Contents

This document includes a run-through on our program using two command-line settings. It will include our input and what the program outputs.

Appendix includes a list of functions this program implements and the position of their descriptions in this document. If you want a quick guide to where each of these are, you can go to the Appendix for a quick guideline.

1 Command-line Interface

The executable is named as "constructor", and it could follow by the following commands:

- `-seed xxx`: it sets the random number generator's seed to xxx. Default value is 246. If xxx is not a valid integer,

  ```
  ERROR: <xxx> isn't a valid integer.
  ```

  will be thrown.
- `-load xxx`: it loads the game saved in file xxx. If xxx is not a valid file or xxx cannot be opened, then

  ```
  ERROR: unable to open file <xxx>.
  ```

  will be thrown. If the opened file is not in valid format, which follows what `constructor.pdf` says, then

  ```
  ERROR: <xxx> is in invalid format.
  ```

- `-board xxx`: it loads the game with the board specified in file xxx. If xxx is not a valid file or xxx cannot be opened, the same error message as previous will be thrown. If the opened file is not in valid format, the same error message as previous will be thrown.
- `-random-board`: it starts the game with a randomly generated board.
- `-players xxx`: it initializes the game with xxx players. If xxx is not an integer, the "Invalid Integer" error message will be thrown (see `-seed xxx`). If xxx is smaller than 2 or greater than 4, then

  ```
  ERROR: invalid player size.
  ```

  will be thrown.
- `-computer_player xxx`: it starts the program with xxx computer players. The computer players will always roll fair dice (result will not be 7) and will not do anything during its turn. It will not accept any trade offers and always give the valid vertex when asked to build basement at the beginning of the game. If xxx is not a valid integer, "Invalid Integer" error message will be thrown. If xxx is smaller than 1 or greater than $p - 1$, where p is the number of players (with default set to be 4), then

  ```
  ERROR: invalid computer player size.
  ```

will be thrown.

- if any other command other than above is given, then

  ```
  ERROR: unrecognized command
  ```

  will be thrown.

Note that one command cannot be given twice, otherwise

```
ERROR: already specified <command> once before.
```

will be thrown.

Also, `-load`, `-board`, or `-random-board` command cannot appear at the same time as any of the other. For example, if the player give

```
./constructor -load xxx.txt -board xxx.txt
```

then

```
ERROR: already specified -load, can’t also specify -board
```

will be thrown.

The command-line options can be given in any order. For example, the following command-line are acceptable:

```
./constructor -seed 33 -board layout.txt -players 3 -computer_player 1
./constructor -load high.txt -computer_player 1 -seed 246 -players 4
```

We will use the both command-line for the demo game (we have enclosed `high.txt` and `layout.txt` in our submission, but here is what they looks like:)

```
high.txt
0
18 18 18 18 19 r h 0 H 22 B
21 20 20 20 20 r h 4 B 15 B
20 20 20 20 20 r h 10 B 8 B
20 20 20 20 20 r h 17 B 2 B
2 2 1 5 4 6 1 3 2 3 0 3 3 3 0 4 2 4 1 11 4 11 0 8 0 8 3 11 3 8 1 11 4 9 5 7 2 12
-1
```

```
layout.txt
0 3 1 10 3 5 1 4 5 7 3 10 2 11 0 3 3 8 0 2 0 6 1 8 4 12 1 5 4 11 2 4 4 6 2 9 2 9
```

2 Beginning of the Game

The builders will be asked to choose 2 locations (vertex) to build their initial basement. Note that the built basement cannot be adjacent to each other.

Using the first command-line listed above, here is what the game looks like

```
./constructor -seed 33 -board layout.txt -players 3 -computer_player 1
                    | 0|-- 0--| 1|
                      |         |
                      1    0    2
                      |  BRICK  |
          | 2|-- 3--| 3|   3  | 4|-- 4--| 5|
            |         |         |         |
            5    1    6         7    2    8
            |  ENERGY |         |  HEAT   |
| 6|-- 9--| 7|  10  | 8|--10--| 9|   5  |10|--11--|11|
  |         |         |         |         |         |
 12    3   13        14    4   15        16    5   17
  |  ENERGY |         |  PARK   |         |  HEAT   |
|12|   4  |13|--18--|14|      |15|--19--|16|  10  |17|
  |         |         |         |         |         |
 20        21    6   22        23    7   24        25
  |         |  GLASS  |         |  BRICK  |         |
|18|--26--|19|  11  |20|--27--|21|   3  |22|--28--|23|
  |         |         |         |         |         |
 29    8   30        31    9   32        33   10   34
  |  HEAT   |         |  BRICK  |         |  BRICK  |
|24|   8  |25|--35--|26|   2  |27|--36--|28|   6  |29|
  |         |         |         |         |         |
 37        38   11   39        40   12   41        42
  |         |  ENERGY |         |  WIFI   |         |
|30|--43--|31|   8  |32|--44--|33|  12  |34|--45--|35|
  |         |         |         |         |         |
 46   13   47        48   14   49        50   15   51
  |  ENERGY |         |  WIFI   |         |  GLASS  |
|36|   5  |37|--52--|38|  11  |39|--53--|40|   4  |41|
  |         |         |         |         |         |
 54        55   16   56        57   17   58        59
  |         |  WIFI   |         |  GLASS  |         |
|42|--60--|43|   6  |44|--61--|45|   9  |46|--62--|47|
            |         |         |         |
           63        64   18   65        66
            |         |  GLASS  |         |
          |48|--67--|49|   9  |50|--68--|51|
                      |         |
                     69        70
                      |         |
                    |52|--71--|53|
Builder Blue, where do you want to build a basement?
```

and we will input 0,

```
> 0
Builder Red, where do you want to build a basement?
```

we will input 4

```
> 4
Builder Orange, where do you want to build a basement?
```

Since Orange is a computer player, it will automatically generate a valid location:

```
> 2
Builder Orange, where do you want to build a basement?
> 6
Builder Red, where do you want to build a basement?
```

we will input 8

```
> 8
Builder Blue, where do you want to build a basement?
```

we will input 15

```
> 15
```

The beginning of the game ends here, since all 3 players have chosen their first two basement locations. The game will then enter the next stage.

3 During the Game

We will use the second command-line here, since using the first command-line will not give any resources to the players at the beginning, which will not be so convenient for us to show the functionality of most of our features.

```
./constructor -load high.txt -computer_player 1 -seed 246 -players 4
                    |BH|-- 0--| 1|
                      |         |
                      1    0    2
                      |  GLASS  |
          |YB|-- 3--| 3|   2  |RB|-- 4--| 5|
            |         |         |         |
            5    1    6         7    2    8
            |  ENERGY |         |  WIFI   |
| 6|-- 9--| 7|   5  |OB|--10--| 9|   6  |OB|--11--|11|
  |         |         |         |         |         |
 12    3   13        14    4   15        16    5   17
  |  ENERGY |         |  GLASS  |         |  BRICK  |
|12|   3  |13|--18--|14|   3  |RB|--19--|16|   3  |YB|
  |         |         |         |         |         |
 20        21    6   22        23    7   24        25
  |         |  HEAT   |         |  BRICK  |         |
|18|--26--|19|   3  |20|--27--|21|   4  |BB|--28--|23|
  |         |         |         |         |         |
 29    8   30        31    9   32        33   10   34
  |  GLASS  |         |  ENERGY |         |  WIFI   |
|24|   4  |25|--35--|26|  11  |27|--36--|28|  11  |29|
  |         |         |         |         |         |
 37        38   11   39        40   12   41        42
  |         |  BRICK  |         |  BRICK  |         |
|30|--43--|31|   8  |32|--44--|33|   8  |34|--45--|35|
  |         |         |         |         |         |
 46   13   47        48   14   49        50   15   51
  |  HEAT   |         |  HEAT   |         |  ENERGY |
|36|  11  |37|--52--|38|   8  |39|--53--|40|  11  |41|
  |         |         |         |         |         |
 54        55   16   56        57   17   58        59
  |         |  WIFI   |         |  PARK   |         |
|42|--60--|43|   9  |44|--61--|45|      |46|--62--|47|
            |         |         |         |
           63        64   18   65        66
            |         |  GLASS  |         |
          |48|--67--|49|  12  |50|--68--|51|
                      |         |
                     69        70
                      |         |
                    |52|--71--|53|
Builder Blue’s turn.
```

Now, we need to choose to roll a dice. We first use help to see all the valid commands:

```
> help
Valid commands:
~ load : changes current builder’s dice type to ’loaded’
~ fair : changes current builder’s dice type to ’fair’
~ roll : rolls the dice and distributes resources.
~ status : prints the current status of all builders in order from builder 0 to 3.
~ help : prints out the list of commands.
```

we will choose to roll 5 here. The default dice is a loaded dice, so we can just choose to roll the dice without setting the dice:

```
> roll
Input a roll between 2 and 12:
> 5
Builder YELLOW gained:
1 ENERGY
Builder ORANGE gained:
1 ENERGY
Enter a command:
```

We first use help to see all the valid commands now:

```
> help
Valid commands:
~ board : prints the current board.
~ status : prints the current status of all builders in order from builder 0 to 3.
~ residences : prints the residences the current builder has currently completed.
~ build-road <road#> : attempts to builds the road at <road#>.
~ build-res <housing#> : attempts to builds a basement at <housing#>.
~ improve <housing#> : attempts to improve the residence at <housing#>.
~ trade <colour> <give> <take> : attempts to trade with builder <colour>,
giving one resource of type <give> and receiving one resource of type <take>.
~ bank : attempts to apply for a mortgage using an existing residence.
Further instructions will be given when the command is chosen.
~ market <give> <take> : attempts to trade with the market,
giving four resources of type <give> and receiving one resource of type <take>.
~ next : passes control onto the next builder in the game.
~ save <file> : saves the current game state to <file>.
~ help : prints out the list of commands.
Enter a command:
```

we will choose to improve the basement at 22:

```
> improve 22
Builder BLUE has successfully built a house at 22.
Enter a command:
```

we will choose to build a road at 33:

```
> build-road 33
Builder BLUE has successfully built a road at 33.
Enter a command:
```

We now want to check the other builders' status:

```
> status
Builder BLUE    has 4 building points, 18 BRICK, 18 ENERGY, 16 GLASS, 14 HEAT, 18 WIFI.
Builder RED     has 2 building points, 21 BRICK, 20 ENERGY, 20 GLASS, 20 HEAT, 20 WIFI.
Builder ORANGE  has 2 building points, 20 BRICK, 21 ENERGY, 20 GLASS, 20 HEAT, 20 WIFI.
Builder YELLOW  has 2 building points, 20 BRICK, 21 ENERGY, 20 GLASS, 20 HEAT, 20 WIFI.
Enter a command:
```

we now switch to the next builder's turn:

```
> next
Builder Red's turn.
```

We choose to roll a fair dice here:

```
> fair
Builder Red now has fair Dice.
```

we roll the dice:

```
> roll
The number you rolled is 5
Builder YELLOW gained:
1 ENERGY
Builder ORANGE gained:
1 ENERGY
Enter a command:
```

we want to check the current residences that Red has built:

```
> residences
RED has built:
4 B
15 B
Enter a command:
```

we want to check the current board layout:

```
> board
                    |BH|-- 0--| 1|
                      |         |
                      1    0    2
                      |  GLASS  |
          |YB|-- 3--| 3|   2  |RB|-- 4--| 5|
            |         |         |         |
            5    1    6         7    2    8
            |  ENERGY |         |  WIFI   |
| 6|-- 9--| 7|   5  |OB|--10--| 9|   6  |OB|--11--|11|
  |         |         |         |         |         |
 12    3   13        14    4   15        16    5   17
  |  ENERGY |         |  GLASS  |         |  BRICK  |
|12|   3  |13|--18--|14|   3  |RB|--19--|16|   3  |YB|
  |         |         |         |         |         |
 20        21    6   22        23    7   24        25
  |         |  HEAT   |         |  BRICK  |         |
|18|--26--|19|   3  |20|--27--|21|   4  |BH|--28--|23|
  |         |         |         |         |         |
 29    8   30        31    9   32        BR   10   34
  |  GLASS  |         |  ENERGY |         |  WIFI   |
|24|   4  |25|--35--|26|  11  |27|--36--|28|  11  |29|
  |         |         |         |         |         |
 37        38   11   39        40   12   41        42
  |         |  BRICK  |         |  BRICK  |         |
|30|--43--|31|   8  |32|--44--|33|   8  |34|--45--|35|
  |         |         |         |         |         |
 46   13   47        48   14   49        50   15   51
  |  HEAT   |         |  HEAT   |         |  ENERGY |
|36|  11  |37|--52--|38|   8  |39|--53--|40|  11  |41|
  |         |         |         |         |         |
 54        55   16   56        57   17   58        59
  |         |  WIFI   |         |  PARK   |         |
|42|--60--|43|   9  |44|--61--|45|      |46|--62--|47|
            |         |         |         |
           63        64   18   65        66
            |         |  GLASS  |         |
          |48|--67--|49|  12  |50|--68--|51|
                      |         |
                     69        70
                      |         |
                    |52|--71--|53|
Enter a command:
```

We want to build a road a 7:

```
> build-road 7
Builder RED has successfully built a road at 7.
Enter a command:
```

We want to mortage our basement at 4

```
> bank
Here is the rules for applying a mortgage.
          Original price                                What you will get
Basement: 1 BRICK, 1 ENERGY, 1 GLASS, 0 HEAT, 1 WIFI => 1 BRICK, 1 ENERGY, 0 GLASS, 0 HEAT, 0 WIFI
House   : 0 BRICK, 0 ENERGY, 2 GLASS, 3 HEAT, 0 WIFI => 1 BRICK, 1 ENERGY, 1 GLASS, 1 HEAT, 0 WIFI
Tower   : 3 BRICK, 2 ENERGY, 2 GLASS, 2 HEAT, 1 WIFI => 2 BRICK, 2 ENERGY, 2 GLASS, 2 HEAT, 1 WIFI
Enter the vertex if you want to continue, or else ’quit’.
> 4
You have successfully mortgaged your basement at 4!
Enter a command:
```

If we want to quit the mortgage, we can just type `quit` and the game will go back to the main commands without any change to the residences or resources.

we now check our status:

```
Builder BLUE    has 4 building points, 18 BRICK, 18 ENERGY, 16 GLASS, 14 HEAT, 18 WIFI.
Builder RED     has 1 building points, 21 BRICK, 20 ENERGY, 19 GLASS, 19 HEAT, 18 WIFI.
Builder ORANGE  has 2 building points, 20 BRICK, 22 ENERGY, 20 GLASS, 20 HEAT, 20 WIFI.
Builder YELLOW  has 2 building points, 20 BRICK, 22 ENERGY, 20 GLASS, 20 HEAT, 20 WIFI.
Enter a command:
```

and we can see that our resources have increased by the setted amount.

We want to build a residence at 21, which we cannot do since there is a residence at 15:

```
> build-res 21
You cannot build here.
Enter a command:
```

checking the current board:

```
> board
                    |BH|-- 0--| 1|
                      |         |
                      1    0    2
                      |  GLASS  |
          |YB|-- 3--| 3|   2  | 4|-- 4--| 5|
            |         |         |         |
            5    1    6         RR    2    8
            |  ENERGY |         |  WIFI   |
| 6|-- 9--| 7|   5  |OB|--10--| 9|   6  |OB|--11--|11|
  |         |         |         |         |         |
 12    3   13         14    4   15         16    5   17
  |  ENERGY |         |  GLASS  |         |  BRICK  |
|12|   3  |13|--18--|14|   3  |RB|--19--|16|   3  |YB|
  |         |         |         |         |         |
 20        21    6   22         23    7   24         25
  |         |  HEAT   |         |  BRICK  |         |
|18|--26--|19|   3  |20|--27--|21|   4  |BH|--28--|23|
  |         |         |         |         |         |
 29    8   30         31    9   32         BR   10   34
  |  GLASS  |         |  ENERGY |         |  WIFI   |
|24|   4  |25|--35--|26|  11  |27|--36--|28|  11  |29|
  |         |         |         |         |         |
 37        38   11   39         40   12   41         42
  |         |  BRICK  |         |  BRICK  |         |
|30|--43--|31|   8  |32|--44--|33|   8  |34|--45--|35|
  |         |         |         |         |         |
 46   13   47         48   14   49         50   15   51
  |  HEAT   |         |  HEAT   |         |  ENERGY |
|36|  11  |37|--52--|38|   8  |39|--53--|40|  11  |41|
  |         |         |         |         |         |
 54        55   16   56         57   17   58         59
  |         |  WIFI   |         |  PARK   |         |
|42|--60--|43|   9  |44|--61--|45|      |46|--62--|47|
            |         |         |         |
           63         64   18   65         66
            |         |  GLASS  |         |
          |48|--67--|49|  12  |50|--68--|51|
                      |         |
                     69         70
                      |         |
                    |52|--71--|53|
Enter a command:
```

We want to build a road at 4, but we accidently input it as ’four’:

```
> four
Invalid command.
Please enter ’help’ for a list of valid commands.
Enter a command:
```

Oops, we enter the right command:

```
> build-road 4
Builder RED has successfully built a road at 4.
Enter a command:
```

We want to improve our basement at 15, but we accidently typed 25

```
> improve 25
You cannot build here.
Enter a command:
```

Let’s change it back:

```
> improve 15
Builder RED has successfully built a house at 15.
Enter a command:
```

We want some more Wifi, so we asked the market to exchange some Wifi by our bricks:

```
> market BRICK WIFI
Builder RED gained:
1 WIFI
Enter a command:
```

we go to the next player.

```
> next
Builder Orange’s turn.
```

We will roll the dice to 7, which will find a GEESE:

```
> roll
Input a roll between 2 and 12:
> 7
The number you rolled is 7. You found a GEESE!
Builder BLUE loses 42 resources to the geese. They lose:
7 BRICK
6 ENERGY
11 GLASS
4 HEAT
14 WIFI
Builder RED loses 46 resources to the geese. They lose:
5 BRICK
12 ENERGY
10 GLASS
7 HEAT
12 WIFI
Builder ORANGE loses 51 resources to the geese. They lose:
9 BRICK
6 ENERGY
13 GLASS
13 HEAT
10 WIFI
Builder YELLOW loses 51 resources to the geese. They lose:
9 BRICK
6 ENERGY
13 GLASS
13 HEAT
10 WIFI
Choose where to place the GEESE
```

We want to place it at 3

```
3
Builder ORANGE has no builders to steal from.
Enter a command:
```

and we have no builders to steal from. We now check the status of the players:

```
> status
Builder BLUE    has 4 building points, 11 BRICK, 12 ENERGY, 5 GLASS, 10 HEAT, 4 WIFI.
Builder RED     has 2 building points, 12 BRICK, 8 ENERGY, 7 GLASS, 8 HEAT, 6 WIFI.
Builder ORANGE  has 2 building points, 11 BRICK, 16 ENERGY, 7 GLASS, 7 HEAT, 10 WIFI.
Builder YELLOW  has 2 building points, 11 BRICK, 16 ENERGY, 7 GLASS, 7 HEAT, 10 WIFI.
Enter a command:
```

We can see that the number of resources have reduced. We want to try the market again. If we typed the resources’ name wrong (they have to be captalized!), the following error message will pop up:

```
> market brick Energy
ERROR: brick is not a valid resource.
```

and it will ask you to input the right resource name again:

```
> BRICK ENERGY
Builder ORANGE gained:
1 ENERGY
Enter a command:
```

We want to trade with Yellow, which is a computer player, and the answer will always be "no":

```
> trade Yellow BRICK WIFI
Orange offers Yellow one BRICK for one WIFI.
Does Yellow accept this offer?
> no
Enter a command:
```

We will go to the next player, which is a computer player:

```
> next
Builder Yellow’s turn.
> The number you rolled is 5
Builder YELLOW gained:
1 ENERGY
Builder ORANGE gained:
1 ENERGY
Enter a command:
> next
Builder Blue’s turn.
> roll 8
Input a roll between 2 and 12:
> No builders gained resources.
Enter a command:
```

We now want to quit the game. Before that, we will save our status to `sample.txt`:

```
> save sample.txt
Enter a command:
```

and then we will quit the game by giving eof, and the following will be printed:

```
> End of file reached.

Saving to backup.sv...
```

We will include sample.txt in our submission, and here is what it looks like:

```
0
11 12 5 10 4 r 33 h 22 H 0 H
13 9 8 8 7 r 7 4 h 15 H
7 18 7 7 10 r h 10 B 8 B
11 17 7 7 10 r h 17 B 2 B
2 2 1 5 4 6 1 3 2 3 0 3 3 3 0 4 2 4 1 11 4 11 0 8 0 8 3 11 3 8 1 11 4 9 5 7 2 12
3
```

4 End of Game

We will use the second command-line again, but this time, we will use a fast winning strategy, so that we can show you what the end of game looks like. We will use `win.in`, which will be enclosed with this submission.

```
./constructor -load high.txt -computer_player 1 -seed 246 -players 4
win.in
fair
roll
build-road 33
```

```
build-road 41
improve 0
improve 0
build-res 34
build-road 45
build-road 42
build-res 29
improve 22
improve 22
improve 34
improve 34
no
```

and the output will be included in `win.out`

```
                    |BH|-- 0--| 1|
                      |         |
                      1    0    2
                      |  GLASS  |
          |YB|-- 3--| 3|   2  |RB|-- 4--| 5|
            |         |         |         |
            5    1    6         7    2    8
            |  ENERGY |         |  WIFI   |
| 6|-- 9--| 7|   5  |OB|--10--| 9|   6  |OB|--11--|11|
  |         |         |         |         |         |
 12    3   13        14    4   15        16    5   17
  |  ENERGY |         |  GLASS  |         |  BRICK  |
|12|   3  |13|--18--|14|   3  |RB|--19--|16|   3  |YB|
  |         |         |         |         |         |
 20        21    6   22        23    7   24        25
  |         |  HEAT   |         |  BRICK  |         |
|18|--26--|19|   3  |20|--27--|21|   4  |BB|--28--|23|
  |         |         |         |         |         |
 29    8   30        31    9   32        33   10   34
  |  GLASS  |         |  ENERGY |         |  WIFI   |
|24|   4  |25|--35--|26|  11  |27|--36--|28|  11  |29|
  |         |         |         |         |         |
 37        38   11   39        40   12   41        42
  |         |  BRICK  |         |  BRICK  |         |
|30|--43--|31|   8  |32|--44--|33|   8  |34|--45--|35|
  |         |         |         |         |         |
 46   13   47        48   14   49        50   15   51
  |  HEAT   |         |  HEAT   |         |  ENERGY |
|36|  11  |37|--52--|38|   8  |39|--53--|40|  11  |41|
  |         |         |         |         |         |
 54        55   16   56        57   17   58        59
  |         |  WIFI   |         |  PARK   |         |
|42|--60--|43|   9  |44|--61--|45|      |46|--62--|47|
            |         |         |         |
           63        64   18   65        66
            |         |  GLASS  |         |
          |48|--67--|49|  12  |50|--68--|51|
                      |         |
                     69        70
                      |         |
                    |52|--71--|53|
Builder Blue’s turn.
> Builder Blue now has fair Dice.
> The number you rolled is 5
Builder YELLOW gained:
1 ENERGY
Builder ORANGE gained:
1 ENERGY
```

```
Enter a command:
> Builder BLUE has successfully built a road at 33.
Enter a command:
> Builder BLUE has successfully built a road at 41.
Enter a command:
> Builder BLUE has successfully built a tower at 0.
Enter a command:
> Enter a command:
> Builder BLUE has successfully built a basement at 34.
Enter a command:
> Builder BLUE has successfully built a road at 45.
Enter a command:
> Builder BLUE has successfully built a road at 42.
Enter a command:
> Builder BLUE has successfully built a basement at 29.
Enter a command:
> Builder BLUE has successfully built a house at 22.
Enter a command:
> Builder BLUE has successfully built a tower at 22.
Enter a command:
> Builder BLUE has successfully built a house at 34.
Enter a command:
> Builder BLUE has successfully built a tower at 34.
Congratulations to Blue! You have won the game!
Builder Blue, would you like to play again?
```

The game will immediately finish as soon as it finds one builder has at least 10 building points. It asks all the players if they want to play again, and if one player responds by "no", the program will terminates, otherwise the program will restarts to the beginning with the same command-line settings.

5 Appendix

- -seed
- -load
- -board
- -random-board
- -players
- -computer_players
- invalid command-line and valid command-line
- loaded dice
- fair dice
- help during rolling dice
- residences
- board
- status
- build-road
- build-res
- improve
- invalid build
- trade

- bank
- market
- invalid market
- Geese
- next
- save
- help during main game
- winning the game