CmpE 260 – Principles of Programming Languages

Smalltalk Project - Turn-based DotA Game

Due Date
Part 1: April 27, 2017 23:55 PM
Part 2: May 14, 2017 23:55 PM
(Details are given in Section 7)

"gg wp."

1 Introduction

In this project, you are going to implement a simple version of the worldwide famous game DotA (Defence of the Ancients). In order to give a brief introduction, DotA was initially designed as a custom map for Warcraft III, then it is served as a standalone game (DotA 2) to its users. It plays an important role in the popularity of the e-sports. Every year, a worldwide championship is organized with a number of professional teams all around the world.

For this project, you are going to implement a simple version of this game by coding with Smalltalk, which is an object-oriented programming language. Although the original game consists of various details and processes, the Smalltalk implementation will consist of a simple battle between 2 heroes in a turn-based manner. The aim of this project is learning the essence of objects and relations between different objects depends on the messages sent. You should use **Pharo** environment for implementing your Smalltalk project. Although there are other Smalltalk environments available, using "Pharo" is a must for this project.

2 Heroes and Skills

In DotA, there are two sides: Sentinels and Scourges. Although usually the teams are able to select any hero, there are some modes that restricts the hero pool for a team to either Sentinels or Scourges. Within Sentinels and Scourges, there are 3 types of heroes: Strength, Agility and Intelligence. Strength type heroes mostly consist of the ones that are durable. Agility type heroes are usually the "killing machines" if used correctly. Lastly, Intelligence type heroes come to forefront with their spells. Each of the heroes have 4 different skills (there are some exceptions). The skills are either active or passive. The usage of the skills drains your Mana.

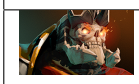
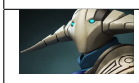
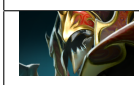
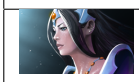
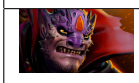
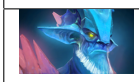
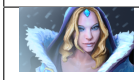
In order to simplify the game, in this project, you will implement 12 different heroes (6 for Scourges, 6 for Sentinels) and 2 skills for each. In Table 1, you can find the detailed information about the heroes.

The detailed information about the skills are depicted in Table 2. These skills are either passive or active. The passive skills are not activated by using the available mana, they always ready at the background. On the other hand, the active skills are used by using a portion of your mana. "Pulse Nova" is an exceptional skill that has a characteristic feature differing from the remaining. The player controlling "Leshrac" can activate "Pulse Nova" at a turn. Until it is closed, it provides 50 extra damage at each turn for Leshrac. Then, the player can deactivate the "Pulse Nova" at a Leshrac's turn in order to preserve some Mana. Watch out: deactivating Pulse Nova does not waste the turn, player can take another action in addition to deactivating "Pulse Nova" within that turn.

Each hero has a Max HP and Mana. At the beginning of the game, each hero starts with maximum values. The usage of skills drains your mana as stated. The HP represents the health of a hero. If the HP of a hero reaches to zero, the game finishes. For this project, you need to implement 12 different heroes with their features and skills. The game goes on like this:

1. Player1 chooses a hero for Scourge
2. Player2 chooses a hero for Sentinel
3. The game starts with the first action of the Player1
4. The game is turn-based, the hero can take an action if it is the turn.

Table 1: The list of heroes and their features.

Hero	Hero Name	Side	HP	Mana	Skill 1	Skill 2	Armor	Damage
	Skeleton King	Scourge	2270	993	Wraithfire Blast	Vampiric Aura	11	151-153
	Tidehunter	Scourge	2316	998	Anchor Smash	Ravage	11	139-145
	Sven	Sentinel	2198	874	Storm Hammer	God's Strength	14	149-151
	Earthshaker	Sentinel	2270	1030	Fissure	Enchant Totem	10	136-146
	Nyx Assassin	Scourge	1784	1149	Impale	Mana Burn	14	122-126
	Mortred	Scourge	1754	892	Blur	Coup de Grace	18	142-144
	Mirana	Sentinel	1697	996	Starstorm	Sacred Arrow	16	137-148
	Magina	Sentinel	1495	1017	Mana Break	Mana Void	14	136-140
	Lion	Scourge	1609	1456	Earth Spike	Finger of Death	9	139-145
	Leshrac	Scourge	1518	1534	Split Earth	Pulse Nova	12	133-137
	Rylai	Sentinel	1609	1373	Frostbite	Freezing Field	9	125-131
	Ogre Magi	Sentinel	2426	1105	Fireblast	Multicast	16	126-132

2.1 Characteristics of the Skills & Gameplay

The possible actions for a hero at a turn is composed of these:

- Attack – gives damage
- Use Spell 1 (if it is active)
- Use Spell 2 (if it is active)
- Use Health Potion
- Use Mana Potion

The usage of potions are explained in detail in Section 3. This section briefly explains the characteristics of the skills and the effects on usage.

The active skills can be used by players at each turn if there is enough Mana and there is not any cooldown. The passive skills are not activated by the players, they are always effective at each turn without need of activating them.

For example, Mortred has the skill of "Coup de Grace" which is passive. This skill provide a chance for mortred to give x4 times more damage to the enemy with 15% at each turn. The player using Mortred does not have to activate this skill, it automatically gives this chance to the hero.

At each turn, the player can take only 1 action from the list given above. One cannot attack and use spell at the same turn (there are some exceptions like Pulse Nova).

There are cooldowns for the skills. This means that if a hero uses a skill, that skill is not available for the amount of given at the table. After the cooldown is over, the skill is available again to be used. For example, the cooldown period for "Anchor Smash" is 3 turns. This means that, after Tidehunter uses "Anchor Smash", it cannot use it

again for 3 turns. Watch out that these 3 turns are not consecutive turns, it is the corresponding player's turns. An example is given at the information given below:

> Tidehunter (Player 1) uses Anchor Smash
> Player 2 takes an action
> Anchor Smash is not available, it is in cooldown. Earthshaker takes another action
> Player 2 takes an action
> Anchor Smash is not available, it is in cooldown. Earthshaker takes another action
> Player 2 takes an action
> Anchor Smash is not available, it is in cooldown. Earthshaker takes another action
> Player 2 takes an action
> Anchor Smash is available now, Earthshaker can use it.

2.2 Attack, Damage & Armor

The attack damages are given for each hero at Table 1. As observed, these are not discrete numbers, there is some randomized operations. During the project, you need to implement a random damage if player selects to attack.

Damage(turn,percent/value,value), enemy Attack(same), enemyMana, Evasion, cooldown, mana usage

Table 2: The list of skills and detailed information.

Skill Name	Type	Details	Cooldown	Mana Usage
Wraithfire Blast	Active	300 Damage	5 turns	140
Vampiric Aura	Passive	Heals itself with the 15% of the given damage	-	-
Anchor Smash	Active	225 Damage, Decrease Enemy Attack 60% for 1 turn	3 turns	60
Ravage	Active	380 Damage	8 turns	325
Storm Hammer	Active	325 Damage,	5 turns	140
God's Strength	Active	x2 Damage for 3 turn	5 turns	200
Fissure	Active	260 Damage	5 turns	170
Enchant Totem	Active	x4 Damage for the next attack	5 turns	50
Impale	Active	260 Damage	5 turns	225
Mana Burn	Active	Decrease 20% of the enemy Mana	5 turns	50
Blur	Passive	40% chance of evasion	-	-
Coup de Grace	Passive	x4 Damage with 15% chance	-	-
Starstorm	Active	300 Damage	4 turns	160 Mana
Sacred Arrow	Active	320 damage with 75% chance	4 turns	100
Mana Break	Passive	Decrease 100 Mana per attack	-	-
Mana Void	Active	1.1 x (enemy missing mana) as Damage	7 turns	275
Earth Spike	Active	260 Damage	5 turns	160
Finger of Death	Active	850 Damage	8 turns	650
Split Earth	Active	300 Damage	5 turns	160
Pulse Nova	Active	50 spell damage at each turn	-	150 for each turn
Frost Bite	Active	300 Damage	5 turns	150
Freezing Field	Active	800 Damage	8 turns	600
Fireblast	Active	220 Damage	5 turns	225
Multicast	Passive	60% chance for x2 damage with Fireblast 25% chance for x3 damage 12.5% chance for x4 damage	-	-

For example, damage for Tidehunter is 139-145. If player choose to attack, a number between 139 and 145 is randomly selected as the given damage (139 and 145 are included). Let's say that the game chooses 141 as the given damage.

However, this does not mean that 141 HP is decreased from the enemy hero because there is the effect of armor. The decrease in the HP is calculated like this:

$$ActualDamage = GivenDamage * (1 - (0.06 * EnemyArmor)/(1 + (0.06 * EnemyArmor)))$$

(Hint: Round if ActualDamage is floating)

As an example case, suppose Skeleton King and Mirana is fighting. The player using Skeleton King chooses to attack and the given attack is randomly selected as 152 (it is between 151-153). Since the armor of Mirana is 16, the actual damage (decrease in HP) is calculated as this:

$$ActualDamage = 152 * (1 - (0.06 * 16)/(1 + (0.06 * 16)))$$

$$ActualDamage = 78$$

So, 78 HP is decreased from Mirana after this attack.

The skills or spells are not affected by the armors. Their effect is explicit. If Lion uses "Finger of Death", 850 HP is decreased from the enemy hero.

Watch out: The Vampiric Aura of Skeleton King considers the ActualDamage, not GivenDamage.

3 Items

At the beginning of the game, 11000 golds is given to each player. With these golds, the player can buy items before starting the game, after choosing the heroes. The list of the allowed items are given at Table 3. You cannot buy every item you want because of the costs of the items!

Table 3: The list of items and detailed information.

Item Name	Cost	Details
Battle Fury	4500 gold	+55 Damage, +50 Mana at each turn
Hood of Defiance	2000 gold	Decrease 25% of the skill damage taken
Vitality Booster	1200 gold	Increase Max HP by 250
Energy Booster	1100 gold	Increase Max Mana by 250
Butterfly	5500 gold	+30 Damage, 25% evasion
Daedalus	5500 gold	+75 Damage, 25% chance of x2 damage
Desolator	4000 gold	+50 Damage, Decrease enemy armor by 5 (only once)
Vanguard	2500 gold	+250 Max HP, 20% chance of decreasing the received damage by 60
Heart of Tarrasque	5600 gold	+250 Max HP, increase current HP by 7% at each turn
Health Potion	200 gold	+300 current HP
Mana Potion	200 gold	+ 300 current Mana

The items are available at each turn and players does not have to activate them. After the players choose their heroes, they can choose 4 of the items at the list given at Table 3. One can buy 2 or more of the same item type. However, watch out this rule: If you buy 2 Butterfly, the evasion chance is not 50%, it is 37.5%. If you buy 2 Vanguards, this means that the decreased damage is 60 with 30% chance. In other words, it does not decrease

120 damage with 20% chance. The 60 damage is decreased from the ActualDamage, not the GivenDamage. If GivenDamage is 152, the ActualDamage is 88 as mentioned. If the enemy hero has Vanguard, the received damage is 28 with 20% chance, not 92. On the other hand, 2 health potion is considered as 1 item. Same applies for the mana potion. If you buy 2 mana potion, it is considered as 1 item, not 2. So buying 2 potion instead of 1 does not waste your item slot.

(Hint: Evasion is the chance of dodging the enemy attack. Does not work against enemy skills. If you have Butterfly, you have 25% chance to dodge the enemy attack at a turn.)

For items that provide features with a certain probability "x" (such as 25% chance of evasion), buying "n" pieces of the same item results in the chance:
Total Chance = x + x/2 + x/3 + ... + x/n.

For instance, 2 Daedalus = 37.5% of x2 damage, 3 Daedalus = 25 + 12.5 + 8.33 = 46.

These calculations only apply for the probabilistic stuffs. Buying 2 Battle Fury will give a hero +110 Damage and +100 Mana (mana increase at each turn).

(Hint: The calculation for the probabilistic features only applies when a player buys the same item more than once. If a skill and item provides a certain chance for the same feature, you can simply sum them. For instance:
Mortred without any item – 40% chance of evasion
Mortred with 1 Butterfly – 40 + 25 = 65% chance of evasion
Mortred with 2 Butterfly – 40 + 25 + 25/2 = 77.5% of evasion)

At each turn, a player can attack, use a skill or use a potion. It is not possible to use a potion and attack at the same turn. So, be careful about the usage of the potions, you need to determine the most appropriate turn!

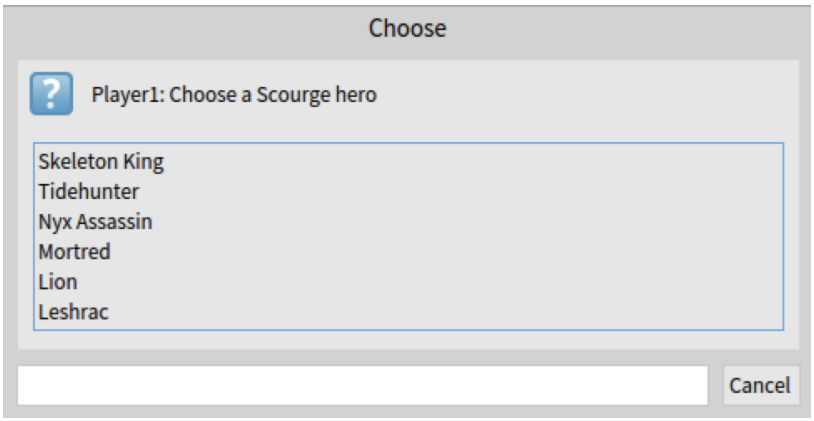


Figure 1: Choosing a Scourge hero for Player1.

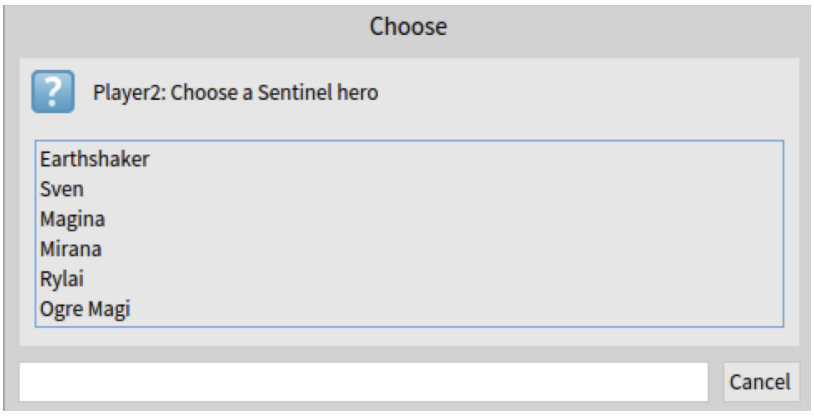


Figure 2: Choosing a Sentinel hero for Player2.

4 Gameplay & Rules

When the game is started, a popup appears at the screen that gives the list of heroes of Scourge. After Player1 chooses a hero from the given list, another popup appears that gives the list of Sentinel heroes. The Player2 chooses a hero from the list. Now it is time to buy items. After Player1 buys items from the list, Player2 does the same thing. The remaining golds after each buying should be printed on the Transcript. If there is still a slot for a player but not enough golds for any item, there should not be any more popup for asking to buy item. An example case of starting the game is depicted in Figure 1, Figure 2 and Figure 3.

After the players are ready, Player1 takes the first action. Then, Player2 takes an action.... The game goes on like this until the HP of a hero reaches to zero. After each turn, the Transcript should print these information for each player in addition to the turn information:

- Hero
- Recent HP / Max HP
- Recent Mana / Max Mana
- Last Action
- Remaining potions
- Skills in Cooldown

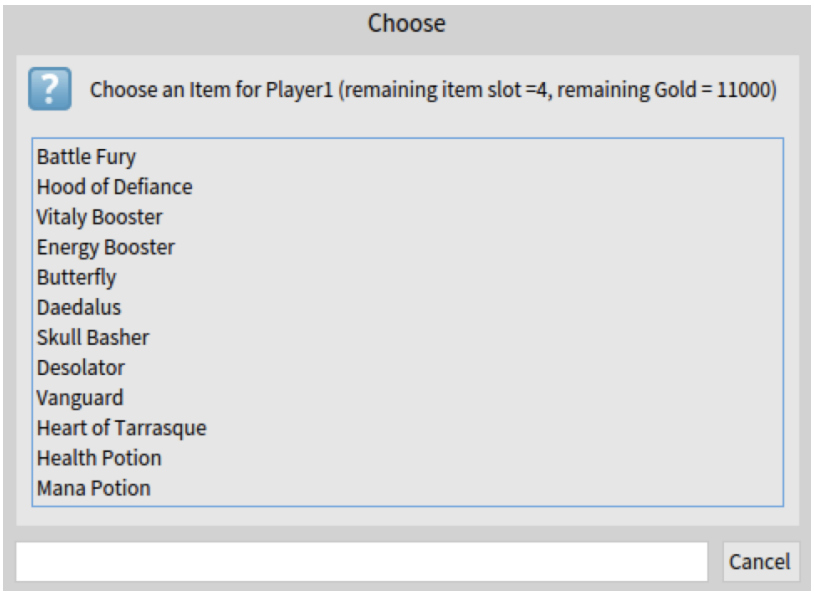


Figure 3: Buying an item for Player1.

Example Log after a turn
Player1's turn!

Player1
Hero: Earthshaker
570 / 2270 HP
1125 / 1030 Mana
Last Action: Fissure
Remaining Potions: 1 Health, 1 Mana
Skills in Cooldown: Fissure (not available for 2 turns)

Player2
Hero: Nyx Assassin
800 / 1784 HP
200 / 1149 Mana
Last Action: Health Potion
Remaining Potions: None
Skills in Cooldown: None

This kind of logging should be provided by Transcript after a player takes an action. After the HP of a hero reaches to zero, the Transcript should print the recent status, then it should announce the winner of the game.

The end of the game
Player1
Hero: Earthshaker
570 / 2270 HP
1125 / 1030 Mana
Last Action: Fissure
Skills in Cooldown: Fissure (not available for 2 turns)

Player2
Hero: Nyx Assassin
0 / 1784 HP
200 / 1149 Mana
Last Action: Impale
Skills in Cooldown: Impale (not available for 1 turn)

Player1 (Earthshaker) is the winner of the game !!!

5 Implementation Details & Rules

The implementation of the project has a format. Firstly, you need to create the following classes by considering the hierarchy:

- Dota
  - GameArena
  - Hero
    - Scourge
      - Skeleton King
      - Tidehunter
      - Nyx Assassin
      - Mortred
      - Lion
      - Leshrac
    - Sentinel
      - Sven
      - Earthshaker
      - Mirana
      - Magina
      - Rylai
      - Ogre Magi
  - Item
    - Battle Fury
    - Hood of Defiance
    - Vitality Booster
    - Energy Booster
    - Butterfly
    - Daedalus
    - Desolator
    - Vanguard
    - Heart of Tarrasque
    - Health Potion

* Mana Potion

You need to add the corresponding variables and methods for the classes. There is not any strict format for the name of the variables and methods, excepts the method for starting the game. The game should start like this:

Starting the game
GameArena start.

The popup boxes should appear as in the Figure 1, Figure 2 and Figure 3. The ordering of the hero names and items names are up to you in the boxes. After the game starts, it should follow a loop until the end of the game. If you want to play one more game, you need to execute the code above (GameArena start.) again.

6 Standards

Although the whole document gives you the exact formats of some classes and methods, this section summarizes them all. Beside of these, you can implement other methods or required stuffs in any method you want.

- You must use Pharo as Smalltalk environment for implementing your project.
- The names of the classes and the hierarchy are given at Section 5. The format is strict. However, you can create your own classes in addition to them.
- If required, define constructors as abstract and leave the responsibility to the subclass.
- The game should start with **GameArena start.**
- After the code is executed, a popup should appear and asks Player 1 to select a hero from Scourges. Then, another popup should ask Player 2 to select a hero from Sentinels. After the hero selection is done, initially Player 1 buys items by selecting from the popup list. After Player 1 buys the first item, another popup may appear to buy the second item, until the slot is full. However, if there is still slot for Player 1 but not enough gold for any item, the item popup should not appear any more. Then Player 2 does the same. After the players buy the items, the game starts with a popup asks Player 1 to take an action with (Attack, Use Potion, Use Skill). An example illustration is given in Figure 4.
- The method for damage calculation should be implemented at "Hero" class. GameArena is the one that sends "damageCalculation" message with its parameters to the "Hero" class.
- After each turn, the Transcript should print the recent status for each hero. The information and the format are given at Section 4.
- If the HP of a hero reaches to zero, the Transcript should print a message and announce the winner. The format is given at Section 4.
- The game is turn-based. The players take actions sequentially.

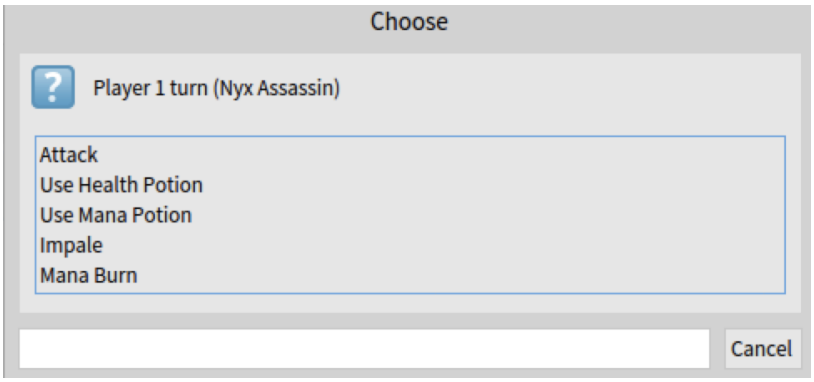


Figure 4: Taking an action for Player 1.

- The heroes should not access to enemy heroes variables (even with get methods) and should not modify anything with set methods. The only authorized mechanism for setting and getting variables is **GameArena**. All HP decreases in case of an attack or skill usage, armor modifications etc. should be done by GameArena. On the other hand, a hero should not modify itself too. If Player 1 uses a potion, GameArena should increase its HP.
- The hierarchy and inheritance should be taken into consideration. For example, the common variables (such as HP) and their get-set methods should be defined at the "Hero" class instead of declaring them for every single hero class.

7 Details of Part 1 & Part 2

This project consists of 2 separate parts. Part 1 covers the creation of the classes (with variables), the hierarchy and the declaration of the methods (not the implementation of them). Part 1 compose the 30% and Part 2 compose the 70% of the total grade.

1. Part 1 (30% of the total grade)
   - **Deadline: April 27, 2017 23:55 PM**
   - Creating the classes and the hierarchy
   - Defining the variables of the classes
   - Declaring the methods for each class (implementation is not included in this part)
2. Part 2 (70% of the total grade)
   - **Deadline: May 14, 2017 23:55 PM**
   - Using Part 1 as a base of the game
   - Implementation of the methods
   - Implementing the main logic of the game
   - Creating the game that is playable between 2 people with a turn-based manner

8 Submission Process

- Your classes should be included in a new package. The name of your package should be [StudentID] without the brackets. So that, when you export your package consists of your codes, the exported file will be **StudentID.st**
- It is obligatory to write comments for each of the class and instance methods.
- You should group the methods under appropriate protocols.
- Submit a zipped file on Moodle until the given deadline.
- For Part 1:
  - Submit **StudentID.st** which includes the class definitions, hierarchy and method declarations.
  - Submit your file to the **"Smalltalk Project - Part 1"** at the Moodle until the given deadline.
- For Part 2:
  - Submit a zipped file to the **"Smalltalk Project - Part 2"** at the Moodle until the given deadline. The zipped file should include:
    - **StudentID.st** which includes the everything you have implemented (including Part 1).
    - **StudentID.txt** which should include a couple of lines or a paragraph that explain how to start the game.
    - The name of the zipped file should be **[StudentID].zip** without the brackets.
- There will be no late submission. Be aware that, you need to submit all of the projects in order to pass the course.
- There will be demo sessions for Part 2 and you need to demonstrate your applications. The period of demo sessions will be announced. Each demo for a person will consist of 5 minutes.