University of Westminster
School of Computer Science and Engineering

6SENG001W Reasoning About Programs
Coursework 1 (2021/22)

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Unit	Coursework 1
Weighting:	50%
Qualifying mark	30%
Description	Develop a B specification of *a Spaceship & Asteroids Game*, using the B tools Atelier B & ProB.
Learning Outcomes Covered in this Assignment:	The coursework assesses learning outcomes: LO1, LO2, LO3 & LO4.
Handed Out:	Week 5: 22 October 2021
Due Date	**Week 9: 13:00, Monday, 22 November 2021**
Expected deliverables	Electronic files: (a) B Specification Structure Diagram (.pdf) (b) *Spaceship & Asteroids Game* B Specification: B machine (.mch) (c) Graph of ProB Animation Session History (.dot) (d) Screenshot of Atelier B type check (.jpeg/.jpg) All files should be compressed into a single ZIP archive. The ZIP archive should be named using your surname & "cwk", e.g. "howells_cwk.zip". (See section 3 for full details.)
Method of Submission:	**Online via Blackboard**
Type of Feedback and Due Date:	Verbal feedback in tutorial(s) before the assessment is submitted. Sample answers of the assessment after 15 working days (3 weeks). Written feedback and marks 15 working days (3 weeks) after the submission deadline. **All marks will remain provisional until formally agreed by an Assessment Board.**

Assessment regulations

Refer to section 4 of the "How you study" guide for undergraduate students for a clarification of how you are assessed, penalties and late submissions, what constitutes plagiarism etc.

Penalty for Late Submission

If you submit your coursework late but within 24 hours or one working day of the specified deadline, 10 marks will be deducted from the final mark, as a penalty for late submission, except for work which obtains a mark in the range 40 – 49%, in which case the mark will be capped at the pass mark (40%). If you submit your coursework more than 24 hours or more than one working day after the specified deadline you will be given a mark of zero for the work in question unless a claim of Mitigating Circumstances has been submitted and accepted as valid.

It is recognised that on occasion, illness or a personal crisis can mean that you fail to submit a piece of work on time. In such cases you must inform the Campus Office in writing on a mitigating circumstances form, giving the reason for your late or non-submission. You must provide relevant documentary evidence with the form. This information will be reported to the relevant Assessment Board that will decide whether the mark of zero shall stand. For more detailed information regarding University Assessment Regulations, please refer to the following website:

http://www.westminster.ac.uk/study/current-students/resources/academic-regulations

Coursework Description

1. Introduction

This coursework requires you to develop a B specification of a very simple version of the old *Spaceship & Asteroids arcade game*, using the B tools Atelier B & ProB.

Figure 1. gives the layout of the regions of space (a rectangular grid shape), the *Spaceship* is represented by the blue triangle, its starting position is its home base (1, 1).

The aim is to move the *Spaceship* from *its home base* through space using the various movement operations to get to the *Starbase (6,4), avoiding the Asteroids.*
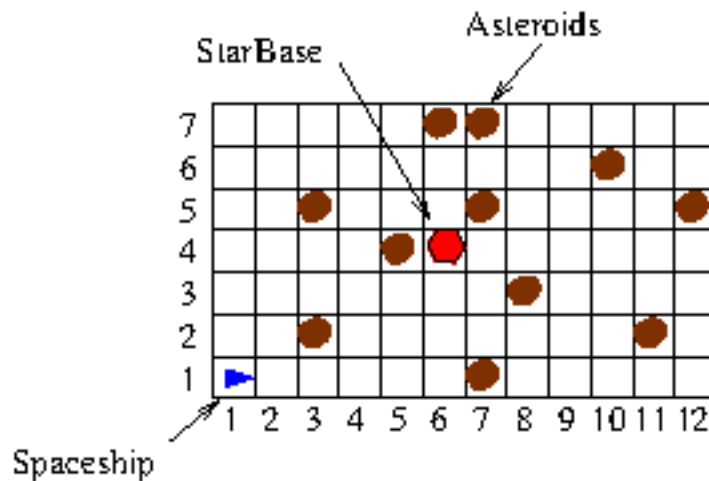

Figure 1. Regions of Space, Spaceship, Star Base & Asteroids

Notes

- Space is made up of regions (squares of the grid) 12 wide by 7 high.

- The regions of space are populated by **11 asteroids**, each in one region of space, & located as shown in Figure 1.

- The Spaceship occupies only one square at a time & can only be in an "empty space square", except when "docked" at the Starbase in its square (6,4).

  For example, the Spaceship can be in region (5, 3), but not (8, 3) as it is occupied by an asteroid.

- The Spaceship is initially in its *homebase*, i.e. the bottom left square (1, 1).

- The spaceship can make a normal move, i.e. from one region of space (grid square) to an adjacent one, in one of four directions: Up, Down, Forward (right) & Reverse (left).

- It uses up **5 units of power** when it makes a normal move.

- The spaceship can engage its *warp-drive* & "jumps" to any region of space, except one occupied by an asteroid. It must not travel outside known space, i.e. outside the grid.

- It uses up **20 units of power** when it engages its warp-drive, no matter how many regions it moves.

- If the spaceship crashes into one of the asteroids it **loses 10 units of power**.

- If it has less than the required amount of power to do either a normal move or a warp-drive jump it can not do that type of move.

- The state of the game is one of the following:

    - the spaceship docks at the Starbase, in which case the game has been **Won.**

    - the spaceship is **not docked** at the Starbase & **can not move** because it has run out of power, in which case the game is **Lost.**

    - otherwise the game is **not over**.

2 Develop a B Specification of the Regions of Space, Spaceship & Asteroids

Your B specification, i.e. collection of 1 or more B machines, should include the following elements.

2.1 Sets and Constants

Any sets and constants that are required to define the data and state of the spaceship, space, asteroids and their properties.
(Hints: Represent space and the asteroids as relations. What is the relationship between space, "empty space" & the asteroids locations?)

2.2 System State

The state variables required to represent space, asteroids and the spaceship. Including the state invariant and initialisation.

You can assume that the spaceship starts at its homebase, has no power, has not had any collisions and it has only visited the regions of space its homebase is located in.

2.3 New Game

To start or re-start the game use the *NewGame(power)* operation. This should reset the spaceship to the initial state, except that it sets its power level to the value of the *power* parameter.

2.4 Spaceship Movements in Space

Note that all movement operations must report the outcome of an attempted movement. That is, either it was successful, failed due to space boundary issues, failed due to an asteroid, or failed for some other reason.

2.4.1 Normal Spaceship Movements

The following operations are the basic movements that all move the spaceship one region (square) in the appropriate direction in space and uses up 5 units of the spaceship's power:

- *MoveUp*
- *MoveDown*
- *MoveForward*
- *MoveBackward* (i.e. reverse)

Note that If the move results in the spaceship hitting an asteroid the spaceship remains in its current location, but its **power is reduced by 10 units**.

If any attempted movement cannot be performed because of the boundary of space or insufficient power then **an error is reported**.

2.4.2 Warp-drive Spaceship Movement

The movement operation:

- *EngageWarpDrive(newposition)*

where the player enters the *newposition* parameter**,** the region of space (i.e. grid co-ordinates) that the spaceship should warp jump to. Engaging the warp-drive **uses up 20 units** of the spaceship's power.

If the warp-drive cannot be used because the destination region input is either not within the known regions of space or is occupied by an asteroid or if there is insufficient power to use the warp-drive then an **appropriate error message should be reported**.

2.5 Spaceship's Mission Status

An enquiry operation *MissionStatus* that reports the current status of the spaceship:

- its current location,
- its current power reserves,
- how many asteroid collisions it has had.

2.6 Spaceship's Mission Route

An enquiry operation *RegionsVisited* that reports the regions of space that the spaceship has travelled through.

2.7 Spaceship is Docked at Starbase

An enquiry operation *DockedAtStarbase* that reports whether the Spaceship is "docked" at the Starbase, i.e. its current location is the Starbase.

2.7 Game Status

An enquiry operation *GameStatus* that reports:

- "Game WON" if the game is over & has been won;
- "Game LOST" if over & has been lost; and
- "Game Not Over" if its not over.

2.8 General Requirements

The B specification should use the appropriate features to define the data and operations in your B machine.

The specification must be syntactically and type correct, as checked by using the Atelier B tool.

The specification must be animated by ProB. That is it must *initialise* correctly and all operations can be *animated* successfully and used to move the Spaceship around the regions of space, e.g. from the homebase to the Starbase using a combination of **all** of the movement operations, including the warp jump.

3. Submission & Lab Demonstration

3.1 Blackboard Submission

The following 3 components are to be submitted via Blackboard:

1. The Structure Diagram of your *Spaceship & Asteroids* System B machine. You must also include as a "plain English" description of the "state invariants" of the system.   Examples of Structure Diagrams can be found in the lecture notes and in the tutorial exercises.
    SUBMIT: 1 ".pdf" file.   **[15%]**

2. The B Specification of the *Spaceship & Asteroids* System.
     SUBMIT: the B machine ".mch" file as is. (**DO NOT submit it as a Word file.**)   **[70%]**

3. Examples of successfully using the 2 B tools Atelier B and Prob.

    For Atelier B: a single screen shot showing the B specification in the Atelier B editor and in Atelier B's main window the successful type checking of the specification, i.e. the "specification box" with the "green TC" circle.

    For ProB: a Graph representation of a complete ProB Animation Session history.   Using ProB perform an animation sessions that shows how the Spaceship is moved from the **homebase square** to the **Starbase square** using **a combination of all of the movement operations,** including examples of non-successful operations.
    Notes the submitted example animation should not just consist of a single warp from the homebase to the Starbase.   View this Animation Session as a "DOT" graph and then save it.

    SUBMIT:

    *   1 Atelier B screen shot in either ".jpg" or ".jpeg" format.

    *   1 ProB animation history graph ".dot" file as is. **(DO NOT open using Word.)**

                                                                                                                            [15%]

NOTE: All files should be compressed into a single ZIP archive. **ONLY ZIP format archives will be accepted.** The ZIP archive should be named using your surname & "cwk", e.g. "howells_cwk.zip".

Coursework Marking Scheme Overview

The Coursework will be marked based on the following main component marking criteria, the full marking criteria details will be published on the module's Blackboard site.

Criteria	Mark per component	Mark provided	Comments
B Specification Structure Diagram of the *Spaceship & Asteroids* System, with invariant descriptions.	15		
B Specification of *Spaceship & Asteroids* System	70		
Atelier B type check screen shot, ProB Animation Session History Graph	15		
Total	**100**		