BBB Testing Documentation

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Contents

1 Testing approach

The application is composed of five main components:

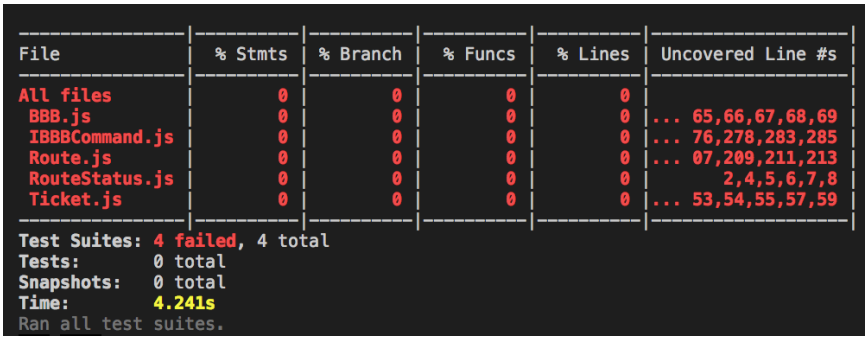
- `Ticket`: Class that holds ticket information
- `Route`: Class that holds route information as well as associated tickets, available seats, etc.
- `RouteStatus`: Enumaration that indicates the status of a `Route`
- `IBBBCommand`: Interface and several implementations that each fulfill one specific funcitonality such as creating a new route, purchasing a ticket, etc.
- `BBB`: Class that uses as the composition of overall functionality which parses the given commands and loads/stores routes from/in a file

We tried to reach 100% branch coverage in the code by the use of unit tests. For this, all components that we created were tested individually until 100% branch coverage was reached. For every component we looked at each method, property or constructor to identify the branches to be tested. This allowed us to look at a single functionality in each test case and made it a lot easier to identify all the necessary test cases for each component. We decided not to target all components in the first sprint because we expected a high number of required test cases which would have made it a bit more unstructured and harder to understand. Instead we targeted the classes `Ticket` and `Route` in the first iteration. In the second iteration we added the test cases for `Ticket` and `Route` that we identified missing and targeted `IBBBCommand` and `BBB` as well. The third iteration was the last one and only included test cases that were identified to be missing in iteration two. The `RouteStatus` enumeration is not targeted individually because this is done implicitly when testing the `Route` class.

We used the testing framework Jest that enabled us to run automated tests on individual files. We did not find any non-reachable code but we found several faults that we fixed as described in the documented below.

2 Description of Coverage Screenshot

The coverage tool shows a table with 6 columns. Each row shows a file that has been tested and below the table there is some additional information about how many passed/failed test suites and about how many tests out of these test suits passed/failed. Each row in the table shows coverage information of a certain file and includes percentage of covered statements, branches, functions and lines. Given any lines are still uncovered after running the tests, those lines are shown in the most right column. The screenshot below shows an example of the coverage output where no tests have been executed.



File	% Stmts	% Branch	% Funcs	% Lines	Uncovered Line #s
All files	0	0	0	0	
BBB.js	0	0	0	0	... 65,66,67,68,69
IBBBCommand.js	0	0	0	0	... 76,278,283,285
Route.js	0	0	0	0	... 07,209,211,213
RouteStatus.js	0	0	0	0	2,4,5,6,7,8
Ticket.js	0	0	0	0	... 53,54,55,57,59

```
Test Suites: 4 failed, 4 total
Tests:       0 total
Snapshots:   0 total
Time:        4.241s
Ran all test suites.
```

The goal for this assignment is to reach a value of 100% in the column `% Branch` for all files without any tests failing.

3 Notes

We found that the document was better readable when not using tables and decided to use a list formatting for better readability. Some test cases required the targeted class to be in a certain state. Therefore, we added a `Precondition` to those test cases. For instance, the precondition `Route{ id: ‘‘R1’’, source: "Madrid", destination: "Toledo", ...}` means that a `Route` instance should be initialized with the stated properties in the arrangement of the test case. If no class name is stated at the beginning, it means that we are referring to a simple object representation or single variables instead of a class instance. A value of `N/A` indicates that no precondition or input is required. For shortening the definition of a list of `Tickets` we used values as for instance T1_R1_9 which corresponds to a `Ticket` instance on `Route` R1 with seat 9 which is not boarded, e.g. Ticket { id: "T1", seat: 9, boarded: false }.

The complete source code of the tested application is shown in the attachment.

4 Iteration 1

Iteration 1 targets the classes `Ticket` and `Route`

4.1 Specify Test Cases

4.1.1 Class Ticket

TC_Ticket_1 initializes correctly

Goal Test that the `Ticket` class initializes correctly

Class Ticket

Method constructor

Precondition N/A

Input { id: “T1”, seat: 1 }

Expected Output Ticket{ id: “T1”, seat: 1, boarded: false }

TC_Ticket_2 throws error for invalid id

Goal Test that the `Ticket` class fails the initialization when an invalid id is passed

Class Ticket

Method constructor

Precondition N/A

Input { id: " ", seat: 1 }

Expected Output Error("Invalid id")

TC_Ticket_3 throws error for invalid seat

Goal Test that the `Ticket` class fails the initialization when an invalid seat number is passed

Class Ticket

Method constructor

Precondition N/A

Input { id: "T1", seat: -1 }

Expected Output Error("Invalid seat")

TC_Ticket_4 changes value correctly

Goal Test that the `boarded` property changes it's value correctly

Class Ticket

Method setter boarded

Precondition Ticket{ boarded: false }

Input true

Expected Output Ticket{ boarded: true }

TC_Ticket_5 creates object correctly

Goal Test that the `toObject()` method creates a correct object representation of the `Ticket`

Class Ticket

Method toObject

Precondition Ticket{ id: "T1", seat: 1, boarded: false }

Input N/A

Expected Output Object{id: "T1", seat: 1, boarded: false }

TC_Ticket_6 creates ticket correctly

Goal Test the the `fromObject()` method creates a correct `Ticket` instance from it's object representation

Class Ticket

Method fromObject

Precondition N/A

Input Object{ id: "T1", seat: 1, boarded: false }

Expected Output Ticket{id: "T1", seat: 1, boarded: false }

TC_Ticket_7 throws error for invalid ticket object

Goal Test that the `fromObject()` method throws an error if an invalid object representation is passed

Class Ticket

Method fromObject

Precondition N/A

Input Object{ id_X: "T1", seat: 1, boarded: false }

Expected Output Error("Invalid object")

4.1.2 Class Route

TC_Route_1 initializes correctly

Goal Test that the `Route` class initializes correctly

Class Route

Method constructor

Precondition N/A

Input { id: "R1", source: "Madrid", destination: "Toledo", capacity: 10 }

Expected Output Route{ id: "R1", source: "Madrid", destination: "Toledo", capacity: 10, tickets: [], departed: null, availableSeats: [0, ... , 9]}

TC_Route_2 throws error on invalid id

Goal Test that the `Route` class fails initialization if an invalid id is passed

Class Route

Method constructor

Precondition N/A

Input { id: “ ”, source: “Madrid”, destination: “Toledo”, capacity: 10 }

Expected Output Error(“Invalid id”)

TC_Route_3 throws error on invalid source

Goal Test that the `Route` class fails initialization if an invalid source is given

Class Route

Method constructor

Precondition N/A

Input { id: “R1”, source: “ ”, destination: “Toledo”, capacity: 10 }

Expected Output Error(“Invalid source”)

TC_Route_4 throws error on invalid destination

Goal Test that the `Route` class fails initialization if an invalid destination is given

Class Route

Method constructor

Precondition N/A

Input { id: “R1”, source: “Madrid”, destination: null, capacity: 10 }

Expected Output Error(“Invalid source”)

TC_Route_5 throws error on invalid capacity

Goal Test that the `Route` class fails initialization if an invalid capacity is given

Class Route

Method constructor

Precondition N/A

Input { id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: -1 }

Expected Output Error(“Invalid capacity”)

TC_Route_6 returns status “travelling” on travelling

Goal Test that the property `status` returns "travelling" if it has departed

Class Route

Method getter status

Precondition Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [], departed: “2008-09-15T15:53:00”, availableSeats: [0, . . . , 9]}

Input N/A

Expected Output “travelling”

Note The date set for departed is an example. For the test the current date and time will be set

TC_Route_7 returns status “empty” on empty

Goal Test that the property `status` returns "empty" if it has not departed and no ticket has been purchased

Class Route

Method getter status

Precondition Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [], departed: null, availableSeats: [0, . . . , 9]}

Input N/A

Expected Output “empty”

TC_Route_8 returns status “available” on available

Goal Test that the property `status` returns "available" if it has not departed and at least one ticket has been purchased

Class Route

Method getter status

Precondition Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T_R1_9], departed: null, availableSeats: [0, . . . , 8]}

Input N/A

Expected Output “available”

TC_Route_9 returns status “full” on full

Goal Test that the property `status` returns "full" if it has not departed and all available tickets have been purchased

Class Route

Method getter status

Precondition Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T_R1_9, . . . , T_R1_0], departed: null, availableSeats: []}

Input N/A

Expected Output “full”

TC_Route_10 successfully purchase ticket

Goal Test that the method `purchaseTicket()` successfully creates a new `Ticket` instance and removes one available seat

Class Route

Method purchaseTicket

Precondition Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [], departed: null, availableSeats: [0, . . . , 9]}

Input N/A

Expected Output { success: true, ticket: Ticket{ id: “T1_R1_9”, seat: 9, boarded: false } }, Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T1_R1_9], departed: null, availableSeats: [0, . . . , 8]}

TC_Route_11 purchase ticket fails on no available tickets

Goal Test that the method `purchaseTicket()` fails if there are no available seats left

Class Route

Method purchaseTicket

Precondition Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T1_R1_9, . . . T1_R1_0], departed: null, availableSeats: []}

Input N/A

Expected Output { success: false, reason: “No tickets available” }, Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T1_R1_9, ... T1_R1_0], departed: null, availableSeats: []}

TC_Route_12 successfully board ticket

Goal Test that the method `boardTicket()` successfully changes the property "boarded" of the corresponding `Ticket` to "true" and does not alter any other `Ticket`

Class Route

Method boardTicket

Precondition Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T1_R1_9, ... T1_R1_0], departed: null, availableSeats: []}, T1_R1_9{ id: “T1_R1_9”, seat: 9, boarded: false }

Input { ticketId: “T1_R1_9” }

Expected Output { success: true, ticket: Ticket{ id: “T1_R1_9”, seat: 9, boarded: true } }, Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T1_R1_9, ... T1_R1_0], departed: null, availableSeats: []}

TC_Route_13 board ticket fails for invalid ticketId

Goal Test that the method `boardTicket()` fails if the passed `ticketId` does not match any `Ticket`

Class Route

Method boardTicket

Precondition Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T1_R1_9, ... T1_R1_0], departed: null, availableSeats: []}

Input { ticketId: “T1_R1_XXX” }

Expected Output { success: false, reason: “Ticket does not exist” }, Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T1_R1_9, ... T1_R1_0], departed: null, availableSeats: []}

TC_Route_14 board ticket fails for already boarded ticketId

Goal Test that the method `boardTicket()` fails if the property `boarded` of the corresponding `Ticket` is already set to true

Class Route

Method boardTicket

Precondition Route{ id: "R1", source: "Madrid", destination: "Toledo", capacity: 10, tickets: [T1_R1_9, ... T1_R1_0], departed: null, availableSeats: []}, T1_R1_9{ id: "T1_R1_9", seat: 9, boarded: true }

Input { ticketId: "T1_R1_9" }

Expected Output { success: false, reason: "Ticket is already boarded" }, Route{ id: "R1", source: "Madrid", destination: "Toledo", capacity: 10, tickets: [T1_R1_9, ... T1_R1_0], departed: null, availableSeats: []}, T1_R1_9{ id: "T1_R1_9", seat: 9, boarded: true }

TC_Route_15 successfully cancel ticket

Goal Test that the method `cancelTicket()` successfully removes the corresponding `Ticket` from the list of `Tickets` and adds the seat of the `Ticket` back to the list of the available seats.

Class Route

Method cancelTicket

Precondition Route{ id: "R1", source: "Madrid", destination: "Toledo", capacity: 10, tickets: [T1_R1_9, ... T1_R1_0], departed: null, availableSeats: []}, T1_R1_9{ id: "T1_R1_9", seat: 9, boarded: false }

Input { ticketId: "T1_R1_9" }

Expected Output { success: true, ticket: Ticket{ id: "T1_R1_9", seat: 9, boarded: false } }, Route{ id: "R1", source: "Madrid", destination: "Toledo", capacity: 10, tickets: [T1_R1_8, ... T1_R1_0], departed: null, availableSeats: [9]}

TC_Route_16 cancel ticket fails for invalid ticketId

Goal Test that the method `cancelTicket()` fails if the passed `ticketId` does not match any `Ticket`

Class Route

Method cancelTicket

Precondition Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T1_R1_9, . . . T1_R1_0], departed: null, availableSeats: []}

Input { ticketId: “T1_R1_XXX” }

Expected Output { success: false, reason: “Ticket does not exist” }, Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T1_R1_9, . . . T1_R1_0], departed: null, availableSeats: []}

TC_Route_17 cancel ticket fails for already boarded ticketId

Goal Test that the method `cancelTicket()` fails if the property `boarded` of the corresponding `Ticket` is already set to true

Class Route

Method cancelTicket

Precondition Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T1_R1_9, . . . T1_R1_0], departed: null, availableSeats: []}, T1_R1_9{ id: “T1_R1_9”, seat: 9, boarded: true }

Input { ticketId: “T1_R1_9” }

Expected Output { success: false, reason: “Ticket is already boarded” }, Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T1_R1_9, . . . T1_R1_0], departed: null, availableSeats: []}, T1_R1_9{ id: “T1_R1_9”, seat: 9, boarded: true }

TC_Route_18 depart successfully sets departure time

Goal Test that the method `depart()` successfully sets the departure of the `Route` with a current timestamp

Class Route

Method depart

Precondition Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [], departed: null, availableSeats: [0, . . . , 9]}

Input N/A

Expected Output Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [], departed: “2008-09-15T15:53:00”, availableSeats: [0, . . . , 9]}

Note The date set for departed is an example. For the test the current date and time will be set

TC_Route_19 hasArrived successfully resets the Route

Goal Test that the method `hasArrived()` successfully resets the departure to null if the departure is set and at least 10 seconds have been passed since the departure

Class Route

Method hasArrived

Precondition Route{ id: "R1", source: "Madrid", destination: "Toledo", capacity: 10, tickets: [T1_R1_9, ... T1_R1_0], departed: "2008-09-15T15:53:00", availableSeats: []}

Input N/A

Expected Output true, Route{ id: "R1", source: "Toledo", destination: "Madrid", capacity: 10, tickets: [], departed: null, availableSeats: [0, ..., 9]}

Note The date set for departed is an example. For the test the current date and time will be set

TC_Route_20 hasArrived does not reset the Route if no departed yet

Goal Test that the method `hasArrived()` does nothing if no departure is set

Class Route

Method hasArrived

Precondition Route{ id: "R1", source: "Madrid", destination: "Toledo", capacity: 10, tickets: [T1_R1_9, ... T1_R1_0], departed: null, availableSeats: []}

Input N/A

Expected Output false, Route{ id: "R1", source: "Madrid", destination: "Toledo", capacity: 10, tickets: [T1_R1_9, ... T1_R1_0], departed: null, availableSeats: []}

TC_Route_21 hasArrived does not reset the Route if still travelling

Goal Test that the method `hasArrived()` does nothing if the departure is set but less than 10 seconds have been passed since departure

Class Route

Method hasArrived

Precondition Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T1_R1_9, ... T1_R1_0], departed: “2008-09-15T15:53:00”, availableSeats: []}

Input N/A

Expected Output false, Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T1_R1_9, ... T1_R1_0], departed: “2008-09-15T15:53:00”, availableSeats: []}

Note The date set for departed is an example. For the test the current date and time will be set so that the 10 seconds have not passed yet

TC_Route_22 fromObject successfully creates new Route with set departure

Goal Test that the `fromObject()` method successfully creates a `Route` instance from it's object representation that has a departure set

Class Route

Method fromObject

Precondition N/A

Input { id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T1_R1_9, ... T1_R1_3], departed: “2008-09-15T15:53:00”, availableSeats: [0, 1, 2]}

Expected Output Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T1_R1_9, ... T1_R1_3], departed: “2008-09-15T15:53:00”, availableSeats: [0, 1, 2]}

Note The date set for departed is an example

TC_Route_23 fromObject successfully creates new Route without set departure and tickets

Goal Test that the `fromObject()` method successfully creates a `Route` instance from it's object representation that does not have a departure set

Class Route

Method fromObject

Precondition N/A

Input { id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [], departed: null, availableSeats: [0, . . . , 9]}

Expected Output Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [], departed: null, availableSeats: [0, . . . , 9]}

TC_Route_24 toObject successfully creates new Object with set departure

Goal Test that the `toObject()` method successfully creates a object representation of the `Route` that has a departure set

Class Route

Method toObject

Precondition Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T1_R1_9, . . . T1_R1_3], departed: “2008-09-15T15:53:00”, availableSeats: [0, 1, 2]}

Input N/A

Expected Output Object{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T1_R1_9, . . . T1_R1_3], departed: “2008-09-15T15:53:00”, availableSeats: [0, 1, 2]}

TC_Route_25 toObject successfully creates new Object without departure

Goal Test that the `toObject()` method successfully creates a object representation of the `Route` that does not have a departure set

Class Route

Method toObject

Precondition Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T1_R1_9, . . . T1_R1_3], departed: null, availableSeats: [0, 1, 2]}

Input N/A

Expected Output Object{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T1_R1_9, . . . T1_R1_3], departed: null, availableSeats: [0, 1, 2]}

4.2 Run Test Cases

4.2.1 Class Ticket

- **TC_Ticket_1**

  Expected Output Ticket{ id: “T1”, seat: 1, boarded: false }
  Observed Output Ticket{ id: “T1”, seat: 1, boarded: false }
  Failure None

- **TC_Ticket_2**

  Expected Output Error(“Invalid id”)
  Observed Output Error(“Invalid id”)
  Failure None

- **TC_Ticket_3**

  Expected Output Error(“Invalid seat”)
  Observed Output Error(“Invalid seat”)
  Failure None

- **TC_Ticket_4**

  Expected Output Ticket{ boarded: true }
  Observed Output Ticket{ boarded: true }
  Failure None

- **TC_Ticket_5**

  Expected Output Object{id: “T1”, seat: 1, boarded: false }
  Observed Output Object{id: “T1”, seat: 1, boarded: false }
  Failure None

- **TC_Ticket_6**

  Expected Output Ticket{id: “T1”, seat: 1, boarded: false }
  Observed Output Ticket{id: “T1”, seat: 1, boarded: false }
  Failure None

- **TC_Ticket_7**

  Expected Output Error(“Invalid object”)
  Observed Output Error(“Invalid object”)
  Failure None

4.2.2 Class Route

- **TC_Route_1**

  Expected Output Route{ id: "R1", source: "Madrid", destination: "Toledo", capacity: 10, tickets: [], departed: null, availableSeats: [0, ... , 9]}

  Observed Output Route{ id: "R1", source: "Madrid", destination: "Toledo", capacity: 10, tickets: [], departed: null, availableSeats: [0, ... , 9]}

  Failure None

- **TC_Route_2**

  Expected Output Error("Invalid id")

  Observed Output Error("Invalid id")

  Failure None

- **TC_Route_3**

  Expected Output Error("Invalid source")

  Observed Output Error("Invalid source")

  Failure None

- **TC_Route_4**

  Expected Output Error("Invalid source")

  Observed Output Error("Invalid source")

  Failure None

- **TC_Route_5**

  Expected Output Error("Invalid capacity")

  Observed Output Error("Invalid capacity")

  Failure None

- **TC_Route_6**

  Expected Output "travelling"

  Observed Output 0

  Failure Yes

- **TC_Route_7**

  Expected Output “empty”

  Observed Output 1

  Failure Yes

- **TC_Route_8**

  Expected Output “available”

  Observed Output 3

  Failure Yes

- **TC_Route_9**

  Expected Output “full”

  Observed Output 2

  Failure Yes

- **TC_Route_10**

  Expected Output { success: true, ticket: Ticket{ id: “T1_R1_9”, seat: 9, boarded: false } }, Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T1_R1_9], departed: null, availableSeats: [0, . . . , 8]}

  Observed Output { success: true, ticket: Ticket{ id: “T1_R1_9”, seat: 9, boarded: false } }, Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T1_R1_9], departed: null, availableSeats: [0, . . . , 8]}

  Failure None

- **TC_Route_11**

  Expected Output { success: false, reason: “No tickets available” }, Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T1_R1_9, . . . T1_R1_0], departed: null, availableSeats: []}

  Observed Output { success: false, reason: “No tickets available” }, Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T1_R1_9, . . . T1_R1_0], departed: null, availableSeats: []}

Failure None

- **TC_Route_12**

  Expected Output { success: true, ticket: Ticket{ id: "T1_R1_9", seat: 9, boarded: true } }, Route{ id: "R1", source: "Madrid", destination: "Toledo", capacity: 10, tickets: [T1_R1_9, ... T1_R1_0], departed: null, availableSeats: []}

  Observed Output { success: true, ticket: Ticket{ id: "T1_R1_9", seat: 9, boarded: true } }, Route{ id: "R1", source: "Madrid", destination: "Toledo", capacity: 10, tickets: [T1_R1_9, ... T1_R1_0], departed: null, availableSeats: []}

  Failure None

- **TC_Route_13**

  Expected Output { success: false, reason: "Ticket does not exist" }, Route{ id: "R1", source: "Madrid", destination: "Toledo", capacity: 10, tickets: [T1_R1_9, ... T1_R1_0], departed: null, availableSeats: []}

  Observed Output { success: false, reason: "Ticket does not exist" }, Route{ id: "R1", source: "Madrid", destination: "Toledo", capacity: 10, tickets: [T1_R1_9, ... T1_R1_0], departed: null, availableSeats: []}

  Failure None

- **TC_Route_14**

  Expected Output { success: false, reason: "Ticket is already boarded" }, Route{ id: "R1", source: "Madrid", destination: "Toledo", capacity: 10, tickets: [T1_R1_9, ... T1_R1_0], departed: null, availableSeats: []}, T1_R1_9{ id: "T1_R1_9", seat: 9, boarded: true }

  Observed Output { success: false, reason: "Ticket is already boarded" }, Route{ id: "R1", source: "Madrid", destination: "Toledo", capacity: 10, tickets: [T1_R1_9, ... T1_R1_0], departed: null, availableSeats: []}, T1_R1_9{ id: "T1_R1_9", seat: 9, boarded: true }

  Failure None

- **TC_Route_15**

Expected Output { success: true, ticket: Ticket{ id: “T1_R1_9”, seat: 9, boarded: false } }, Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T1_R1_8, . . . T1_R1_0], departed: null, availableSeats: [9]}

Observed Output { success: true, ticket: Ticket{ id: “T1_R1_9”, seat: 9, boarded: false } }, Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T1_R1_8, . . . T1_R1_0], departed: null, availableSeats: []}

Failure Yes

- **TC_Route_16**

  Expected Output { success: false, reason: “Ticket does not exist” }, Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T1_R1_9, . . . T1_R1_0], departed: null, availableSeats: []}

  Observed Output { success: false, reason: “Ticket does not exist” }, Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T1_R1_9, . . . T1_R1_0], departed: null, availableSeats: []}

  Failure None

- **TC_Route_17**

  Expected Output { success: false, reason: “Ticket is already boarded” }, Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T1_R1_9, . . . T1_R1_0], departed: null, availableSeats: []}, T1_R1_9{ id: “T1_R1_9”, seat: 9, boarded: true }

  Observed Output { success: false, reason: “Ticket is already boarded” }, Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T1_R1_9, . . . T1_R1_0], departed: null, availableSeats: []}, T1_R1_9{ id: “T1_R1_9”, seat: 9, boarded: true }

  Failure None

- **TC_Route_18**

  Expected Output Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [], departed: “2008-09-15T15:53:00”, availableSeats: [0, . . . , 9]}

Observed Output Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [], departed: “2008-09-15T15:53:00”, availableSeats: [0, . . . , 9]}

Failure None

- **TC_Route_19**

  Expected Output true, Route{ id: “R1”, source: “Toledo”, destination: “Madrid”, capacity: 10, tickets: [], departed: null, availableSeats: [0, . . . , 9]}

  Observed Output true, Route{ id: “R1”, source: “Toledo”, destination: “Madrid”, capacity: 10, tickets: [], departed: null, availableSeats: [0, . . . , 9]}

  Failure None

- **TC_Route_20**

  Expected Output false, Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T1_R1_9, . . . T1_R1_0], departed: null, availableSeats: []}

  Observed Output false, Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T1_R1_9, . . . T1_R1_0], departed: null, availableSeats: []}

  Failure None

- **TC_Route_21**

  Expected Output false, Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T1_R1_9, . . . T1_R1_0], departed: “2008-09-15T15:53:00”, availableSeats: []}

  Observed Output false, Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T1_R1_9, . . . T1_R1_0], departed: “2008-09-15T15:53:00”, availableSeats: []}

  Failure None

- **TC_Route_22**

  Expected Output Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T1_R1_9, . . . T1_R1_3], departed: “2008-09-15T15:53:00”, availableSeats: [0, 1, 2]}

Observed Output Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T1_R1_9, ... T1_R1_3], departed: “2008-09-15T15:53:00”, availableSeats: [0, 1, 2]}

Failure None

- **TC_Route_23**

  Expected Output Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [], departed: null, availableSeats: [0, ..., 9]}

  Observed Output Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [], departed: null, availableSeats: [0, ..., 9]}

  Failure None

- **TC_Route_24**

  Expected Output Object{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T1_R1_9, ... T1_R1_3], departed: “2008-09-15T15:53:00”, availableSeats: [0, 1, 2]}

  Observed Output Object{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T1_R1_9, ... T1_R1_3], departed: “2008-09-15T15:53:00”, availableSeats: [0, 1, 2]}

  Failure None

- **TC_Route_25**

  Expected Output Object{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T1_R1_9, ... T1_R1_3], departed: null, availableSeats: [0, 1, 2]}

  Observed Output Object{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T1_R1_9, ... T1_R1_3], departed: null, availableSeats: [0, 1, 2]}

  Failure None

4.3 Check Coverage

```
-----------------|----------|----------|----------|----------|-------------------
File             |  % Stmts | % Branch |  % Funcs |  % Lines | Uncovered Line #s
-----------------|----------|----------|----------|----------|-------------------
All files        |    36.06 |    39.22 |    35.37 |    36.24 |
 BBB.js          |        0 |        0 |        0 |        0 | ... 58,61,66,68,69
 IBBBCommand.js  |        0 |        0 |        0 |        0 | ... 78,280,285,287
 Route.js        |    98.18 |    95.92 |      100 |    98.11 |         191,200
 RouteStatus.js  |      100 |      100 |      100 |      100 |
 Ticket.js       |      100 |      100 |      100 |      100 |
-----------------|----------|----------|----------|----------|-------------------
Test Suites: 1 failed, 1 passed, 2 total
Tests:       5 failed, 27 passed, 32 total
Snapshots:   0 total
Time:        3.741s, estimated 4s
Ran all test suites.
```

Using the coverage tool we identified following lines/branches not covered (red line means the line was not executed, "I" indicates that the "if" path was never taken). The test cases covering those lines will be added in iteration 2.

```
Route.fromObject = function (object) {
    I if (!object.hasOwnProperty('id') ||
        !object.hasOwnProperty('source') ||
        !object.hasOwnProperty('destination') ||
        !object.hasOwnProperty('capacity') ||
        !object.hasOwnProperty('departed') ||
        !object.hasOwnProperty('availableSeats') ||
        !object.hasOwnProperty('tickets')) {
        throw new Error('Invalid object');
    }
    var route = new Route(object.id, object.source, object.destination, object.capacity
    if (object.departed === null) {
        route._departed = null;
    }
    else {
        route._departed = moment(object.departed);
        I if (!route._departed.isValid()) {
            throw new Error('Invalid departed time');
        }
    }
    route._availableSeats = object.availableSeats;
    for (var i in object.tickets) {
        var ticket = Ticket_1.Ticket.fromObject(object.tickets[i]);
        route._tickets.push(ticket);
    }
    return route;
};
return Route;
```

4.4 Trace failures to faults

4.4.1 TC_Route_6, TC_Route_7, TC_Route_8, TC_Route_9

Failure The output of the `status` property of the `Route` class returns an `int` value instead of a meaningful `string` value

Fault The `RouteStatus` enumeration uses `int` representation (default behavior) instead of `string` representations

```
export enum RouteStatus {
    travelling,
    empty,
    full,
    available
}
```

Fix Assign `string` values to `RouteStatus` enumeration:

```
export enum RouteStatus {
    travelling = 'travelling',
    empty = 'empty',
    full = 'full',
    available = 'available'
}
```

4.4.2 TC_Route_15

Failure When cancelling a `Ticket` the seat that is available again is not added again to the list of available seats

Fault The `cancelTicket()` method misses the necessary statements that push the seat of the cancelled `Ticket` back onto the `availableSeats` list

```
cancelTicket = (ticketId: string) => {
    const ticketIndex = this._tickets.map((t) => t.id).indexOf(ticketId)

    if (ticketIndex === -1) {
        return {
            success: false,
            reason: 'Ticket does not exist'
        }
    }

    const ticket = this._tickets[ticketIndex]

    if (ticket.boarded === true) {
        return {
            success: false,
            reason: 'Ticket is already boarded'
        }
    }

    this._tickets = this._tickets.filter((t) => t.id !== ticketId)

    return {
        success: true,
        ticket: ticket
    }
}
```

Fix Added the seat of the ticket to the list of available seats:

```
cancelTicket = (ticketId: string) => {
    const ticketIndex = this._tickets.map((t) => t.id).indexOf(ticketId)

    if (ticketIndex === -1) {
        return {
            success: false,
            reason: 'Ticket does not exist'
        }
    }

    const ticket = this._tickets[ticketIndex]

    if (ticket.boarded === true) {
        return {
            success: false,
            reason: 'Ticket is already boarded'
        }
    }

    this._tickets = this._tickets.filter((t) => t.id !== ticketId)

    const seat = ticket.seat
    this._availableSeats.push(seat)

    return {
        success: true,
        ticket: ticket
    }
}
```

5 Iteration 2

Iteration 2 first specifies the test cases that were identified missing from iteration 1. Then `IBBBCommand` and `BBB` are targeted.

5.1 Specify Test Cases

5.1.1 Class Route (Identified to be missing in last iteration)

TC_Route_26 fromObject fails on invalid object

Goal Test that the `fromObject()` method throws an error if an invalid object representation is passed

Class Route

Method fromObject

Precondition N/A

Input { id_X: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [], departed: null, availableSeats: [0, 1, 2, 3, 4, 5, 6, 7, 8, 9]}

Expected Output Error(‘Invalid object’)

Note The date set for departed is an example

TC_Route_27 fromObject fails on invalid departure time

Goal Test that the `fromObject()` method throws an error if departed is set to an invalid value

Class Route

Method fromObject

Precondition N/A

Input { id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [], departed: “4711”, availableSeats: [0, 1, 2, 3, 4, 5, 6, 7, 8, 9]}

Expected Output Error(‘Invalid departed time’)

5.1.2 Class IBBBCommand

TC_RegisterRouteCommand_1 returns correct id

Goal Test that the `commandId` of the `RegisterRouteCommand` returns the correct value

Class RegisterRouteCommand

Method commandId get

Precondition N/A

Input N/A

Expected Output ‘registerroute’

TC_RegisterRouteCommand_2 fails for invalid number of arguments

Goal Test that the `RegisterRouteCommand` displays the correct error message if an invalid number of arguments is given

Class RegisterRouteCommand

Method execute

Precondition BBB{ _routes: [] }

Input []

Expected Output BBB{ _routes: [] } Console: 'Invalid number of arguments given'

TC_RegisterRouteCommand_3 fails for invalid route

Goal Test that the `RegisterRouteCommand` displays the correct error message if an invalid value for route is given

Class RegisterRouteCommand

Method execute

Precondition BBB{ _routes: [] }

Input [" ", "Madrid", "Toledo", 10]

Expected Output BBB{ _routes: [] } Console: 'Invalid value for route given'

TC_RegisterRouteCommand_4 fails for invalid source

Goal Test that the `RegisterRouteCommand` displays the correct error message if an invalid value for source is given

Class RegisterRouteCommand

Method execute

Precondition BBB{ _routes: [] }

Input ["R1", null, "Toledo", 10]

Expected Output BBB{ _routes: [] } Console: 'Invalid value for source given'

TC_RegisterRouteCommand_5 fails for invalid destination

Goal Test that the `RegisterRouteCommand` displays the correct error message if an invalid destination is given

Class RegisterRouteCommand

Method execute

Precondition BBB{ _routes: [] }

Input ["R1", "Madrid", undefined, 10]

Expected Output BBB{ _routes: [] } Console: 'Invalid value for destination given'

TC_RegisterRouteCommand_6 fails for invalid capacity

Goal Test that the `RegisterRouteCommand` displays the correct error message if an invalid capacity is given

Class RegisterRouteCommand

Method execute

Precondition BBB{ _routes: [] }

Input [“R1”, “Madrid”, “Toledo”, “asdf”]

Expected Output BBB{ _routes: [] } Console: ‘Invalid value for capacity’

TC_RegisterRouteCommand_7 succeeds for valid input

Goal Test that the `RegisterRouteCommand` successfully registers a new `Route`

Class RegisterRouteCommand

Method execute

Precondition BBB{ _routes: [] }

Input [“R1”, “Madrid”, “Toledo”, 10”]

Expected Output BBB{ _routes: [Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [], departed: null, availableSeats: [0, . . . , 9]}]} Console: “Created route R1 from Madrid to Toledo with 10 seats”

TC_DeleteRouteCommand_1 returns correct id

Goal Test that the `commandId` of the "DeleteRouteCommand" returns the correct value

Class DeleteRouteCommand

Method commandId get

Precondition N/A

Input N/A

Expected Output ‘deleteroute’

TC_DeleteRouteCommand_2 fails for invalid number of arguments

Goal Test that the `DeleteRouteCommand` displays the correct error message if an invalid number of arguments is given

Class DeleteRouteCommand

Method execute

Precondition BBB{ _routes: [Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T_R1_9], departed: null, availableSeats: [0, . . . , 8]}]}

Input []

Expected Output BBB{ _routes: [Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T_R1_9], departed: null, availableSeats: [0, . . . , 8]}]} Console: ‘Invalid number of arguments given’

TC_DeleteRouteCommand_3 fails for invalid route

Goal Test that the `DeleteRouteCommand` displays the correct error message if an invalid value for route is given

Class DeleteRouteCommand

Method execute

Precondition BBB{ _routes: [Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T_R1_9], departed: null, availableSeats: [0, . . . , 8]}]}

Input [“ ”]

Expected Output BBB{ _routes: [Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T_R1_9], departed: null, availableSeats: [0, . . . , 8]}]} Console: ‘Invalid value for route given’

TC_DeleteRouteCommand_4 fails for route with purchased tickets

Goal Test that the `DeleteRouteCommand` does not delete a `Route` that includes already purchased `Tickets`

Class DeleteRouteCommand

Method execute

Precondition BBB{ _routes: [Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T_R1_9], departed: null, availableSeats: [0, . . . , 8]}]}

Input [“R1”]

Expected Output BBB{ _routes: [Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T_R1_9], departed: null, availableSeats: [0, . . . , 8]}]} Console: “Cannot delete route R1 because there are 1 tickets booked”

TC_DeleteRouteCommand_5 succeeds for valid input

Goal Test that the `DeleteRouteCommand` successfully deletes a `Route` that has no purchased `Tickets`

Class DeleteRouteCommand

Method execute

Precondition BBB{ _routes: [Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [], departed: null, availableSeats: [0, . . . , 9]}]}

Input [“R1”]

Expected Output BBB{ _routes: [] } Console: “Successfully deleted route R1”

TC_DepartCommand_1 returns correct id

Goal Test that the `commandId` of the "DepartCommand" returns the correct value

Class DepartCommand

Method commandId get

Precondition N/A

Input N/A

Expected Output ‘depart’

TC_DepartCommand_2 fails for invalid number of arguments

Goal Test that the `DepartCommand` displays the correct error message if an invalid number of arguments is given

Class DepartCommand

Method execute

Precondition BBB{ _routes: [Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T_R1_9], departed: null, availableSeats: [0, . . . , 8]}]}

Input []

Expected Output BBB{ _routes: [Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T_R1_9], departed: null, availableSeats: [0, . . . , 8]}]} Console: ‘Invalid number of arguments given’

TC_DepartCommand_3 fails for invalid route

Goal Test that the `DepartCommand` displays the correct error message if an invalid value for route is given

Class DepartCommand

Method execute

Precondition BBB{ _routes: [Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T_R1_9], departed: null, availableSeats: [0, . . . , 8]}]}

Input [“R_X”]

Expected Output BBB{ _routes: [Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T_R1_9], departed: null, availableSeats: [0, . . . , 8]}]} Console: ‘Invalid value for route given’

TC_DepartCommand_4 succeeds for valid route

Goal Test that the `DepartCommand` successfully sets the departure of a `Route`

Class DepartCommand

Method execute

Precondition BBB{ _routes: [Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T_R1_9], departed: null, availableSeats: [0, . . . , 8]}]}

Input [“R1”]

Expected Output BBB{ _routes: [Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T_R1_9], departed: “2008-09-15T15:53:00”, availableSeats: [0, . . . , 8]}]} Console: ‘R1 departed’

TC_StatusCommand_1 returns correct id

Goal Test that the `commandId` of the "StatusCommand" returns the correct value

Class StatusCommand

Method commandId get

Precondition N/A

Input N/A

Expected Output 'status'

TC_StatusCommand_2 fails for invalid number of arguments

Goal Test that the `StatusCommand` displays the correct error message if an invalid number of arguments is given

Class StatusCommand

Method execute

Precondition BBB{ _routes: [Route{ id: "R1", source: "Madrid", destination: "Toledo", capacity: 10, tickets: [T_R1_9], departed: null, availableSeats: [0, ... , 8]}, Route{ id: "R2", source: "Barcelona", destination: "Valencia", capacity: 10, tickets: [], departed: null, availableSeats: [0, ... , 9]}]}

Input ["A", "B"]

Expected Output BBB{ _routes: [Route{ id: "R1", source: "Madrid", destination: "Toledo", capacity: 10, tickets: [T_R1_9], departed: null, availableSeats: [0, ... , 8]}, Route{ id: "R2", source: "Barcelona", destination: "Valencia", capacity: 10, tickets: [], departed: null, availableSeats: [0, ... , 9]}]} Console: 'Invalid number of arguments given'

TC_StatusCommand_3 fails for specifying not existing route

Goal Test that the `StatusCommand` does print the correct error message when specifying a not existing `Route`

Class StatusCommand

Method execute

Precondition BBB{ _routes: [Route{ id: "R1", source: "Madrid", destination: "Toledo", capacity: 10, tickets: [T_R1_9], departed: null, availableSeats: [0, ... , 8]}, Route{ id: "R2", source: "Barcelona", destination: "Valencia", capacity: 10, tickets: [], departed: null, availableSeats: [0, ... , 9]}]}

Input ["R3"]

Expected Output BBB{ _routes: [Route{ id: "R1", source: "Madrid", destination: "Toledo", capacity: 10, tickets: [T_R1_9], departed: null, availableSeats: [0, ... , 8]}, Route{ id: "R2", source: "Barcelona", destination: "Valencia", capacity: 10, tickets: [], departed: null, availableSeats: [0, ... , 9]}]} Console: 'Route R3 does not exist'

TC_StatusCommand_4 prints status of one specified route successfully

Goal Test that the `StatusCommand` prints the correct status of a given `Route`

Class StatusCommand

Method execute

Precondition BBB{ _routes: [Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T_R1_9], departed: null, availableSeats: [0, . . . , 8]}, Route{ id: “R2”, source: “Barcelona”, destination: “Valencia”, capacity: 10, tickets: [], departed: null, availableSeats: [0, . . . , 9]}]}

Input [“R2”]

Expected Output BBB{ _routes: [Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T_R1_9], departed: null, availableSeats: [0, . . . , 8]}, Route{ id: “R2”, source: “Barcelona”, destination: “Valencia”, capacity: 10, tickets: [], departed: null, availableSeats: [0, . . . , 9]}]} Console: ‘R2: empty’

TC_StatusCommand_5 prints status without specified route successfully

Goal Test that the `StatusCommand` prints the correct status of all `Routes` if no `Route` was given

Class StatusCommand

Method execute

Precondition BBB{ _routes: [Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T_R1_9], departed: null, availableSeats: [0, . . . , 8]}, Route{ id: “R2”, source: “Barcelona”, destination: “Valencia”, capacity: 10, tickets: [], departed: null, availableSeats: [0, . . . , 9]}]}

Input []

Expected Output BBB{ _routes: [Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T_R1_9], departed: null, availableSeats: [0, . . . , 8]}, Route{ id: “R2”, source: “Barcelona”, destination: “Valencia”, capacity: 10, tickets: [], departed: null, availableSeats: [0, . . . , 9]}]} Console: “R1: available R2: empty’”

TC_BuyCommand_1 returns correct id

Goal Test that the `commandId` of the "BuyCommand" returns the correct value

Class BuyCommand

Method commandId get

Precondition N/A

Input N/A

Expected Output 'buy'

TC_BuyCommand_2 fails for not existing route

Goal Test that the `BuyCommand` does print the correct error message when specifying a not existing `Route`

Class BuyCommand

Method execute

Precondition BBB{ _routes: [Route{ id: "R1", source: "Madrid", destination: "Toledo", capacity: 10, tickets: [T_R1_9], departed: null, availableSeats: [0, ... , 8]}, Route{ id: "R2", source: "Barcelona", destination: "Valencia", capacity: 10, tickets: [], departed: null, availableSeats: [0, ... , 9]}]}

Input ["R3"]

Expected Output BBB{ _routes: [Route{ id: "R1", source: "Madrid", destination: "Toledo", capacity: 10, tickets: [T_R1_9], departed: null, availableSeats: [0, ... , 8]}, Route{ id: "R2", source: "Barcelona", destination: "Valencia", capacity: 10, tickets: [], departed: null, availableSeats: [0, ... , 9]}]} Console: 'Route R3 does not exist'

TC_BuyCommand_3 fails for sold out route

Goal Test that the `BuyCommand` does not buy a `Ticket` if the `Route` is already sold out

Class BuyCommand

Method execute

Precondition BBB{ _routes: [Route{ id: "R1", source: "Madrid", destination: "Toledo", capacity: 10, tickets: [T_R1_9, ... T_R1_0], departed: null, availableSeats: []}, Route{ id: "R2", source: "Barcelona", destination: "Valencia", capacity: 10, tickets: [], departed: null, availableSeats: [0, ... , 9]}]}

Input [“R1”]

Expected Output BBB{ _routes: [Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T_R1_9, ... T_R1_0]], departed: null, availableSeats: []}, Route{ id: “R2”, source: “Barcelona”, destination: “Valencia”, capacity: 10, tickets: [], departed: null, availableSeats: [0, ... , 9]}]} Console: ‘Sorry! You were too late! Tickets are sold out!’

TC_BuyCommand_4 succeeds for valid route

Goal Test that the `BuyCommand` successfully buys a `Ticket` if the `Route` is not sold out

Class BuyCommand

Method execute

Precondition BBB{ _routes: [Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T_R1_9], departed: null, availableSeats: [0, ... , 8]}, Route{ id: “R2”, source: “Barcelona”, destination: “Valencia”, capacity: 10, tickets: [], departed: null, availableSeats: [0, ... , 9]}]}

Input [“R1”]

Expected Output BBB{ _routes: [Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T_R1_9, T_R1_8], departed: null, availableSeats: [0, ... , 7]}, Route{ id: “R2”, source: “Barcelona”, destination: “Valencia”, capacity: 10, tickets: [], departed: null, availableSeats: [0, ... , 9]}]} Console: ‘Successfully purchased ticket T_R1_8 on route R1 from Madrid to Toledo’

TC_CheckinCommand_1 returns correct id

Goal Test that the `commandId` of the "CheckinCommand" returns the correct value

Class CheckinCommand

Method commandId get

Precondition N/A

Input N/A

Expected Output ‘checkin’

TC_CheckinCommand_2 fails for invalid number of arguments

Goal Test that the `CheckinCommand` displays the correct error message if an invalid number of arguments is given

Class CheckinCommand

Method execute

Precondition BBB{ _routes: [Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T_R1_9], departed: null, availableSeats: [0, . . . , 8]}]}, Ticket{ id: “T_R1_9”, seat: 9, boarded: false }

Input []

Expected Output BBB{ _routes: [Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T_R1_9], departed: null, availableSeats: [0, . . . , 8]}]}, Ticket{ id: “T_R1_9”, seat: 9, boarded: false } Console: “Invalid number of arguments given”

TC_CheckinCommand_3 fails for invalid value for ticket

Goal Test that the `CheckinCommand` displays the correct error message if an invalid `Ticket` is specified

Class CheckinCommand

Method execute

Precondition BBB{ _routes: [Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T_R1_9], departed: null, availableSeats: [0, . . . , 8]}]}, Ticket{ id: “T_R1_9”, seat: 9, boarded: false }

Input [“ “]

Expected Output BBB{ _routes: [Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T_R1_9], departed: null, availableSeats: [0, . . . , 8]}]}, Ticket{ id: “T_R1_9”, seat: 9, boarded: false } Console: “Invalid value for ticket given”

TC_CheckinCommand_4 fails for not existing ticket

Goal Test that the `CheckinCommand` displays the correct error message if a not existing `Ticket` is specified

Class CheckinCommand

Method execute

Precondition BBB{ _routes: [Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T_R1_9], departed: null, availableSeats: [0, . . . , 8]}]}, Ticket{ id: “T_R1_9”, seat: 9, boarded: false }

Input [“T_R1_X”]

Expected Output BBB{ _routes: [Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T_R1_9], departed: null, availableSeats: [0, . . . , 8]}]}, Ticket{ id: “T_R1_9”, seat: 9, boarded: false } Console: “Ticket with id T_R1_X does not exist”

TC_CheckinCommand_5 fails already boarded ticket

Goal Test that the `CheckinCommand` fails if a `Ticket` is specified that has already been boarded

Class CheckinCommand

Method execute

Precondition BBB{ _routes: [Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T_R1_9], departed: null, availableSeats: [0, . . . , 8]}]}, Ticket{ id: “T_R1_9”, seat: 9, boarded: true }

Input [“T_R1_9”]

Expected Output BBB{ _routes: [Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T_R1_9], departed: null, availableSeats: [0, . . . , 8]}]}, Ticket{ id: “T_R1_9”, seat: 9, boarded: true } Console: “Unable to checkin ticket T_R1_9: Ticket is already boarded”

TC_CheckinCommand_6 succeeds for valid ticket

Goal Test that the `CheckinCommand` successfully boards a `Ticket` that has not been boarded yet

Class CheckinCommand

Method execute

Precondition BBB{ _routes: [Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T_R1_9], departed: null, availableSeats: [0, . . . , 8]}]}, Ticket{ id: “T_R1_9”, seat: 9, boarded: false }

Input [“T_R1_9”]

Expected Output BBB{ _routes: [Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T_R1_9], departed: null, availableSeats: [0, . . . , 8]}]}, Ticket{ id: “T_R1_9”, seat: 9, boarded: true } Console: “Successfully checked in ticket T_R1_9 on route R1 from Madrid to Toledo and assigned seat 9”

TC_CancelCommand_1 returns correct id

Goal Test that the `commandId` of the "CancelCommand" returns the correct value

Class CancelCommand

Method commandId get

Precondition N/A

Input N/A

Expected Output ‘cancel’

TC_CancelCommand_2 fails for invalid number of arguments

Goal Test that the `CancelCommand` displays the correct error message if an invalid number of arguments is given

Class CancelCommand

Method execute

Precondition BBB{ _routes: [Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T_R1_9], departed: null, availableSeats: [0, . . . , 8]}]}, Ticket{ id: “T_R1_9”, seat: 9, boarded: false }

Input []

Expected Output BBB{ _routes: [Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T_R1_9], departed: null, availableSeats: [0, . . . , 8]}]}, Ticket{ id: “T_R1_9”, seat: 9, boarded: false } Console: “Invalid number of arguments given”

TC_CancelCommand_3 fails for invalid value for ticket

Goal Test that the `CancelCommand` displays the correct error message if an invalid `Ticket` is specified

Class CancelCommand

Method execute

Precondition BBB{ _routes: [Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T_R1_9], departed: null, availableSeats: [0, . . . , 8]}]}, Ticket{ id: “T_R1_9”, seat: 9, boarded: false }

Input [“ “]

Expected Output BBB{ _routes: [Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T_R1_9], departed: null, availableSeats: [0, . . . , 8]}]}, Ticket{ id: “T_R1_9”, seat: 9, boarded: false } Console: “Invalid value for ticket given”

TC_CancelCommand_4 fails for not existing ticket

Goal Test that the `CancelCommand` displays the correct error message if a not existing `Ticket` is specified

Class CancelCommand

Method execute

Precondition BBB{ _routes: [Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T_R1_9], departed: null, availableSeats: [0, . . . , 8]}]}, Ticket{ id: “T_R1_9”, seat: 9, boarded: false }

Input [“T_R1_X”]

Expected Output BBB{ _routes: [Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T_R1_9], departed: null, availableSeats: [0, . . . , 8]}]}, Ticket{ id: “T_R1_9”, seat: 9, boarded: false } Console: “Ticket with id T_R1_X does not exist”

TC_CancelCommand_5 fails already boarded ticket

Goal Test that the `CancelCommand` fails if the specified `Ticket` has already been boarded

Class CancelCommand

Method execute

Precondition BBB{ _routes: [Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T_R1_9], departed: null, availableSeats: [0, . . . , 8]}]}, Ticket{ id: “T_R1_9”, seat: 9, boarded: true }

Input [“T_R1_9”]

Expected Output BBB{ _routes: [Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T_R1_9], departed: null, availableSeats: [0, . . . , 8]}]}, Ticket{ id: “T_R1_9”, seat: 9, boarded: true } Console: “Unable to cancel ticket T_R1_9: Ticket is already boarded”

TC_CancelCommand_6 succeeds for valid ticket

Goal Test that the `CancelCommand` successfully cancels a `Ticket` das has not been boarded yet

Class CancelCommand

Method execute

Precondition BBB{ _routes: [Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T_R1_9], departed: null, availableSeats: [0, . . . , 8]}]}, Ticket{ id: “T_R1_9”, seat: 9, boarded: false }

Input [“T_R1_9”]

Expected Output BBB{ _routes: [Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [], departed: null, availableSeats: [0, . . . , 9]}]} Console: “Cancelled ticket T_R1_9 on route R1 from Madrid to Toledo”

5.1.3 Class BBB

TC_BBB_1 successfully writes file

Goal Test that the method `saveRoutes()` successfully creates a database file persisting the existing `Routes`

Class BBB

Method saveRoutes

Precondition routes: [{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [{id: “T_R1_9”, “seat”: 9, “boarded”: false}], departed: null, availableSeats: [0, . . . , 8]}, { id: “R2”, source: “Barcelona”, destination: “Valencia”, capacity: 10, tickets: [], departed: null, availableSeats: [0, . . . , 9]}]

Input N/A

Expected Output file: [{ “id”: “R1”, “source”: “Madrid”, “destination”: “Toledo”, “capacity”: 10, “tickets”: [{id: “T_R1_9”, “seat”: 9, “boarded”: false}], “departed”: null, “availableSeats”: [0, . . . , 8]}, { “id”: “R2”, “source”: “Barcelona”, “destination”: “Valencia”, “capacity”: 10, “tickets”: [], “departed”: null, “availableSeats”: [0, . . . , 9]}]

TC_BBB_2 successfully reads file with routes

Goal Test that the method `loadRoutes()` successfully reads and initilaizes the `Routes` from an existing database file

Class BBB

Method loadRoutes

Precondition routes: undefined file: [{ “id”: “R1”, “source”: “Madrid”, “destination”: “Toledo”, “capacity”: 10, “tickets”: [{id: “T_R1_9”, “seat”: 9, “boarded”: false)}], “departed”: null, “availableSeats”: [0, . . . , 8]}, { “id”: “R2”, “source”: “Barcelona”, “destination”: “Valencia”, “capacity”: 10, “tickets”: [], “departed”: null, “availableSeats”: [0, . . . , 9]}]

Input N/A

Expected Output routes: [{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T_R1_9], departed: null, availableSeats: [0, . . . , 8]}, { id: “R2”, source: “Barcelona”, destination: “Valencia”, capacity: 10, tickets: [], departed: null, availableSeats: [0, . . . , 9]}]

TC_BBB_3 successfully reads without routes

Goal Test that the method `loadRoutes()` successfully creates a empty list of `Routes` if a database without `Routes` is read

Class BBB

Method loadRoutes

Precondition routes: undefined file: []

Input N/A

Expected Output routes: []

TC_BBB_4 does not read not existing file

Goal Test that the method `loadRoutes()` successfully creates a empty list of `Routes` if no database file is available

Class BBB

Method loadRoutes

Precondition routes : undefined, filePath: "./test/db"

Input N/A

Expected Output routes: []

TC_BBB_5 fails for no arguments given

Goal Test that the method `parseCommand()` displays the correct error message if no arguments are given

Class BBB

Method parseCommand

Precondition N/A

Input args: []

Expected Output Console: "No argument was given"

TC_BBB_6 fails for not existing command

Goal Test that the method `parseCommand()` displays the correct error message if a not existing `Command` is specified

Class BBB

Method parseCommand

Precondition N/A

Input args: ["asdf"]

Expected Output Console: "Command asdf does not exist"

TC_BBB_7 succeeds for existing command

Goal Test that the method `parseCommand()` executes the `execute()` method of the specified `Command`

Class BBB

Method parseCommand

Precondition N/A

Input args: ["status"]

Expected Output _commands["status"].execute was called

5.2 Run Test Cases

5.2.1 Class Route

- **TC_Route_26**

  Expected Output Error('Invalid object')

  Observed Output Error('Invalid object')

  Failure None

- **TC_Route_27**

  Expected Output Error('Invalid departed time')

  Observed Output Route { id: "R1", source: "Madrid", destination: "Toledo", capacity: 10, tickets: [], departed: "4711-01-01T00:00:00.000Z", availableSeats: [0, 1, 2, 3, 4, 5, 6, 7, 8, 9]}

  Failure Yes

5.2.2 Class IBBBCommand

- **TC_RegisterRouteCommand_1**

  Expected Output 'registerroute'

  Observed Output 'registerroute'

  Failure None

- **TC_RegisterRouteCommand_2**

  Expected Output BBB{ _routes: [] }
  Console: 'Invalid number of arguments given'

  Observed Output BBB{ _routes: [] }
  Console: 'Invalid number of arguments given'

  Failure None

- **TC_RegisterRouteCommand_3**

  Input [" ", "Madrid", "Toledo", 10]

  Expected Output BBB{ _routes: [] }
  Console: 'Invalid value for route given'

  Observed Output BBB{ _routes: [] }
  Console: 'Invalid value for route given'

Failure None

- **TC_RegisterRouteCommand_4**

  Expected Output Console: 'Invalid value for source given'

  Observed Output TypeError('Cannot read property 'trim' of null')

  Failure Yes

- **TC_RegisterRouteCommand_5**

  Expected Output Console: 'Invalid value for destination given'

  Observed Output TypeError('Cannot read property 'trim' of undefined')

  Failure Yes

- **TC_RegisterRouteCommand_6**

  Expected Output Console: 'Invalid value for capacity'

  Observed Output RangeError(Invalid array length)

  Failure Yes

- **TC_RegisterRouteCommand_7**

  Expected Output BBB{ _routes: [Route{ id: "R1", source: "Madrid", destination: "Toledo", capacity: 10, tickets: [], departed: null, availableSeats: [0, ... , 9]}]}
  Console: "Created route R1 from Madrid to Toledo with 10 seats"

  Observed Output BBB{ _routes: [Route{ id: "R1", source: "Madrid", destination: "Toledo", capacity: 10, tickets: [], departed: null, availableSeats: [0, ... , 9]}]}
  Console: "Created route R1 from Madrid to Toledo with 10 seats"

  Failure None

- **TC_DeleteRouteCommand_1**

  Expected Output 'deleteroute'

  Observed Output 'deleteroute'

  Failure None

- **TC_DeleteRouteCommand_2**

Expected Output BBB{ _routes: [Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T_R1_9], departed: null, availableSeats: [0, . . . , 8]}]}
Console: ‘Invalid number of arguments given’

Observed Output BBB{ _routes: [Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T_R1_9], departed: null, availableSeats: [0, . . . , 8]}]}
Console: ‘Invalid number of arguments given’

Failure None

- **TC_DeleteRouteCommand_3**

Expected Output BBB{ _routes: [Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T_R1_9], departed: null, availableSeats: [0, . . . , 8]}]}
Console: ‘Invalid value for route given’

Observed Output BBB{ _routes: [Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T_R1_9], departed: null, availableSeats: [0, . . . , 8]}]}
Console: ‘Invalid value for route given’

Failure None

- **TC_DeleteRouteCommand_4**

Expected Output BBB{ _routes: [Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T_R1_9], departed: null, availableSeats: [0, . . . , 8]}]}
Console: “Cannot delete route R1 because there are 1 tickets booked”

Observed Output BBB{ _routes: [Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T_R1_9], departed: null, availableSeats: [0, . . . , 8]}]}
Console: “Cannot delete route R1 because there are 1 tickets booked”

Failure None

- **TC_DeleteRouteCommand_5**

Expected Output BBB{ _routes: [] }
Console: “Successfully deleted route R1”

Observed Output BBB{ _routes: [] }
Console: “Successfully deleted route R1”

Failure None

- **TC_DepartCommand_1**

  Expected Output ‘depart’

  Observed Output ‘depart’

  Failure None

- **TC_DepartCommand_2**

  Expected Output BBB{ _routes: [Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T_R1_9], departed: null, availableSeats: [0, . . . , 8]}]}
  Console: ‘Invalid number of arguments given’

  Observed Output BBB{ _routes: [Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T_R1_9], departed: null, availableSeats: [0, . . . , 8]}]}
  Console: ‘Invalid number of arguments given’

  Failure None

- **TC_DepartCommand_3**

  Expected Output Console: ‘Invalid value for route given’

  Observed Output Console: ‘Route R_X does not exist’

  Failure Yes

- **TC_DepartCommand_4**

  Expected Output BBB{ _routes: [Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T_R1_9], departed: “2008-09-15T15:53:00”, availableSeats: [0, . . . , 8]}]}
  Console: ‘R1 departed’

  Observed Output BBB{ _routes: [Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T_R1_9], departed: “2008-09-15T15:53:00”, availableSeats: [0, . . . , 8]}]}
  Console: ‘R1 departed’

  Failure None

- **TC_StatusCommand_1**

Expected Output 'status'

Observed Output 'status'

Failure None

- **TC_StatusCommand_2**

  Expected Output BBB{ _routes: [Route{ id: "R1", source: "Madrid", destination: "Toledo", capacity: 10, tickets: [T_R1_9], departed: null, availableSeats: [0, ... , 8]}, Route{ id: "R2", source: "Barcelona", destination: "Valencia", capacity: 10, tickets: [], departed: null, availableSeats: [0, ... , 9]}]}
  Console: 'Invalid number of arguments given'

  Observed Output BBB{ _routes: [Route{ id: "R1", source: "Madrid", destination: "Toledo", capacity: 10, tickets: [T_R1_9], departed: null, availableSeats: [0, ... , 8]}, Route{ id: "R2", source: "Barcelona", destination: "Valencia", capacity: 10, tickets: [], departed: null, availableSeats: [0, ... , 9]}]}
  Console: 'Invalid number of arguments given'

  Failure None

- **TC_StatusCommand_3**

  Expected Output BBB{ _routes: [Route{ id: "R1", source: "Madrid", destination: "Toledo", capacity: 10, tickets: [T_R1_9], departed: null, availableSeats: [0, ... , 8]}, Route{ id: "R2", source: "Barcelona", destination: "Valencia", capacity: 10, tickets: [], departed: null, availableSeats: [0, ... , 9]}]}
  Console: 'Route R3 does not exist'

  Observed Output BBB{ _routes: [Route{ id: "R1", source: "Madrid", destination: "Toledo", capacity: 10, tickets: [T_R1_9], departed: null, availableSeats: [0, ... , 8]}, Route{ id: "R2", source: "Barcelona", destination: "Valencia", capacity: 10, tickets: [], departed: null, availableSeats: [0, ... , 9]}]}
  Console: 'Route R3 does not exist'

  Failure None

- **TC_StatusCommand_4**

  Expected Output BBB{ _routes: [Route{ id: "R1", source: "Madrid", destination: "Toledo", capacity: 10, tickets: [T_R1_9], departed:

null, availableSeats: [0, . . . , 8]}, Route{ id: “R2”, source: “Barcelona”, destination: “Valencia”, capacity: 10, tickets: [], departed: null, availableSeats: [0, . . . , 9]}]}
Console: ‘R2: empty’

Observed Output BBB{ _routes: [Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T_R1_9], departed: null, availableSeats: [0, . . . , 8]}, Route{ id: “R2”, source: “Barcelona”, destination: “Valencia”, capacity: 10, tickets: [], departed: null, availableSeats: [0, . . . , 9]}]}
Console: ‘R2: empty’

Failure None

- **TC_StatusCommand_5**

  Expected Output BBB{ _routes: [Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T_R1_9], departed: null, availableSeats: [0, . . . , 8]}, Route{ id: “R2”, source: “Barcelona”, destination: “Valencia”, capacity: 10, tickets: [], departed: null, availableSeats: [0, . . . , 9]}]}
  Console: “R1: available R2: empty’”

  Observed Output BBB{ _routes: [Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T_R1_9], departed: null, availableSeats: [0, . . . , 8]}, Route{ id: “R2”, source: “Barcelona”, destination: “Valencia”, capacity: 10, tickets: [], departed: null, availableSeats: [0, . . . , 9]}]}
  Console: “R1: available R2: empty’”

  Failure None

- **TC_BuyCommand_1**

  Expected Output ‘buy’

  Observed Output ‘buy’

  Failure None

- **TC_BuyCommand_2**

  Expected Output BBB{ _routes: [Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T_R1_9], departed: null, availableSeats: [0, . . . , 8]}, Route{ id: “R2”, source: “Barcelona”, destination: “Valencia”, capacity: 10, tickets: [], departed: null,

availableSeats: [0, . . . , 9]}]}
Console: 'Route R3 does not exist'

Observed Output BBB{ _routes: [Route{ id: "R1", source: "Madrid", destination: "Toledo", capacity: 10, tickets: [T_R1_9], departed: null, availableSeats: [0, . . . , 8]}, Route{ id: "R2", source: "Barcelona", destination: "Valencia", capacity: 10, tickets: [], departed: null, availableSeats: [0, . . . , 9]}]}
Console: 'Route R3 does not exist'

Failure None

- **TC_BuyCommand_3**

  Expected Output Console: 'Sorry! You were too late! Tickets are sold out!'

  Observed Output TypeError(Cannot read property 'id' of undefined)

  Failure Yes

- **TC_BuyCommand_4**

  Expected Output BBB{ _routes: [Route{ id: "R1", source: "Madrid", destination: "Toledo", capacity: 10, tickets: [T_R1_9, T_R1_8], departed: null, availableSeats: [0, . . . , 7]}, Route{ id: "R2", source: "Barcelona", destination: "Valencia", capacity: 10, tickets: [], departed: null, availableSeats: [0, . . . , 9]}]}
  Console: 'Successfully purchased ticket T_R1_8 on route R1 from Madrid to Toledo'

  Observed Output BBB{ _routes: [Route{ id: "R1", source: "Madrid", destination: "Toledo", capacity: 10, tickets: [T_R1_9, T_R1_8], departed: null, availableSeats: [0, . . . , 7]}, Route{ id: "R2", source: "Barcelona", destination: "Valencia", capacity: 10, tickets: [], departed: null, availableSeats: [0, . . . , 9]}]}
  Console: 'Successfully purchased ticket T_R1_8 on route R1 from Madrid to Toledo'

  Failure None

- **TC_CheckinCommand_1**

  Expected Output 'checkin'

  Observed Output 'checkin'

  Failure None

- **TC_CheckinCommand_2**

  Expected Output Console: “Invalid number of arguments given”

  Observed Output Console: “Invalid number of arguments given” “Ticket with id null does not exist”

  Failure Yes

- **TC_CheckinCommand_3**

  Expected Output Console: “Invalid value for ticket given”

  Observed Output Console: “Invalid value for ticket given” “Ticket with id null does not exist”

  Failure Yes

- **TC_CheckinCommand_4**

  Expected Output BBB{ _routes: [Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T_R1_9], departed: null, availableSeats: [0, . . . , 8]}]}, Ticket{ id: “T_R1_9”, seat: 9, boarded: false }
  Console: “Ticket with id T_R1_X does not exist”

  Observed Output BBB{ _routes: [Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T_R1_9], departed: null, availableSeats: [0, . . . , 8]}]}, Ticket{ id: “T_R1_9”, seat: 9, boarded: false }
  Console: “Ticket with id T_R1_X does not exist”

  Failure None

- **TC_CheckinCommand_5**

  Expected Output Console: “Unable to checkin ticket T_R1_9: Ticket is already boarded”

  Observed Output TypeError(Cannot read property ‘seat’ of undefined)

  Failure Yes

- **TC_CheckinCommand_6**

  Expected Output BBB{ _routes: [Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T_R1_9], departed: null, availableSeats: [0, . . . , 8]}]}, Ticket{ id: “T_R1_9”, seat:

9, boarded: true }
Console: “Successfully checked in ticket T_R1_9 on route R1 from Madrid to Toledo and assigned seat 9”

Observed Output BBB{ _routes: [Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T_R1_9], departed: null, availableSeats: [0, . . . , 8]}]}, Ticket{ id: “T_R1_9”, seat: 9, boarded: true }
Console: “Successfully checked in ticket T_R1_9 on route R1 from Madrid to Toledo and assigned seat 9”

Failure None

- **TC_CancelCommand_1**

  Expected Output ‘cancel’

  Observed Output ‘cancel’

  Failure None

- **TC_CancelCommand_2**

  Expected Output Console: “Invalid number of arguments given”

  Observed Output Console: “Invalid number of arguments given”
  Console: “Ticket with id null does not exist”

  Failure Yes

- **TC_CancelCommand_3**

  Expected Output Console: “Invalid value for ticket given”

  Observed Output Console: “Invalid value for ticket given”
  Console: “Ticket with id null does not exist”

  Failure Yes

- **TC_CancelCommand_4**

  Expected Output BBB{ _routes: [Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T_R1_9], departed: null, availableSeats: [0, . . . , 8]}]}, Ticket{ id: “T_R1_9”, seat: 9, boarded: false }
  Console: “Ticket with id T_R1_X does not exist”

Observed Output BBB{ _routes: [Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T_R1_9], departed: null, availableSeats: [0, . . . , 8]}]}, Ticket{ id: “T_R1_9”, seat: 9, boarded: false }
Console: “Ticket with id T_R1_X does not exist”

Failure None

- **TC_CancelCommand_5**

  Expected Output Console: “Unable to cancel ticket T_R1_9: Ticket is already boarded”

  Observed Output Console: “Unable to cancel ticket T_R1_9: Ticket is already boarded”
  Console: “Cancelled ticket T_R1_9 on route R1 from Madrid to Toledo”

  Failure Yes

- **TC_CancelCommand_6**

  Expected Output BBB{ _routes: [Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [], departed: null, availableSeats: [0, . . . , 9]}]}
  Console: “Cancelled ticket T_R1_9 on route R1 from Madrid to Toledo”

  Observed Output BBB{ _routes: [Route{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [], departed: null, availableSeats: [0, . . . , 9]}]}
  Console: “Cancelled ticket T_R1_9 on route R1 from Madrid to Toledo”

  Failure None

5.2.3 Class BBB

TC_BBB_1 successfully writes file

Expected Output file: [{ “id”: “R1”, “source”: “Madrid”, “destination”: “Toledo”, “capacity”: 10, “tickets”: [{id: “T_R1_9”, “seat”: 9, “boarded”: false}], “departed”: null, “availableSeats”: [0, . . . , 8]}, { “id”: “R2”, “source”: “Barcelona”, “destination”: “Valencia”, “capacity”: 10, “tickets”: [], “departed”: null, “availableSeats”: [0, . . . , 9]}]

Observed Output file: [{ “id”: “R1”, “source”: “Madrid”, “destination”: “Toledo”, “capacity”: 10, “tickets”: [{id: “T_R1_9”, “seat”: 9, “boarded”: false}], “departed”: null, “availableSeats”: [0, . . . , 8]}, { “id”: “R2”, “source”: “Barcelona”, “destination”: “Valencia”, “capacity”: 10, “tickets”: [], “departed”: null, “availableSeats”: [0, . . . , 9]}]

Failure None

TC_BBB_2 successfully reads file with routes

Expected Output routes: [{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T_R1_9], departed: null, availableSeats: [0, . . . , 8]}, { id: “R2”, source: “Barcelona”, destination: “Valencia”, capacity: 10, tickets: [], departed: null, availableSeats: [0, . . . , 9]}]

Observed Output routes: [{ id: “R1”, source: “Madrid”, destination: “Toledo”, capacity: 10, tickets: [T_R1_9], departed: null, availableSeats: [0, . . . , 8]}, { id: “R2”, source: “Barcelona”, destination: “Valencia”, capacity: 10, tickets: [], departed: null, availableSeats: [0, . . . , 9]}]

Failure None

TC_BBB_3 successfully reads without routes

Expected Output routes: []

Observed Output routes: []

Failure None

TC_BBB_4 does not read not existing file

Expected Output routes: []

Observed Output routes: []

Failure None

TC_BBB_5 fails for no arguments given

Expected Output Console: “No argument was given”

Observed Output Console: “No argument was given”

Failure None

TC_BBB_6 fails for not existing command

Expected Output Console: “Command asdf does not exist”

Observed Output Console: “Command asdf does not exist”

Failure None

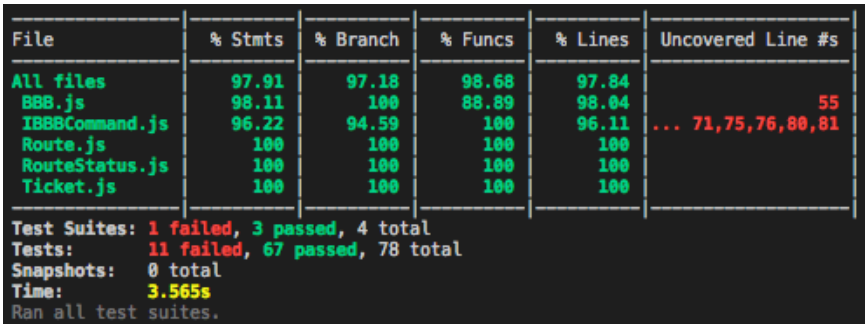
TC_BBB_7 succeeds for existing command

Expected Output _commands[“status”].execute was called

Observed Output _commands[“status”].execute was called

Failure None

5.3 Check Coverage



File	% Stmts	% Branch	% Funcs	% Lines	Uncovered Line #s
All files	97.91	97.18	98.68	97.84	
BBB.js	98.11	100	88.89	98.04	55
IBBBCommand.js	96.22	94.59	100	96.11	... 71,75,76,80,81
Route.js	100	100	100	100	
RouteStatus.js	100	100	100	100	
Ticket.js	100	100	100	100	

```
Test Suites: 1 failed, 3 passed, 4 total
Tests:       11 failed, 67 passed, 78 total
Snapshots:   0 total
Time:        3.565s
Ran all test suites.
```

Using the coverage tools we checked the lines/branches that are not covered.

```
var BBBCommandBase = /** @class */ (function () {
    function BBBCommandBase(bbb) {
        var _this = this;
        this.getRouteFromArgs = function (args) {
            if (args.length !== 1) {
                console.log('Invalid number of arguments given');
                return null;
            }
            var routeId = args[0].trim();
            if (!routeId || routeId.length === 0) {
                console.log('Invalid value for route given');
                return null;
            }
            var routeIndex = _this._bbb.routes.map(function (r) { return r.id; }).indexOf(routeId);
            if (routeIndex === -1) {
                console.log("Route " + routeId + " does not exist");
                return null;
            }
            return _this._bbb.routes[routeIndex];
        };
        this.getTicketIdFromArgs = function (args) {
            if (args.length !== 1) {
                console.log('Invalid number of arguments given');
                return null;
            }
            var ticketId = args[0].trim();
            if (!ticketId || ticketId.length === 0) {
                console.log('Invalid value for ticket given');
                return null;
            }
            return ticketId;
        };
        this.getRouteFromTicketId = function (ticketId) {
            var routes = _this._bbb.routes.filter(function (route) { return route.tickets.map(function (t
            if (routes.length === 0) {
                console.log("Ticket with id " + ticketId + " does not exist");
                return null;
            }
            return routes[0];
        };
        if (bbb === null) {
            throw new Error('Invalid bbb');
        }
        this._bbb = bbb;
    }
    return BBBCommandBase;
}());
```

For the constructor a test case is missing that tests if the initialization fails if an invalid `BBB` instance is passed.

```
exports.BBBCommandBase = BBBCommandBase;
var RegisterRouteCommand = /** @class */ (function (_super) {
    tslib_2.__extends(RegisterRouteCommand, _super);
    function RegisterRouteCommand(bbb) {
        var _this = _super.call(this, bbb) || this;
        _this.execute = function (args) {
            if (args.length !== 4) {
                console.log('Invalid number of arguments given');
                return;
            }
            var routeId = args[0].trim();
            if (!routeId || routeId.length === 0) {
                console.log('Invalid value for route given');
                return;
            }
            var source = args[1].trim();
            I if (!source || source.length === 0) {
                console.log('Invalid value for source given');
                return;
            }
            var destination = args[2].trim();
            I if (!destination || destination.length === 0) {
                console.log('Invalid value for destination given');
                return;
            }
            var capacity = Number(args[3]);
            I if (capacity === NaN || capacity < 1) {
                console.log('Invalid value for capacity given');
                return;
            }
            var route = new Route_1.Route(routeId, source, destination, capacity);
            _this._bbb.routes.push(route);
            console.log("Created route " + routeId + " from " + source + " to " + d
        };
        return _this;
    }
```

For the `RegisterRouteCommand` the not covered lines are a result from the failing test cases. The first two if's are not covered because an exception is thrown in TC_RegisterRouteCommand_4 and TC_RegisterRouteCommand_5 on calling trim() on a null value. Therefore the test fails before going to the if. The third if is never true because of the failure detected in TC_RegisterRouteCommand_6. A comparison using === and "NaN" is always false and therefore the if branch is never taken. Thus it is not necessary to introduce additional test cases after fixing those three test cases.

```
    Object.defineProperty(BBB.prototype, "routes", {
        get: function () {
            return this._routes;
        },
        set: function (newRoutes) {
            this._routes = newRoutes;
        },
        enumerable: true,
        configurable: true
    });
    return BBB;
}());
```

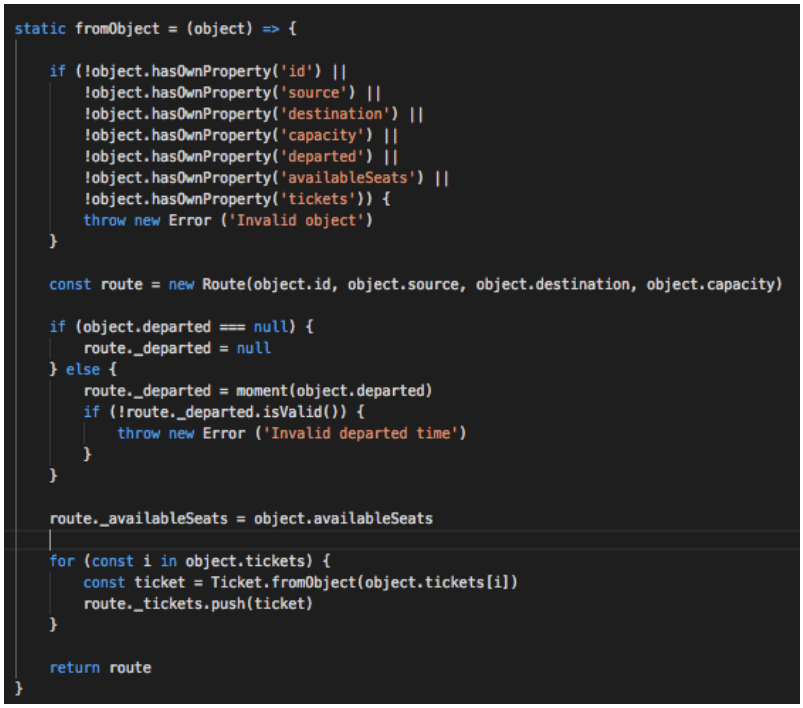
In the class `BBB` the setter for setting the routes is never called. Therefore, an additional test for the setter has to be created.

5.4 Trace failures to faults

5.4.1 TC_Route_27

Failure Instead of throwing an error because of the invalid value for departed a new `Route` instance is created

Fault Departed is not parsed enforcing ISO_8601 date format



```
static fromObject = (object) => {

    if (!object.hasOwnProperty('id') ||
        !object.hasOwnProperty('source') ||
        !object.hasOwnProperty('destination') ||
        !object.hasOwnProperty('capacity') ||
        !object.hasOwnProperty('departed') ||
        !object.hasOwnProperty('availableSeats') ||
        !object.hasOwnProperty('tickets')) {
        throw new Error ('Invalid object')
    }

    const route = new Route(object.id, object.source, object.destination, object.capacity)

    if (object.departed === null) {
        route._departed = null
    } else {
        route._departed = moment(object.departed)
        if (!route._departed.isValid()) {
            throw new Error ('Invalid departed time')
        }
    }

    route._availableSeats = object.availableSeats

    for (const i in object.tickets) {
        const ticket = Ticket.fromObject(object.tickets[i])
        route._tickets.push(ticket)
    }

    return route
}
```

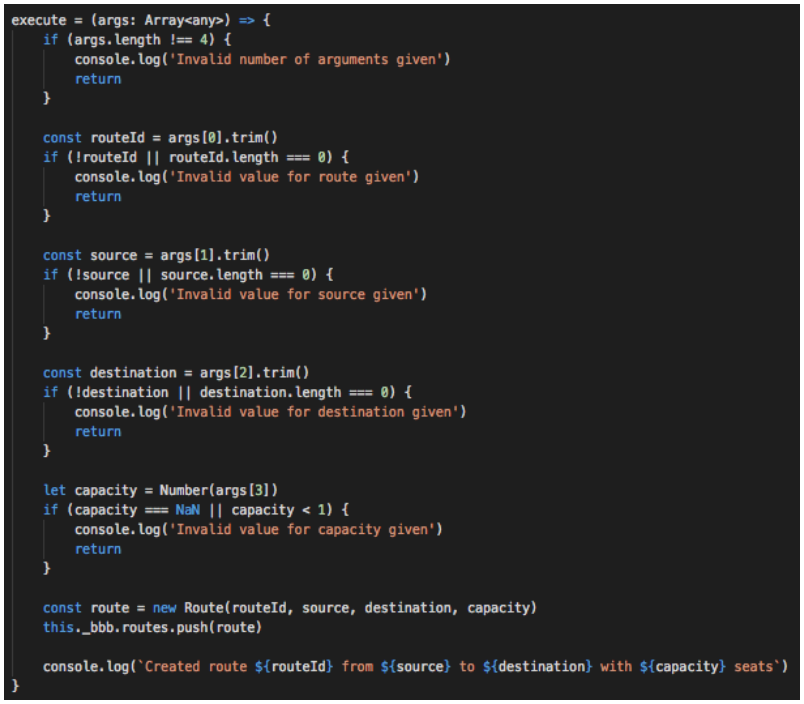
Fix Ensure that the parsing is done enfocring ISO_8601 date format by specifying the format in the constructor

```
static fromObject = (object) => {

    if (!object.hasOwnProperty('id') ||
        !object.hasOwnProperty('source') ||
        !object.hasOwnProperty('destination') ||
        !object.hasOwnProperty('capacity') ||
        !object.hasOwnProperty('departed') ||
        !object.hasOwnProperty('availableSeats') ||
        !object.hasOwnProperty('tickets')) {
        throw new Error ('Invalid object')
    }

    const route = new Route(object.id, object.source, object.destination, object.capacity)

    if (object.departed === null) {
        route._departed = null
    } else {
        if (!moment(object.departed, moment.ISO_8601, true).isValid()) {
            throw new Error ('Invalid departed time')
        }
        route._departed = moment(object.departed, moment.ISO_8601, true)
    }

    route._availableSeats = object.availableSeats

    for (const i in object.tickets) {
        const ticket = Ticket.fromObject(object.tickets[i])
        route._tickets.push(ticket)
    }

    return route
}
```

5.4.2 TC_RegisterRouteCommand_4

Failure Instead of showing a meaningful error message a `TypeError` is thrown

Fault The method `trim()` is called on the first argument `args[0]` which is `null`



```
execute = (args: Array<any>) => {
    if (args.length !== 4) {
        console.log('Invalid number of arguments given')
        return
    }

    const routeId = args[0].trim()
    if (!routeId || routeId.length === 0) {
        console.log('Invalid value for route given')
        return
    }

    const source = args[1].trim()
    if (!source || source.length === 0) {
        console.log('Invalid value for source given')
        return
    }

    const destination = args[2].trim()
    if (!destination || destination.length === 0) {
        console.log('Invalid value for destination given')
        return
    }

    let capacity = Number(args[3])
    if (capacity === NaN || capacity < 1) {
        console.log('Invalid value for capacity given')
        return
    }

    const route = new Route(routeId, source, destination, capacity)
    this._bbb.routes.push(route)

    console.log(`Created route ${routeId} from ${source} to ${destination} with ${capacity} seats`)
}
```

Fix Ensure that `args[1]` is not null before using the `trim()` method

```
execute = (args: Array<any>) => {
    if (args.length !== 4) {
        console.log('Invalid number of arguments given')
        return
    }

    if (!args[0] || args[0].trim().length === 0) {
        console.log('Invalid value for route given')
        return
    }
    const routeId = args[0].trim()

    if (!args[1] || args[1].trim().length === 0) {
        console.log('Invalid value for source given')
        return
    }
    const source = args[1].trim()

    if (!args[2] || args[2].trim().length === 0) {
        console.log('Invalid value for destination given')
        return
    }
    const destination = args[2].trim()

    let capacity = Number(args[3])
    if (isNaN(capacity) || capacity < 1) {
        console.log('Invalid value for capacity given')
        return
    }

    const route = new Route(routeId, source, destination, capacity)
    this._bbb.routes.push(route)

    console.log(`Created route ${routeId} from ${source} to ${destination} with ${capacity} seats`)
}
```

5.4.3 TC_RegisterRouteCommand_5

The same failure and fault as in TC_RegisterRouteCommand_4 but with second argument `args[2]`. Is fixed the same way as TC_RegisterRouteCommand_4 and already shown in the previous screenshotss.

5.4.4 TC_RegisterRouteCommand_6

Failure Instead of showing a meaninigful error message a `RangeError` is thrown in the constructor of the `Route`

Fault The check if an invalid capacity has been given is done using the condition `capacity === NaN` but performing a `===` check on `NaN` always yields false

Fix Use the method `isNaN()` for checking for an invalid capacity (the fault and fix are also shown in the screenshots from TC_RegisterRouteCommand_4)

5.4.5 TC_DepartCommand_3

Failure Message "Invalid value for route given" is shown instead of the message "Route R_X does not exist"

Fault Actually, the observed output is correct and it is the test case that was specified wrongly

Fix Update the test case so that the expected output is a console message "Route R_X does not exist" and the title states "fails for not existing route"

5.4.6 TC_BuyCommand_3

Failure Instead of showing an error message saying the tickets are sold out a `TypeError` is thrown because it is tried to access the property `id` of undefined

Fault After checking if the purchase of a `Ticket` was unsuccessful a return statement is missing

```
execute = (args: Array<any>) => {

    const route = this.getRouteFromArgs(args)
    if (route === null) {
        return
    }

    const result = route.purchaseTicket()

    if (!result.success) {
        console.log('Sorry! You were too late! Tickets are sold out!')
    }

    const ticket = result.ticket

    console.log(`Successfully purchased ticket ${ticket.id} on route ${route.id} from ${route.source} to ${route.destination}`)
    return
}
```

Fix Add the return statement in the case of an unsuccessful purchase attempt

```
execute = (args: Array<any>) => {

    const route = this.getRouteFromArgs(args)
    if (route === null) {
        return
    }

    const result = route.purchaseTicket()

    if (!result.success) {
        console.log('Sorry! You were too late! Tickets are sold out!')
        return
    }

    const ticket = result.ticket

    console.log(`Successfully purchased ticket ${ticket.id} on route ${route.id} from ${route.source} to ${route.destination}`)
    return
}
```

5.4.7 TC_CheckinCommand_2

Failure In addition to the "Invalid number of arguments given" error message "Ticket with id null does exist" is shown

Fault After parsing the `ticketId` from the arguments it is not checked whether the "ticketId" is null in order to return

```
execute = (args: Array<any>) => {

    const ticketId = this.getTicketIdFromArgs(args)
    const route = this.getRouteFromTicketId(ticketId)
    if (route == null) {
        return
    }

    const result = route.boardTicket(ticketId)

    if (!result.success) {
        console.log(`Unable to checkin ticket ${ticketId}: ${result.reason}`)
    }

    const ticket = result.ticket

    console.log(`Successfully checked in ticket ${ticketId} on route ${route.id} from ${route.source} to ${route.destination} and
    assigned seat ${ticket.seat}`)
    return
}
```

Fix Added the missing `null` check and return statement before proceeding with finding the `Route` with the `ticketId`

5.4.8 TC_CheckinCommand_3

The same failure and fault as in TC_CheckinCommand_2. Is fixed the same way.

5.4.9 TC_CheckinCommand_5

Failure Instead of showing the expected error message saying that the ticket is already boarded a `TypeError` is thrown

Fault After checking if the checkin of the `Ticket` was unsuccessful a return statement is missing

```
execute = (args: Array<any>) => {

    const ticketId = this.getTicketIdFromArgs(args)
    const route = this.getRouteFromTicketId(ticketId)
    if (route == null) {
        return
    }

    const result = route.boardTicket(ticketId)

    if (!result.success) {
        console.log(`Unable to checkin ticket ${ticketId}: ${result.reason}`)
    }

    const ticket = result.ticket

    console.log(`Successfully checked in ticket ${ticketId} on route ${route.id} from ${route.source} to ${route.destination} and
    assigned seat ${ticket.seat}`)
    return
}
```

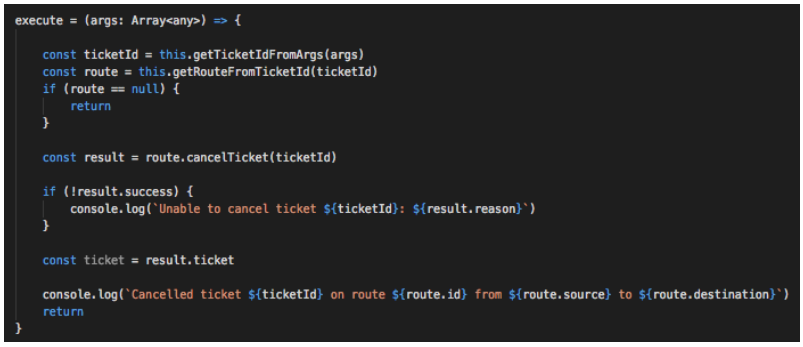
Fix Added the return statement in the cases of an unsuccessful checkin attempt

```
execute = (args: Array<any>) => {

    const ticketId = this.getTicketIdFromArgs(args)
    if (ticketId === null) {
        return
    }

    const route = this.getRouteFromTicketId(ticketId)
    if (route === null) {
        return
    }

    const result = route.boardTicket(ticketId)

    if (!result.success) {
        console.log(`Unable to checkin ticket ${ticketId}: ${result.reason}`)
        return
    }

    const ticket = result.ticket

    console.log(`Successfully checked in ticket ${ticketId} on route ${route.id} from ${route.source} to ${route.destination} and
    assigned seat ${ticket.seat}`)
    return
}
```

5.4.10 TC_CancelCommand_2

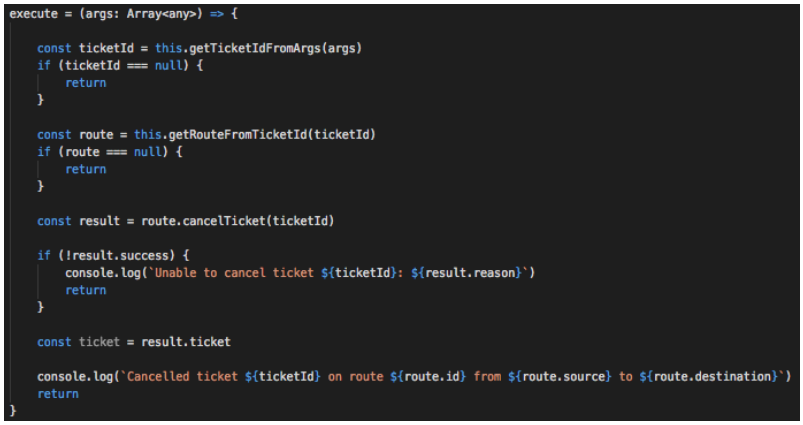
Failure In addition to the expected "Invalid number of arguments given" error message the message "Ticket with id null does not exist" is shown

Fault After parsing the `ticketId` from the arguments it is not checked whether the "ticketId" is null in order to return



```
execute = (args: Array<any>) => {

    const ticketId = this.getTicketIdFromArgs(args)
    const route = this.getRouteFromTicketId(ticketId)
    if (route == null) {
        return
    }

    const result = route.cancelTicket(ticketId)

    if (!result.success) {
        console.log(`Unable to cancel ticket ${ticketId}: ${result.reason}`)
    }

    const ticket = result.ticket

    console.log(`Cancelled ticket ${ticketId} on route ${route.id} from ${route.source} to ${route.destination}`)
    return
}
```

Fix Added the missing `null` check and return statement before proceeding with finding the `Route` with the `ticketId`



```
execute = (args: Array<any>) => {

    const ticketId = this.getTicketIdFromArgs(args)
    if (ticketId === null) {
        return
    }

    const route = this.getRouteFromTicketId(ticketId)
    if (route === null) {
        return
    }

    const result = route.cancelTicket(ticketId)

    if (!result.success) {
        console.log(`Unable to cancel ticket ${ticketId}: ${result.reason}`)
        return
    }

    const ticket = result.ticket

    console.log(`Cancelled ticket ${ticketId} on route ${route.id} from ${route.source} to ${route.destination}`)
    return
}
```

5.4.11 TC_CancelCommand_3

The same failure and fault as in TC_CancelCommand_2. Is fixed the same way and already shown in the previous screenshots from TC_CancelCommand_2.

5.4.12 TC_CancelCommand_5

Failure After showing the expected unable to cancel ticket message the message for successfully canceled the ticket is shown

Fault After checking if the cancelation of the `Ticket` was unsuccessful a return statement is missing (the fault is already shown in the screenshot from TC_CancelCommand_2)

Fix Added the return statement in the cases of an unsuccessful cancel attempt (the fix is already shown in the screenshot from TC_CancelCommand_2)

6 Iteration 3

Iteration 3 does not target a new component and only adds test cases that are missing to get full coverage.

6.1 Specify Test Cases

6.1.1 Class IBBBCommand

TC_CancelCommand_7 fails when initialized with invalid bbb

Goal Test that the constructor of an `IBBBCommand` fails when initialized with an invalid `BBB`

Class CancelCommand

Method constructor

Precondition N/A

Input null

Expected Output Error("Invalid bbb")

6.1.2 BBB Class

TC_BBB_8 set routes

Goals Test that the property `routes` can be set correctly

Class BBB

Method set route

Precondition routes: [{ id: "R1", source: "Madrid", destination: "Toledo", capacity: 10, tickets: [{id: "T_R1_9", "seat": 9, "boarded": false}], departed: null, availableSeats: [0, ... , 8]}, { id: "R2", source: "Barcelona", destination: "Valencia", capacity: 10, tickets: [], departed: null, availableSeats: [0, ... , 9]}]

Input routes: [{ id: "R1", source: "Berlin", destination: "Toledo", capacity: 11, tickets: [], departed: null, availableSeats: [0, ... , 9]}]

Expected Output routes: [{ id: "R1", source: "Berlin", destination: "Toledo", capacity: 11, tickets: [], departed: null, availableSeats: [0, ... , 9]}]

6.2 Run Test Cases

6.2.1 Class IBBBCommand

TC_CancelCommand_7 fails when initialized with invalid bbb

Expected Output Error("Invalid bbb")

Observed Output Error("Invalid bbb")

Failure None

6.2.2 Class BBB

TC_BBB_8 set routes

Expected Output routes: [{ id: "R1", source: "Berlin", destination: "Toledo", capacity: 11, tickets: [], departed: null, availableSeats: [0, ... , 9]}]

Observed Output routes: [{ id: "R1", source: "Berlin", destination: "Toledo", capacity: 11, tickets: [], departed: null, availableSeats: [0, ... , 9]}]

Failure None

6.3 Check Coverage

```
----------------|----------|----------|----------|----------|-------------------|
File            |  % Stmts | % Branch |  % Funcs |  % Lines | Uncovered Line #s |
----------------|----------|----------|----------|----------|-------------------|
All files       |      100 |      100 |      100 |      100 |                   |
 BBB.js         |      100 |      100 |      100 |      100 |                   |
 IBBBCommand.js |      100 |      100 |      100 |      100 |                   |
 Route.js       |      100 |      100 |      100 |      100 |                   |
 RouteStatus.js |      100 |      100 |      100 |      100 |                   |
 Ticket.js      |      100 |      100 |      100 |      100 |                   |
----------------|----------|----------|----------|----------|-------------------|

Test Suites: 4 passed, 4 total
Tests:       80 passed, 80 total
Snapshots:   0 total
Time:        1.89s
Ran all test suites.
```

We reached 100% branch coverage for all files without any tests failing. Therefore the white box assignment is completed. Since we used a unit test approach, we tested each component of the application individually and isolated. Even though we reached the full branch coverage which was the aim of this assignment, we would usually also implement integration tests to ensure that the application works correctly when all components are used jointly.