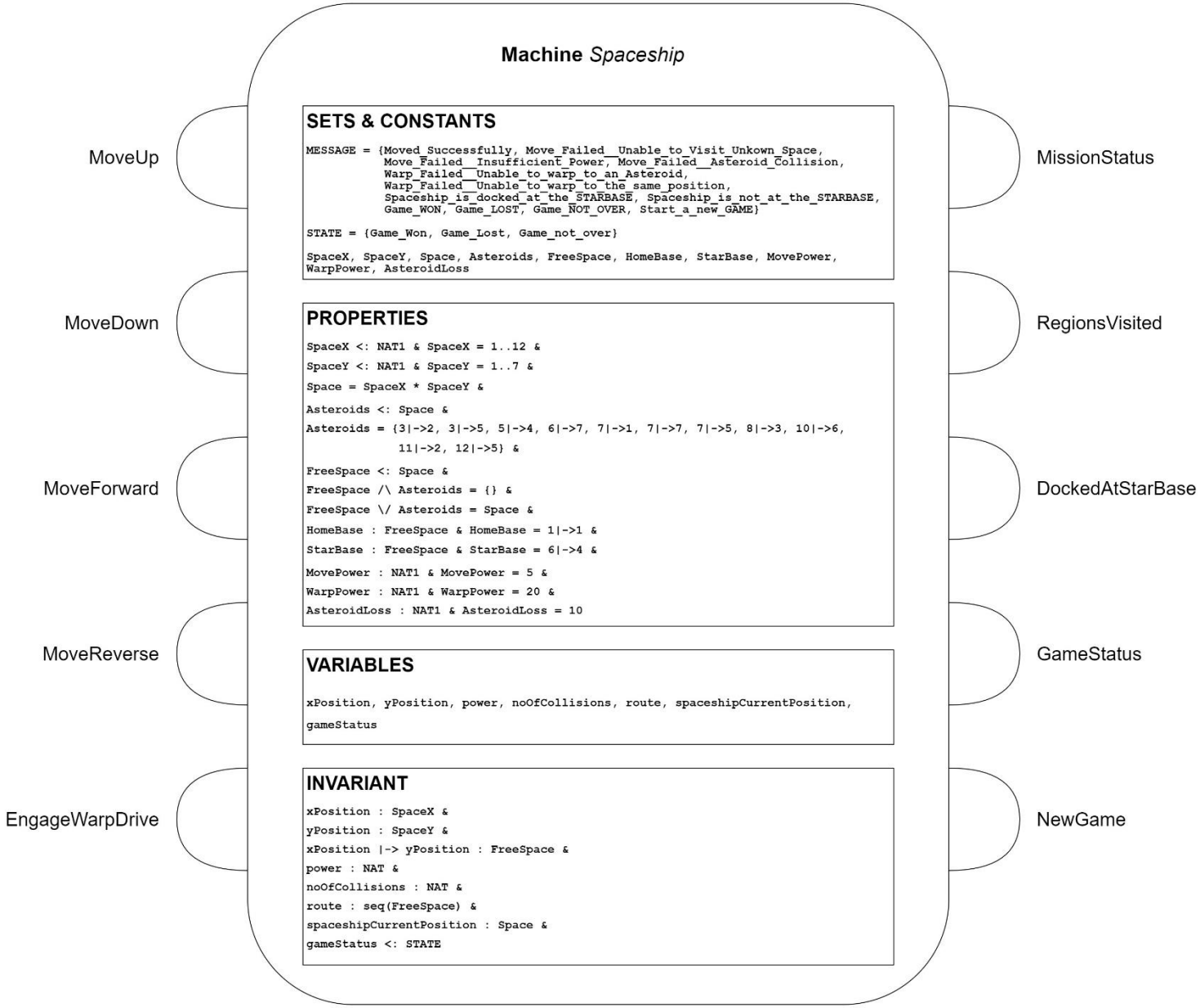
Name: A.M.A. Athindu Umayanga

Student ID: 2018580

UoW ID: w1742249

Contents

1 Structure Diagram



2 Justification & the Explanation

The project is about developing a B specification of a simplified version of the Spaceship & Asteroids arcade game using B tools. Above diagram shows the relevant Structure diagram for the developed B specification. All the assigned and used SETS, CONSTANTS, PROPERTIES, VARIABLES & INVARIANTS are briefly explained down below for further understanding.

SETS

```
MESSAGE = {Moved_Successfully, Move_Failed__Unable_to_Visit_Unkown_Space,
Move_Failed__Insufficient_Power, Move_Failed__Asteroid_Collision,
Warp_Failed__Unable_to_warp_to_an_Asteroid,
Warp_Failed__Unable_to_warp_to_the_same_position,
Spaceship_is_docked_at_the_STARBASE, Spaceship_is_not_at_the_STARBASE,
Game_WON, Game_LOST, Game_NOT_OVER, Start_a_new_GAME};

STATE = {Game_Won, Game_Lost, Game_not_over}
```

Two main sets were initialized for the development of the project.

- `MESSAGE` set includes all the error, success and warning messages which were used throughout the game process to deliver the relevant message according the executed operation.
- Game consists of 3 main states (Win, Lose, In Progress) and `STATE` set was used for showing the current state of the game with every move of the spaceship.

CONSTANTS & PROPERTIES

```
SpaceX, SpaceY, Space, Asteroids, FreeSpace, HomeBase, StarBase, MovePower, WarpPower,
AsteroidLoss


SpaceX <: NAT1 & SpaceX = 1..12 &
SpaceY <: NAT1 & SpaceY = 1..7 &
Space = SpaceX * SpaceY &
Asteroids <: Space &
Asteroids = {3|->2, 3|->5, 5|->4, 6|->7, 7|->1, 7|->7, 7|->5, 8|->3, 10|->6, 11|->2, 12|->5} &
FreeSpace <: Space &
FreeSpace /\ Asteroids = {} &
FreeSpace \/ Asteroids = Space &
HomeBase : FreeSpace & HomeBase = 1|->1 &
StarBase : FreeSpace & StarBase = 6|->4 &
MovePower : NAT1 & MovePower = 5 &
WarpPower : NAT1 & WarpPower = 20 &
AsteroidLoss : NAT1 & AsteroidLoss = 10
```

Few constants were used in the implementation and the use of the relevant constants are justified as shown below.

- `SpaceX` – Used for showing the X axis of the defined space which includes values from 1 to 12.

- `SpaceY` – Used for showing the Y axis of the defined space which includes values from 1 to 7.
- `Space` – Refers to the whole area where the Spaceship has the ability to travel which is the product of SpaceX & SpaceY.
- `Asteroids` – Space includes few Asteroids distributed throughout the Space, hence Asteroids becomes a subset of Space and 11 Asteroids are placed in random locations through the space and they were defined using X-Y coordinate relationship.
- `FreeSpace` – Refers to the free space where the Spaceship can travel without asteroids hence it becomes a subset of the Space too. Asteroids occupies volume from the Space, therefore Asteroids and FreeSpace are mutually exclusive and union of both Asteroids and FreeSpace makes the Space.
- `HomeBase` – Refers to the starting position of the Spaceship. (1,1)
- `StarBase` – Refers to the game wining position. (6,4)
- `MovePower` – Power consumed by the spaceship for a normal movement operation.
- `WarpPower` – Power consumed by the spaceship for a warp jump.
- `AsteroidLoss` – Power lost due to collision with an asteroid.

VARIABLES & INVARIANTS

```
xPosition, yPosition, power, noOfCollisions, route, spaceshipCurrentPosition, gameStatus
```

```
xPosition : SpaceX &
yPosition : SpaceY &
xPosition |-> yPosition : FreeSpace &
power : NAT &
noOfCollisions : NAT &
route : seq(FreeSpace) &
spaceshipCurrentPosition : Space &
gameStatus <: STATE
```

Few variables were initialized to store the values of constantly changing parameters.

- `xPosition, yPosition` – xPosition refers to the x coordinate of the Spaceship's position hence it becomes an element of the SpaceX. yPosition refers to the y coordinate of the Spaceship's position hence it becomes an element of the SpaceY. xPosition and yPosition pair can only change their values within the FreeSpace hence the pair can be identified as an element of the FreeSpace.
- `power` – Used to store the changing power of the Spaceship, power value changes with every normal movement, warp jump and asteroid collision. This variable value can be used when determining whether the Game was lost or not.

- `noOfCollisions` – Refers to the counts of caused asteroid collisions throughout the game.
- `route` – Used to store the Spaceship's path from start to the end of the game, route should include multiple elements and duplicate values should be permitted hence route was defined as a sequence limited to the FreeSpace.
- `spaceshipCurrentPosition` – Refers to the current position of the Spaceship.
- `gameStatus` – Refers to the state property which describes the status of the game. (Win, Lose, In Progress)

INITIALISATION

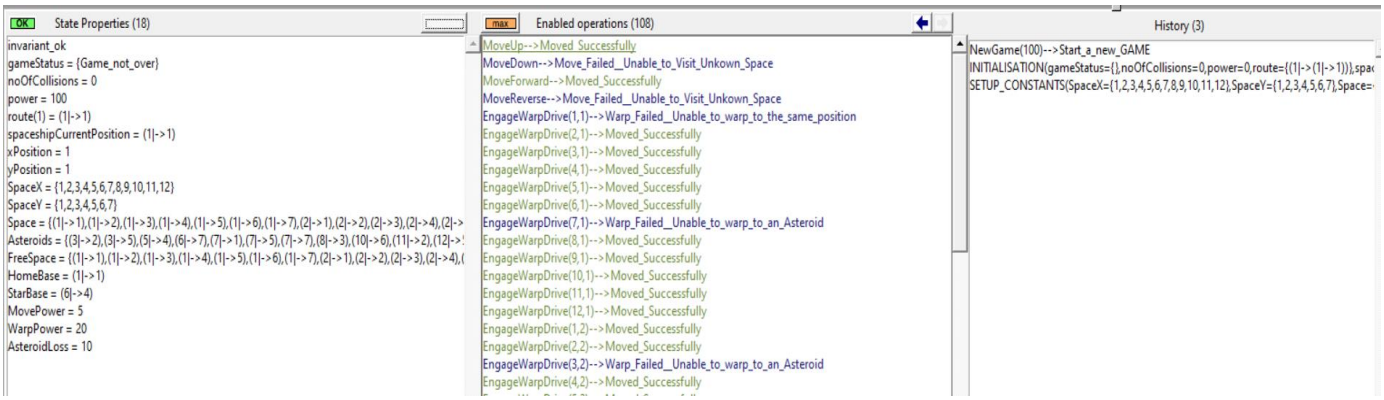
```
power := 0 ||
noOfCollisions := 0 ||
xPosition := 1 ||
yPosition := 1 ||
route := [HomeBase] ||
spaceshipCurrentPosition := HomeBase ||
gameStatus := {}
```

- As per the specification Spaceship has no power, no collisions and should be located on the homebase at the start of the game hence variables were initialised considering those requirements.

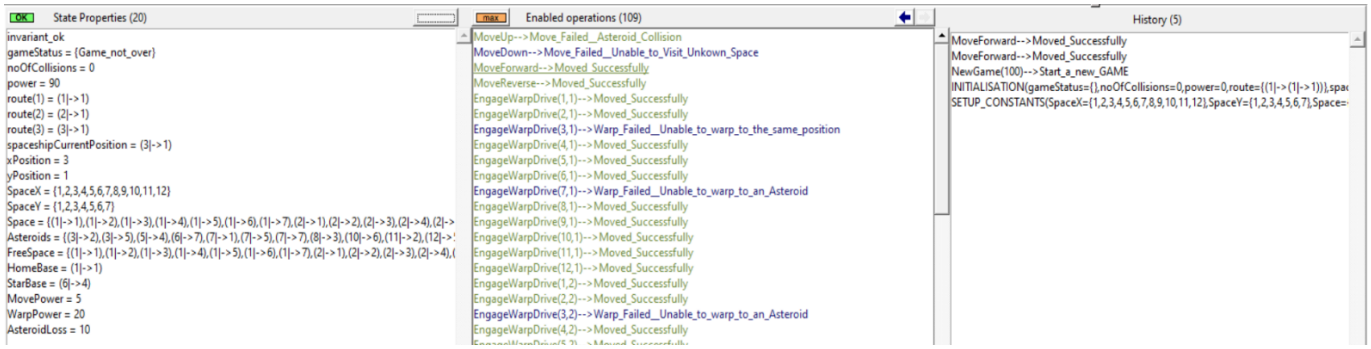
3 Screenshots of the ProB window

1. Initialising the Game

2. Start of the Game

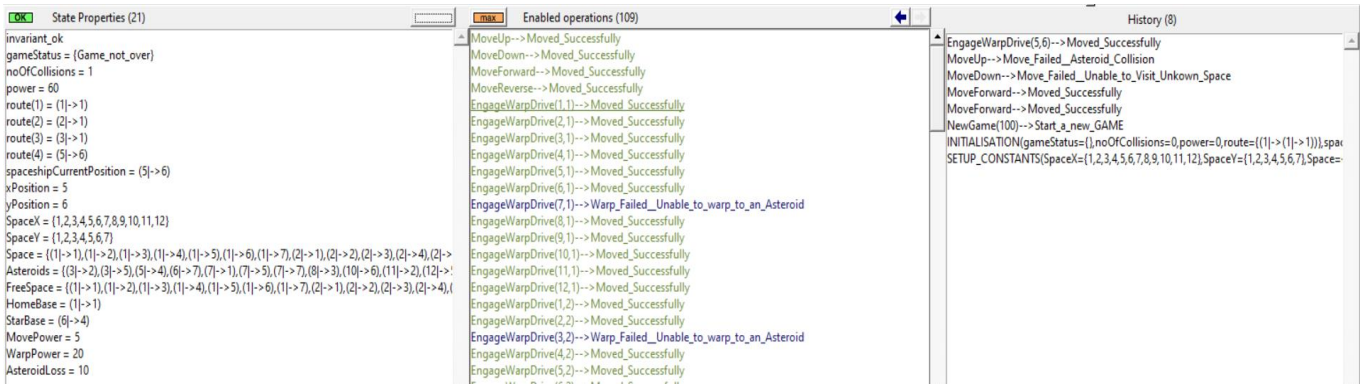


3. Successful Normal Movement



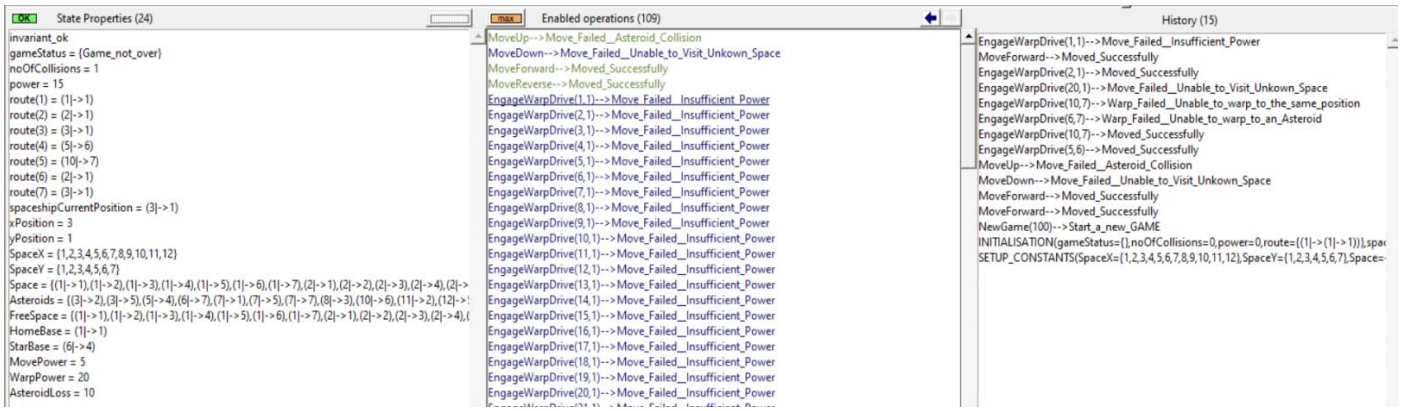
4. Failed movement due to unknown space and asteroid collision

5. Successful warp jump



6. Failed warp jump due to same position, asteroid collision and unknown space errors

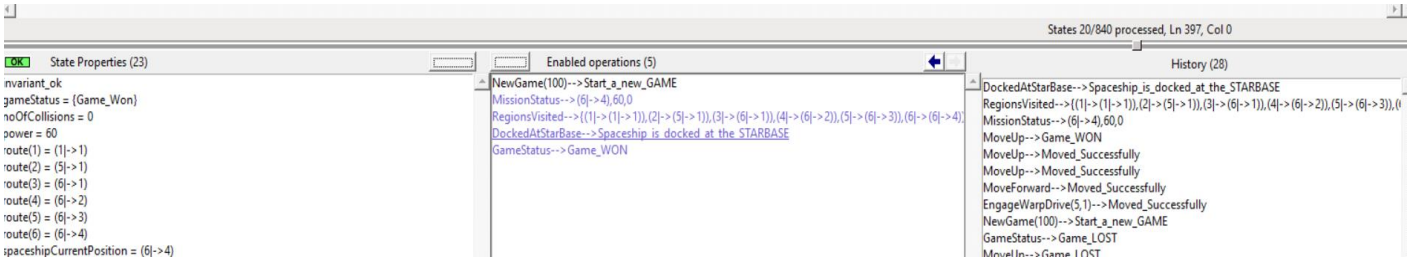
7. Failed warp jump due to insufficient power



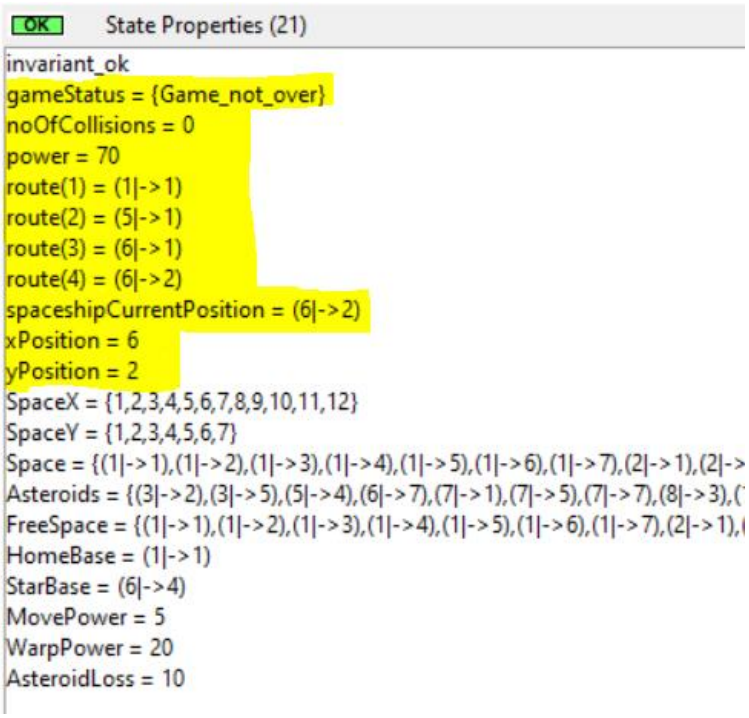
8. Game Lost

9. Game Won

10. Status of the mission, Spaceship visited regions, Spaceship docked at starbase or not

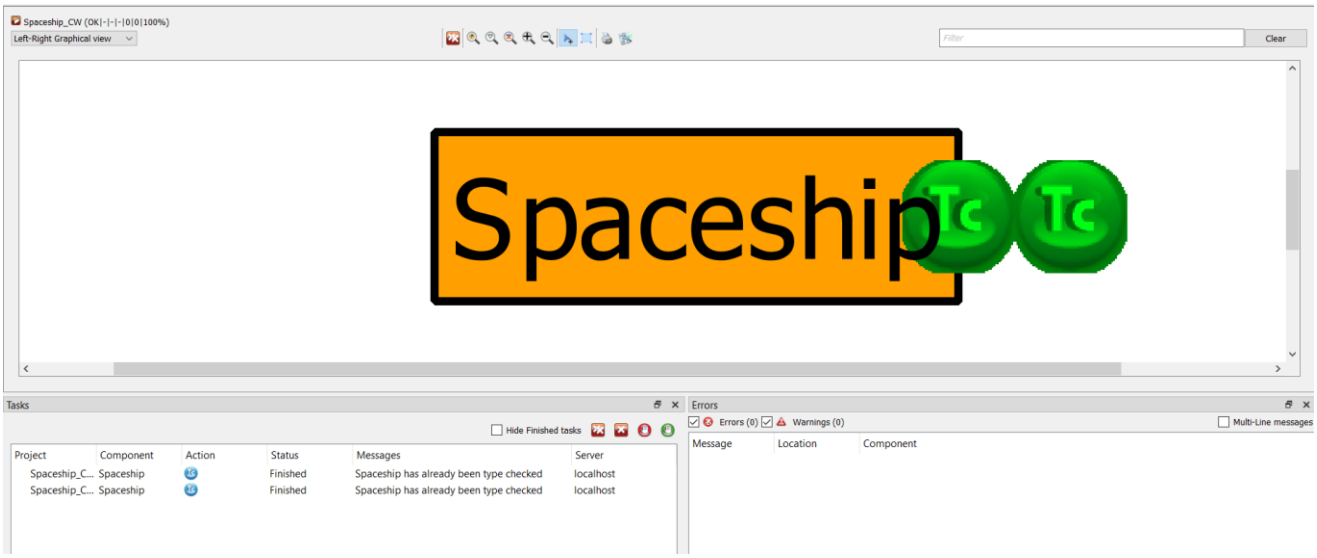


11. State Properties



Highlighted state values change with the movement of the spaceship.

4 Screenshot of the Atelier B Type Check



5 Spaceship Graphical Visualisation