CS5001 Practical 2 – OO Implementation

Report and User Instruction

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User instruction

To compile this program:

In the terminal, open /CS5001-p2-oop/src/towerdefence, input

```
javac -d . *.java
```

To run this program:

In the terminal, open /CS5001-p2-oop/src/towerdefence, input

```
java towerdefence.Play
```

Extensions

1. Extended design for the player to earn money and build more towers during the game.
2. New enemy type (lizard) and new tower (radiation).
3. A simple terminal-based user interface.
4. Optimized shooting strategies for slingshot and catapult towers.

Class Design

This tower defense game project uses a simple terminal-based UI includes a series of classes:

Play.class (enhancement): this class contains the main method to initialize the game and end the game.

Game.class (enhancement): this class implements several methods to advance the game.

Enemy.class, Rat.class, Elephant.class, Tower.class, Slingshot.class, Catapult.class: implements methods that are constrained by the UML.

Lizard.class (enhancement): a new class extending Enemy.

Radiation.class (enhancement): a new class extending Tower.

The detailed design for each class is followed.

Play.class

For this tower defense game, the player is able to customize initial money, total amounts of enemies of different types. The validity of input is considered.

When the game is over, it will judge whether the play win or lose based on the final size of the enemies array list. For the first round, before advance the game, it calls initializeTower() method to build towers.

Game.class

This is the main class initialized by corridor length, money, total numbers of different enemies. For each round of the game, the steps are
(1) counting the round, (2) producing new enemies, (3) tower hitting the enemies and collecting coins, (4) asking the player to build new tower if money is enough, (5) move enemies if they are still alive, (6) show the current game board and statistics.
The methods to show the game board take several designing decisions.

1. To avoid the situation when more than one enemy/tower appear in a single location, I split the corridor into 4 lines: towers, rats, elephant, lizard. And to produce elephants every two rounds so that elephants don't overlap with each other when they are getting ready to move. There are still a major flaw for this strategy: inability to implement tower that slow down enemies. This is an intrinsic limitation of terminal-based UI, a GUI design can tackle this problem effortlessly to refine steps of enemies.
2. For every round the game advances, the method Game.advance() returns a Boolean to decide if the game can still go on. The game will terminate if one of the following situations occurs:
   a) An enemy have made it to the end of corridor.
   b) All of the enemy is destroyed when there is no more enemies to produce.
3. The method to ask player if they want to build more tower. It is very annoying when the player answered no for this round, but the system keeps asking for every round. For instance, you want to save money for a Catapult tower, but the system pauses the game every time it find out you have enough money to build a Slingshot tower. Therefore, I set up a threshold value of current money – if the player answered no, the threshold value will increase by 100, meaning that the system will only ask again if you earn another 100; if the player choose to build a tower, the

threshold value will decrease by 100 to allow play to build two towers continuously.

4. Coin collection is done by returning an integer from the hitEnemy method, to get a summation of the towers' earnings. For the tower classes, their fire method will also return an integer as the coins – if the tower managed to kill an enemy, it will invoke the getCoins() method from the enemy and collect coins.
5. Refreshing screen and freeze. Before showing the board, the following line is invoked:

```
System.out.print("\033[H\033[2J"];
```

This clears the screen and moves the cursor to the first row, first column. Note that, this line is specially design for terminals supporting ANSI escape codes, like Linux and MacOs. It may not work properly on Windows cmd.

And after showing the game board, the system is designed to freeze 1 second by calling:

```
Thread.sleep(1000);
```

Enemy.class (Rat, Lizard, Elephant)

Beside the two enemies required by the UML, I also add another type of enemy, lizard (Table 1). Lizards move 1 unit length for each round, and have 6 initial HP. A getCoins() method is implemented to let players earn money from dead enemies.

In order to let the elephant move every two rounds, I gave it a instance variable step initialized by 0. Every time the advance method is called, step is added by 1; if the step is 2, decrease it by 2 and then move forward.

Table 1. The design of enemies.

Enemy name	Moving speed	Total health	Coins it carries
Elephant	1/2	10	$50
Lizard	1	6	$20
Rat	2	1	$10

Tower.class(Slingshot, Catapult, Radiation)

I design the fire method for different tower to optimize its target choosing strategy (table 2).

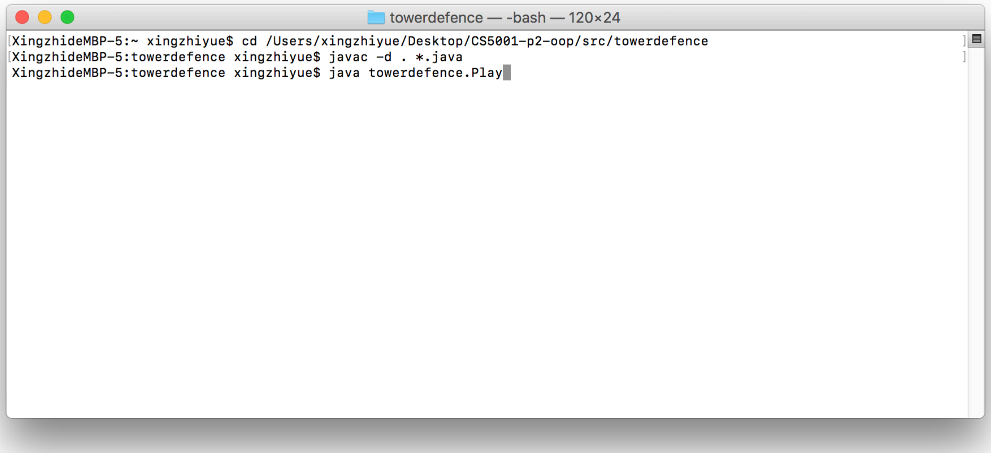
When I was testing the game, it is quite disturbing to see when catapult towers fire their 5-damage bullets to a 1-HP rat after 2 rounds of reloading. Therefore, in the fire method of catapult, when it is ready to fire, the algorithm looks for the first elephant; if there is no elephant left, it looks for the first lizard or rat. And for slingshot towers, the priority is rat, lizard and then elephant. The radiation towers have aoe (area of effect) attack, influencing all the enemies that haven't passed it.

To pass the automatic checker, I pass the number of rounds to the willFire() method for catapult and radiation tower to decide whether they are ready to fire or need to reload. However, if a catapult tower is built in round 5, it will fire in round 6, instead of reloading by definition. Hence, a more sensible way to do this is like the elephant class – give it a build-in counter.

Table 2. The design of towers.

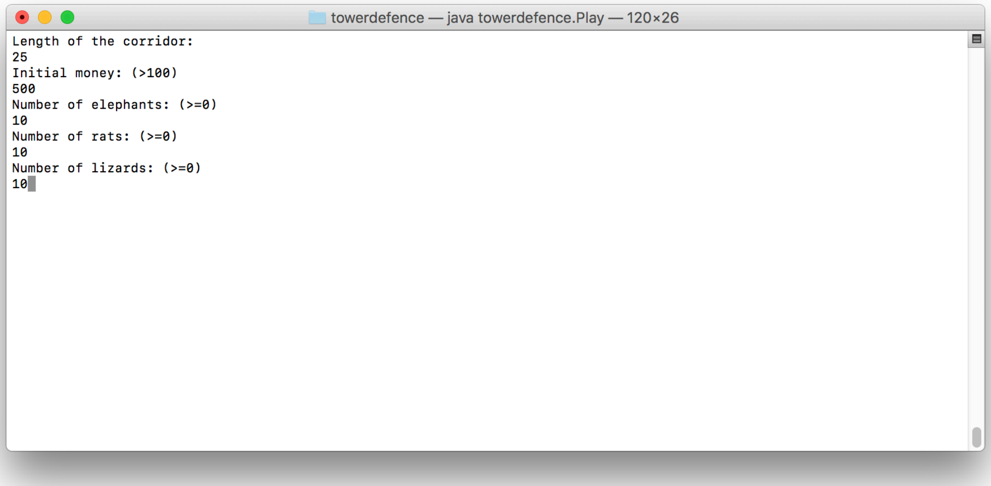
Tower name	Damage	Rounds needed to reload	Price	Shooting scheme (priority)
Slingshot	1	0	$100	Rat > Lizard > Elephant
Catapult	5	2	$200	Elephant > Lizard > Rat
Radiation	2	3	$200	Hit all enemies in front of it

Game demo



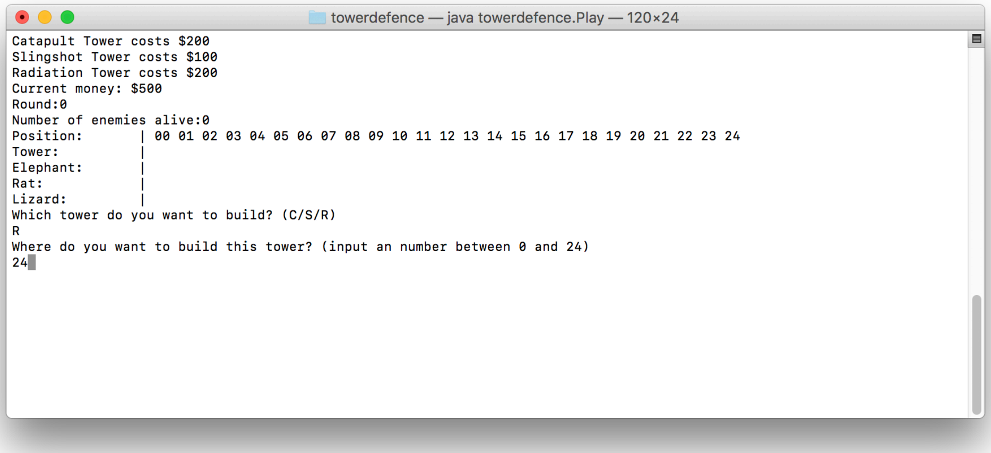
```
XingzhideMBP-5:~ xingzhiyue$ cd /Users/xingzhiyue/Desktop/CS5001-p2-oop/src/towerdefence
XingzhideMBP-5:towerdefence xingzhiyue$ javac -d . *.java
XingzhideMBP-5:towerdefence xingzhiyue$ java towerdefence.Play
```

Figure 1. Open the directory "towerdefence", compile and run.



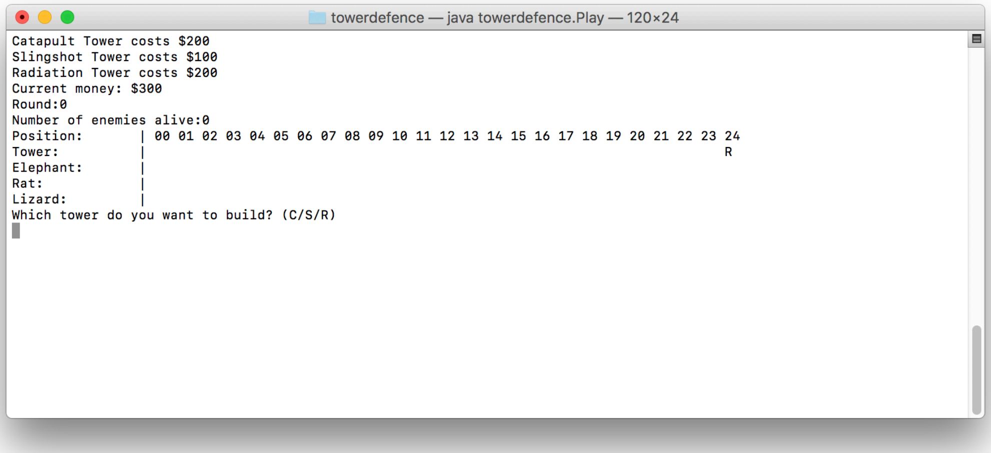
```
Length of the corridor:
25
Initial money: (>100)
500
Number of elephants: (>=0)
10
Number of rats: (>=0)
10
Number of lizards: (>=0)
10
```

Figure 2. Initialize the game with given corridor length and numbers of enemies.



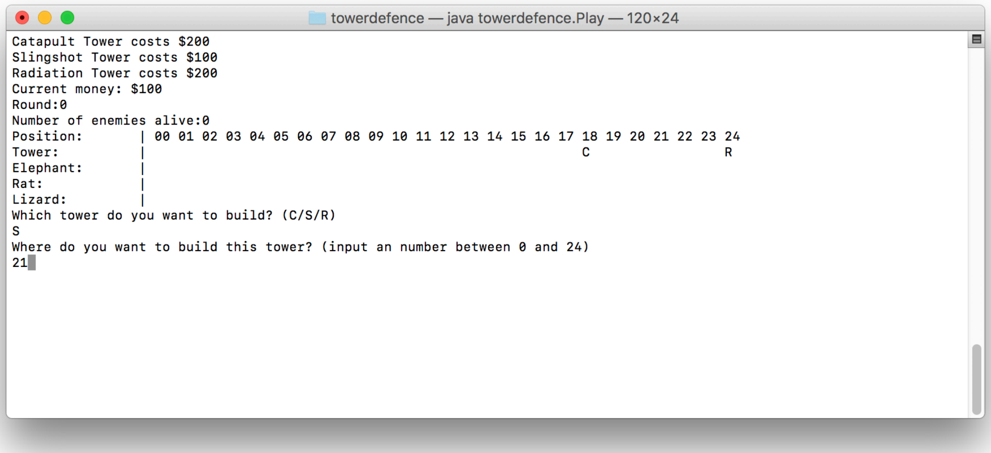
```
Catapult Tower costs $200
Slingshot Tower costs $100
Radiation Tower costs $200
Current money: $500
Round:0
Number of enemies alive:0
Position:       | 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Tower:          |
Elephant:       |
Rat:            |
Lizard:         |
Which tower do you want to build? (C/S/R)
R
Where do you want to build this tower? (input an number between 0 and 24)
24
```

Figure 3. Building first tower: Radiation at 24.



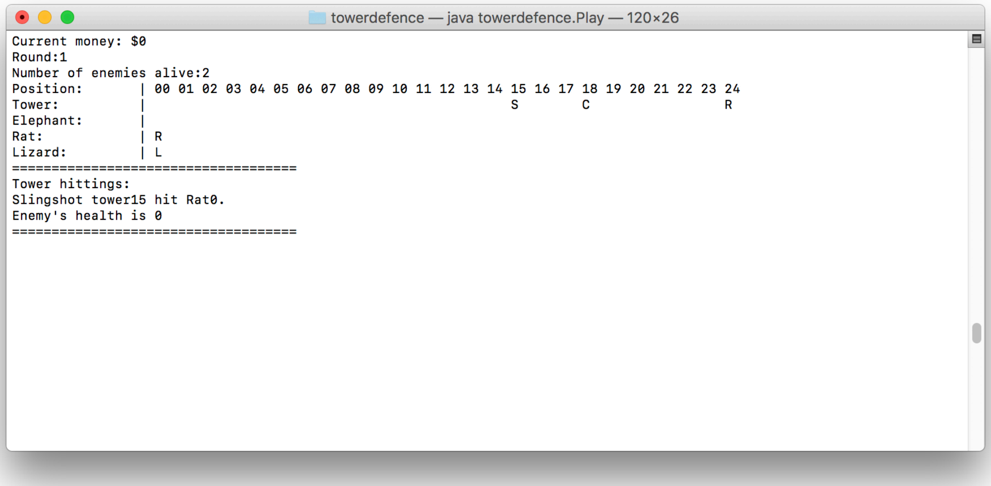
```
Catapult Tower costs $200
Slingshot Tower costs $100
Radiation Tower costs $200
Current money: $300
Round:0
Number of enemies alive:0
Position:       | 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Tower:          |                                                                         R
Elephant:       |
Rat:            |
Lizard:         |
Which tower do you want to build? (C/S/R)
```

Figure 4. The first tower is shown now. And build the second tower.



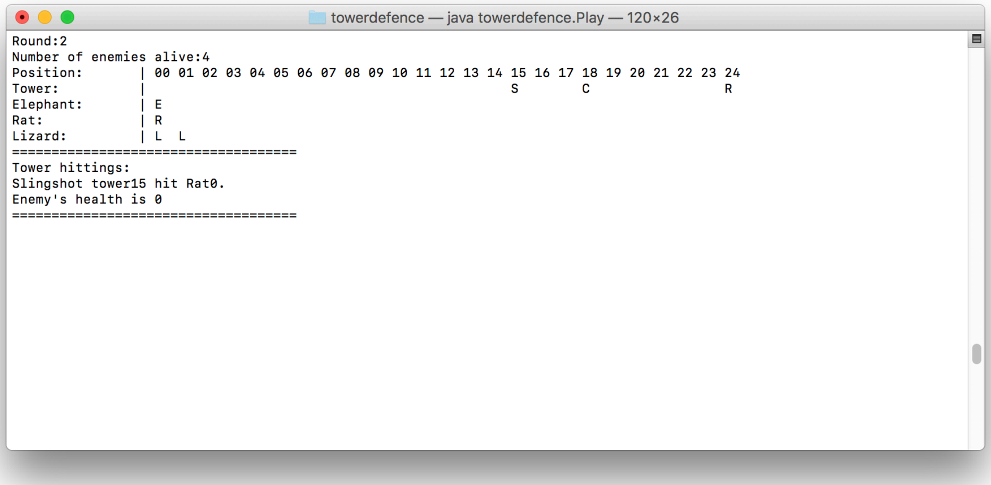
```
Catapult Tower costs $200
Slingshot Tower costs $100
Radiation Tower costs $200
Current money: $100
Round:0
Number of enemies alive:0
Position:       | 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Tower:          |                                                       C                 R
Elephant:       |
Rat:            |
Lizard:         |
Which tower do you want to build? (C/S/R)
S
Where do you want to build this tower? (input an number between 0 and 24)
21
```

Figure 5. Build one of each type of tower, the locations are shown.



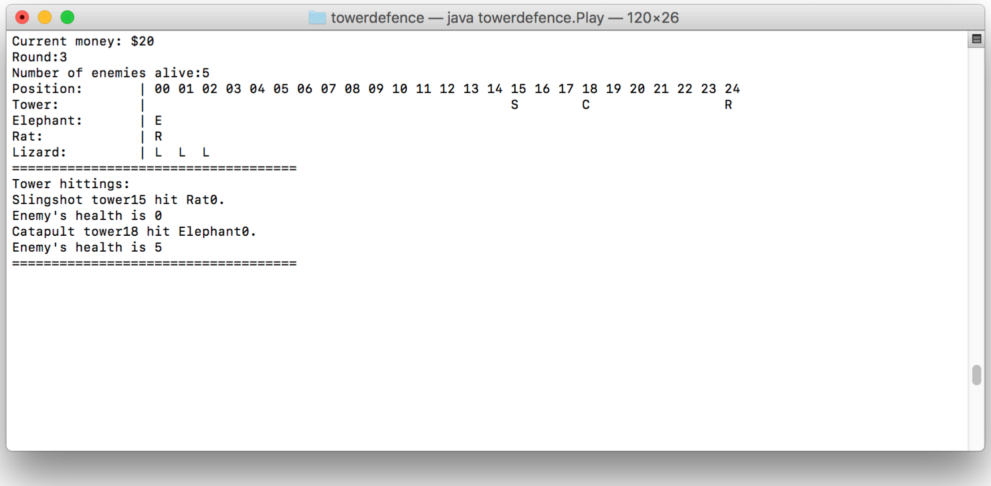
```
Current money: $0
Round:1
Number of enemies alive:2
Position:       | 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Tower:          |                                              S        C                 R
Elephant:       |
Rat:            | R
Lizard:         | L
====================================
Tower hittings:
Slingshot tower15 hit Rat0.
Enemy's health is 0
====================================
```

Figure 6. First round, only slingshot tower can fire, and it shoots rat instead of lizard.



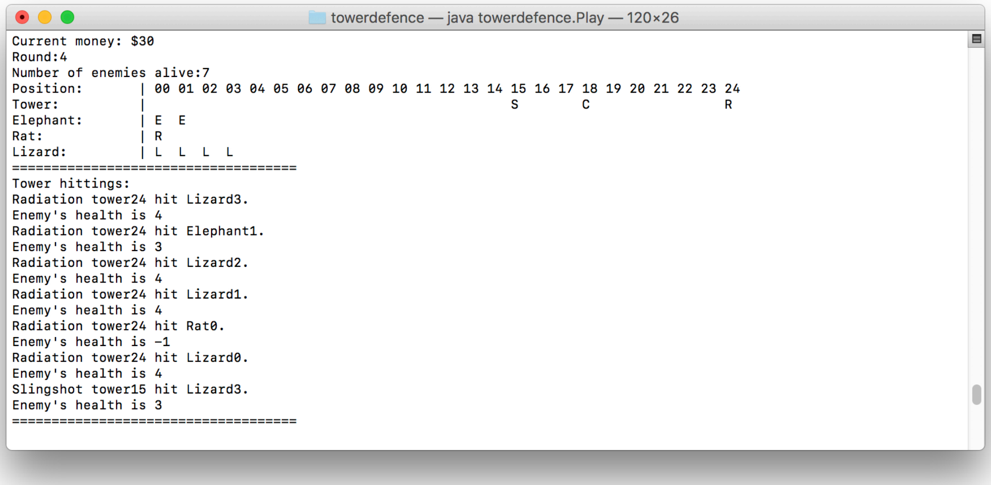
```
Round:2
Number of enemies alive:4
Position:       | 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Tower:          |                                              S        C                 R
Elephant:       | E
Rat:            | R
Lizard:         | L  L
====================================
Tower hittings:
Slingshot tower15 hit Rat0.
Enemy's health is 0
====================================
```

Figure 7. Second round, same as the first round.



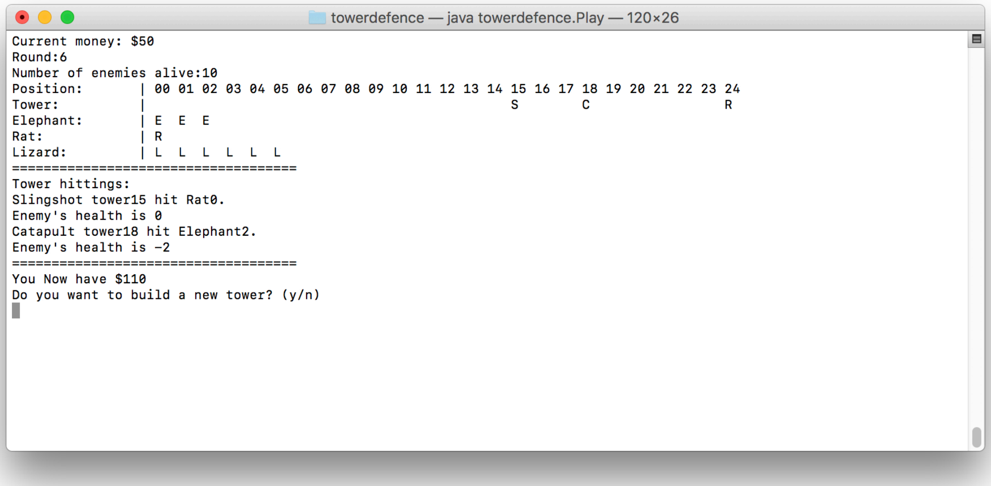
```
Current money: $20
Round:3
Number of enemies alive:5
Position:       | 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Tower:          |                                              S        C                 R
Elephant:       | E
Rat:            | R
Lizard:         | L  L  L
====================================
Tower hittings:
Slingshot tower15 hit Rat0.
Enemy's health is 0
Catapult tower18 hit Elephant0.
Enemy's health is 5
====================================
```

Figure 8. Third round, the catapult tower finished reloading and hit elephant. The elephant has 5 HP remaining.



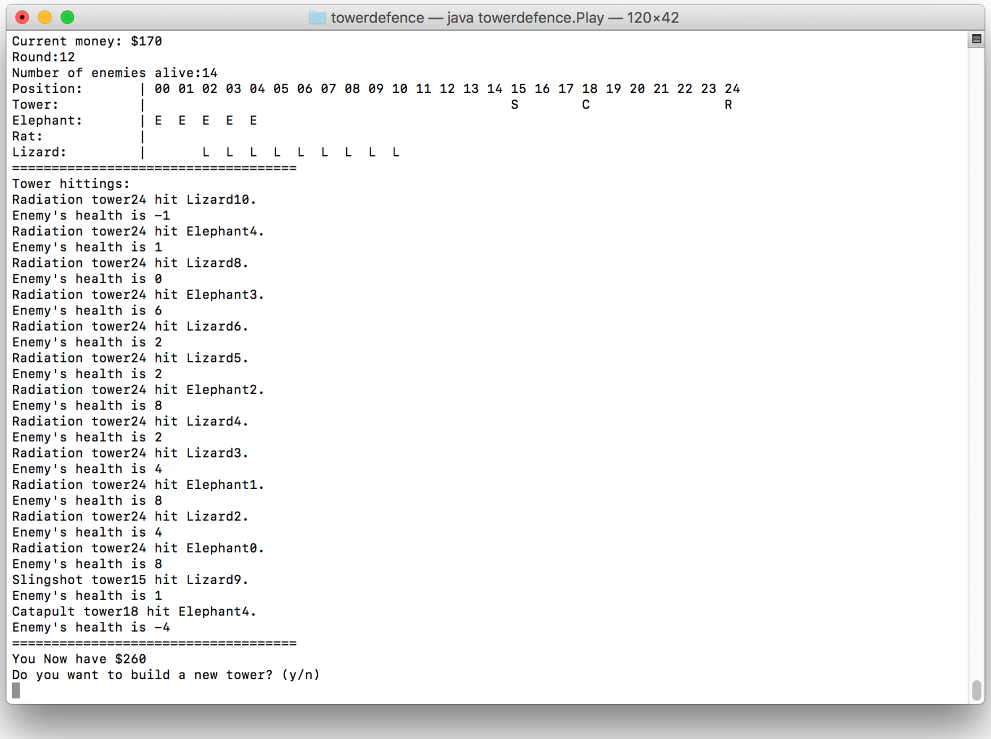
```
Current money: $30
Round:4
Number of enemies alive:7
Position:       | 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Tower:          |                                              S        C                 R
Elephant:       | E  E
Rat:            | R
Lizard:         | L  L  L  L
====================================
Tower hittings:
Radiation tower24 hit Lizard3.
Enemy's health is 4
Radiation tower24 hit Elephant1.
Enemy's health is 3
Radiation tower24 hit Lizard2.
Enemy's health is 4
Radiation tower24 hit Lizard1.
Enemy's health is 4
Radiation tower24 hit Rat0.
Enemy's health is -1
Radiation tower24 hit Lizard0.
Enemy's health is 4
Slingshot tower15 hit Lizard3.
Enemy's health is 3
====================================
```

Figure 9. 4th round, the radiation tower is activated and hit all of the enemies.



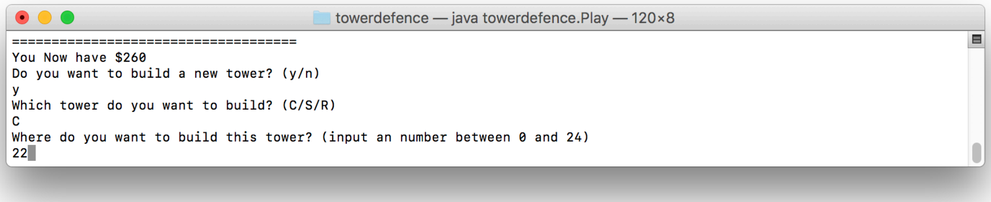
```
Current money: $50
Round:6
Number of enemies alive:10
Position:       | 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Tower:          |                                              S        C                 R
Elephant:       | E  E  E
Rat:            | R
Lizard:         | L  L  L  L  L  L
====================================
Tower hittings:
Slingshot tower15 hit Rat0.
Enemy's health is 0
Catapult tower18 hit Elephant2.
Enemy's health is -2
====================================
You Now have $110
Do you want to build a new tower? (y/n)
```

Figure 10. 6th round of the game and we now have $100. The system ask if we want to build a new tower. We answered no this time.



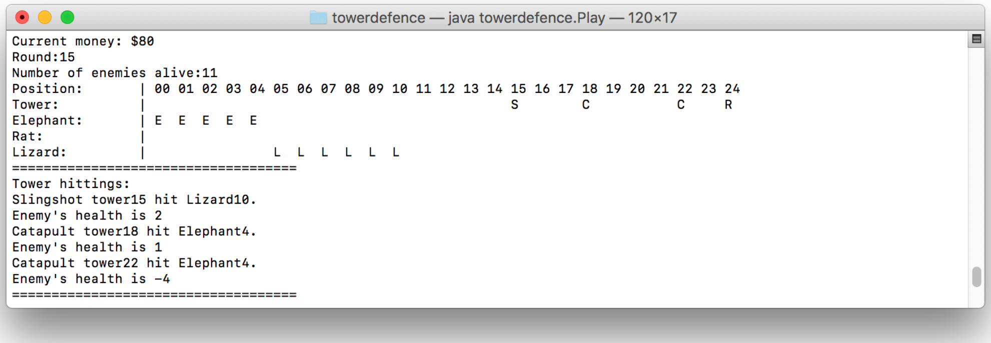
```
Current money: $170
Round:12
Number of enemies alive:14
Position:       | 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Tower:          |                                              S        C                 R
Elephant:       | E  E  E  E  E
Rat:            |
Lizard:         |       L  L  L  L  L  L  L  L  L
====================================
Tower hittings:
Radiation tower24 hit Lizard10.
Enemy's health is -1
Radiation tower24 hit Elephant4.
Enemy's health is 1
Radiation tower24 hit Lizard8.
Enemy's health is 0
Radiation tower24 hit Elephant3.
Enemy's health is 6
Radiation tower24 hit Lizard6.
Enemy's health is 2
Radiation tower24 hit Lizard5.
Enemy's health is 2
Radiation tower24 hit Elephant2.
Enemy's health is 8
Radiation tower24 hit Lizard4.
Enemy's health is 2
Radiation tower24 hit Lizard3.
Enemy's health is 4
Radiation tower24 hit Elephant1.
Enemy's health is 8
Radiation tower24 hit Lizard2.
Enemy's health is 4
Radiation tower24 hit Elephant0.
Enemy's health is 8
Slingshot tower15 hit Lizard9.
Enemy's health is 1
Catapult tower18 hit Elephant4.
Enemy's health is -4
====================================
You Now have $260
Do you want to build a new tower? (y/n)
```

Figure 11. 12th round, we now have $260. The system asked again.



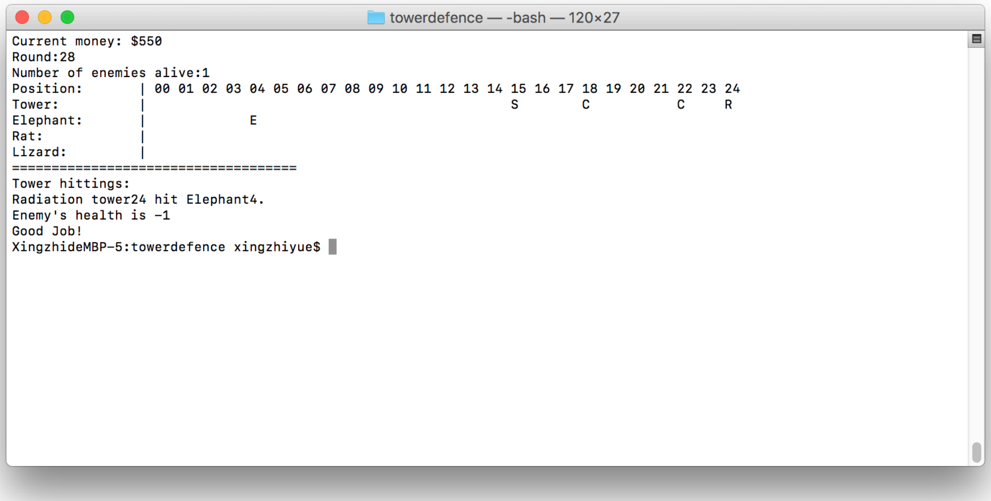
```
====================================
You Now have $260
Do you want to build a new tower? (y/n)
y
Which tower do you want to build? (C/S/R)
C
Where do you want to build this tower? (input an number between 0 and 24)
22
```

Figure 12. We answered yes and build another catapult tower at 22.



```
Current money: $80
Round:15
Number of enemies alive:11
Position:       | 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Tower:          |                                              S        C           C     R
Elephant:       | E  E  E  E  E
Rat:            |
Lizard:         |                L  L  L  L  L  L
====================================
Tower hittings:
Slingshot tower15 hit Lizard10.
Enemy's health is 2
Catapult tower18 hit Elephant4.
Enemy's health is 1
Catapult tower22 hit Elephant4.
Enemy's health is -4
====================================
```

Figure 13. 15th round, we now have two catapult tower and both of them works properly.



```
Current money: $550
Round:28
Number of enemies alive:1
Position:       | 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Tower:          |                                              S        C           C     R
Elephant:       |             E
Rat:            |
Lizard:         |
====================================
Tower hittings:
Radiation tower24 hit Elephant4.
Enemy's health is -1
Good Job!
XingzhideMBP-5:towerdefence xingzhiyue$
```

Figure 14. Won the game at 28th round.