Telecom SudParis
Msc CCN

Formal Software Engineering

Scrabble Project Document

Msc Computer and Communication Networks

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Date: 24th December, 2014

PROPERTIES OF THE SCRABBLE BOARD

Components of the game:

1- The game is played by one player.

2- 15x15 square grid.

3- 100 tiles, each tile contains a letter with its point value. Each tile can fit on one square of the grid. There is a special blank tile which is worth no points, it can be used a substitute for any letter chosen by the player after that it is fixed.

4- On the board there are special squares; if a word is placed on any of these squares the added score will be increased as follows:

a. DL: Double letter square where the point value of the letter is doubled when calculating the score for the word.
b. TL: Triple letter square where the point value of the letter is tripled when calculating the score for the word.
c. DW: double word square where the score of the whole word is multiplied by 2.
d. TW: triple word square where the score of the whole word is multiplied by 3.
e. The middle square of the grid where the first word must pass through is treated as a DW.

RULES OF THE GAME

1- The player draws randomly 7 tiles from the bag that contains 100 tiles initially.

2- Using the 7 tiles in his possession the player forms a word with one of the letters on the square in the centre of the board (starting point), either horizontally (left to right) or vertically (top to bottom) and this word must be a valid one (exists in the chosen dictionary).

3- At each turn the player can:

a) Place a word on the board, the word must have one of its letters attached to a tile that already existed on the board (with exception to the very first turn as specified before).

b) The placed letters must align in one row or column. More than one word can be formed in the same turn by intersecting with other existing tiles to form new words. The new word formed must not change an existing word from valid to invalid.

c) The player must draw tiles from the bag with the same number of letters that were placed on the board to make up 7 tiles again.

d) Exchange Tiles: Replace any number of tiles in his hand by the same number from the bag. The bag should at least contain seven tiles to be able to exchange tiles.

e) Pass: When the player cannot add any other word thus the game ends.

4- The game ends when:

a. When all tiles are placed on the board.
b. When the player cannot add any other word by choosing to pass.

CALCULATING THE SCORE FOR A WORD

1- The player starts with 0 points. After the player places a word on the board, the sum of the point values of each tile is added to the previous score taking into consideration the special squares mentioned previously. The tiles and corresponding point values are shown in table 1.
2- When the game ends, if the player still has tiles in hand, the sum of the point values of those tiles is deducted from the overall score.

Point Value	**Letter x Frequency**
0	Blank tiles x 2
1	**E** ×12, **A** ×9, **I** ×9, **O** ×8, **N** ×6, **R** ×6, **T** ×6, **L** ×4, **S** ×4, **U** ×4
2	**D** ×4, **G** ×3
3	**B** ×2, **C** ×2, **M** ×2, **P** ×2
4	**F** ×2, **H** ×2, **V** ×2, **W** ×2, **Y** ×2
5	**K** ×1
8	**J** ×1, **X** ×1
10	**Q** ×1, **Z** ×1

Table 1

USE CASES AND EXAMPLES:

Various examples of valid and invalid plays for the scrabble are shown in this section.

First Turn

In this turn a player can place a word on the board using the tiles in his possession. This word can be placed either horizontally (left to right) or vertically (top to bottom), at least one of the placed tiles must pass by the middle square. The score of the word formed will be multiplied by 2 as it passes by a special square which is the central square.

TW			DL				TW				DL			TW
	Dw				TL				TL				Dw	
		Dw				DL		DL				Dw		
DL			Dw				DL				Dw			DL
				Dw						Dw				
	TL				TL		A		TL				TL	
		DL				DL	G	DL				DL		
TW			DL				R				DL			TW
		DL				DL	E	DL				DL		
	TL				TL		E		TL				TL	
				Dw						Dw				
DL			Dw				DL				Dw			DL
		Dw				DL		DL				Dw		
	Dw				TL				TL				Dw	
TW			DL				TW				DL			TW

Figure 1

Figure 1 shows a valid play for the first turn, the word ‘agree’ exists in the dictionary, its vertical and passes by the middle square. The score of the player after this turn will be the summation of the score of each tile, then multiplied by 2; (A(1) +G(3) +R(1) + E(1) + E(1)) *2 = 14

Example 2

TW							TW							TW
	Dw				TL				TL				Dw	
		Dw				DL		DL				Dw		
			Dw				DL				Dw			
				Dw						Dw				
	TL				TL				TL				TL	
		DL				DL		DL				DL		
TW			DL				A	G	R	E	E			TW
		DL				DL		DL				DL		
	TL				TL				TL				TL	
				Dw						Dw				
			Dw				DL				Dw			DL
		Dw				DL		DL				Dw		
	Dw				TL				TL				Dw	
TW							TW							TW

Figure 2

Figure 2 shows another valid play for the first turn where the word ‘AGREE’ is placed horizontally. The score after this turn (A(1) +G(3) +R(1) + E(1) + E(1)) *2 is 16.
N.B: Here the last letter ‘E’ passed by a DT square thus its point score is doubled (2 points) when calculating the score.

Example 3

TW							TW							TW
	Dw				TL				TL				Dw	
		Dw				DL		DL				Dw		
			Dw				DL				Dw			
				Dw						Dw				
	TL				TL		A		TL				TL	
		DL				DL	G	DL				DL		
TW			DL				R				DL			TW
		DL				DL	Z	DL				DL		
	TL				TL		E		TL				TL	
				Dw						Dw				
			Dw				DL				Dw			DL
		Dw				DL		DL				Dw		
	Dw				TL				TL				Dw	
TW							TW							TW

Figure 3

Figure 3, shows an invalid play. The word ‘AGRZE” does not exist in the dictionary, the play will be rejected and the player will be asked to place a new word.

Example 4

TW							TW							TW
	Dw				TL				TL				Dw	
		Dw				DL		DL				Dw		
			Dw				DL				Dw			
				Dw						Dw				
	TL				TL				TL				TL	
		DL				DL		DL		T		DL		
TW			DL							W	DL			TW
		DL				DL		DL		O		DL		
	TL				TL				TL				TL	
				Dw						Dw				
			Dw				DL				Dw			DL
		Dw				DL		DL				Dw		
	Dw				TL				TL				Dw	
TW							TW							TW

Figure 4

Figure 4, shows an invalid play as the word ‘TWO’ though it exists in the dictionary, it does not pass by the the middle square coloured in red. The play will be rejected and the player will be asked to place another word passing through the central square.

Example 5

TW							TW							TW
	Dw				TL				TL				Dw	
		Dw				DL		DL				Dw		
			Dw				DL				Dw			
				Dw						Dw				
	TL				TL				TL				TL	
		DL				DL	G	DL				DL		
TW			DL				R				DL			TW
		DL				DL	O	N				DL		
	TL				TL		W		TL				TL	
				Dw						Dw				
			Dw				DL				Dw			DL
		Dw				DL		DL				Dw		
	Dw				TL				TL				Dw	
TW							TW							TW

Figure 5

Figure 5, shows an invalid play, though the words ‘GROW’ and ‘ON’ exist in the dictionary, in one turn all these words must be align at the same row or column. The play will be rejected and the player will be asked to place a valid word.

Design Phase

This phase of the life cycle of the scrabble game provides entity relationship between the various components of the game and how the game will be modeled.
The entities involved in the design phase are the following;

- Player
- Scrabble Board
- Bag of tiles
- Dictionary

Entity Relationship

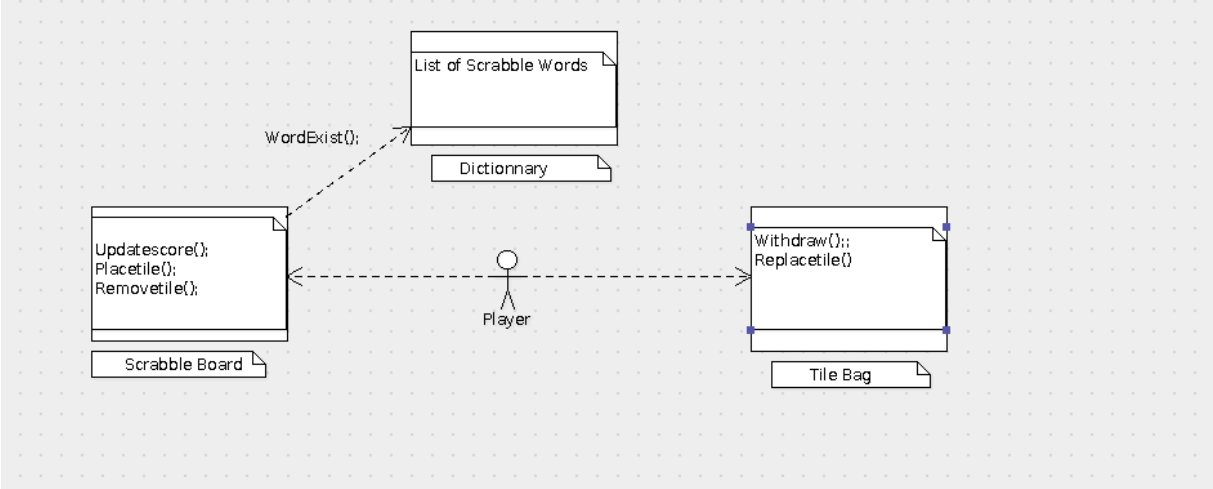

Fig 2

Below are relationship between the Player and other entities;

- The player has the ability to place and remove tiles from the scrabble board.
- The player can only have seven (7) tiles at a time. The player should have seven (7) tiles after each turn, unless the tiles in the bag are not enough.
- Player has the liberty to exchange any number of tiles in possession with any random equivalent number of tiles from the bag of tiles. The bag should have at least 7 tiles to do so.

- The player can pass a turn i.e. player can no longer form or add a new word to the board hence the game ends and final score is displayed to the user.

Scrabble Board and its relationship with other entities;

- The scrabble board checks for words played for existence in the dictionary.
- It updates the user with the score for any valid word added or formed. Tiles can be placed on the board and can also be removed by the player. Tiles that can be removed are the ones placed in the same turn.

Bag of Tiles and its relationships;

- This contains a collection of tiles which the player can have access to.

Dictionary

- The dictionary contains a collection of words.
- The scrabble board checks with the dictionary for validity of a word

Testing Phase

Test cases were developed for the main functions for these files i.e bag.c, board.c

Bag Test Cases

There were six(6) different test cases developed for the bag. These test concern the initialisation of the various bags used during the scrabble game. The bag_inhand, real_bag, size_bag and displaying both the bag_inhand and the real_bag were all successfully tested and no bugs found.
Also test cases were developed for refilling the bag with letters, withdrawing letters randomly from the bag and also the option to exchange letters. No bugs were found during these test cases too.

Board Test Cases

Various test cases were developed for the main functions and these exposed some bugs in our program. Below are some of the challenges faced during the board testing phase

Testing 2nd Play with three words

We had a challenge of updating the score correctly with the second play where the added words are identified correctly but the score is updated with an incorrect value..

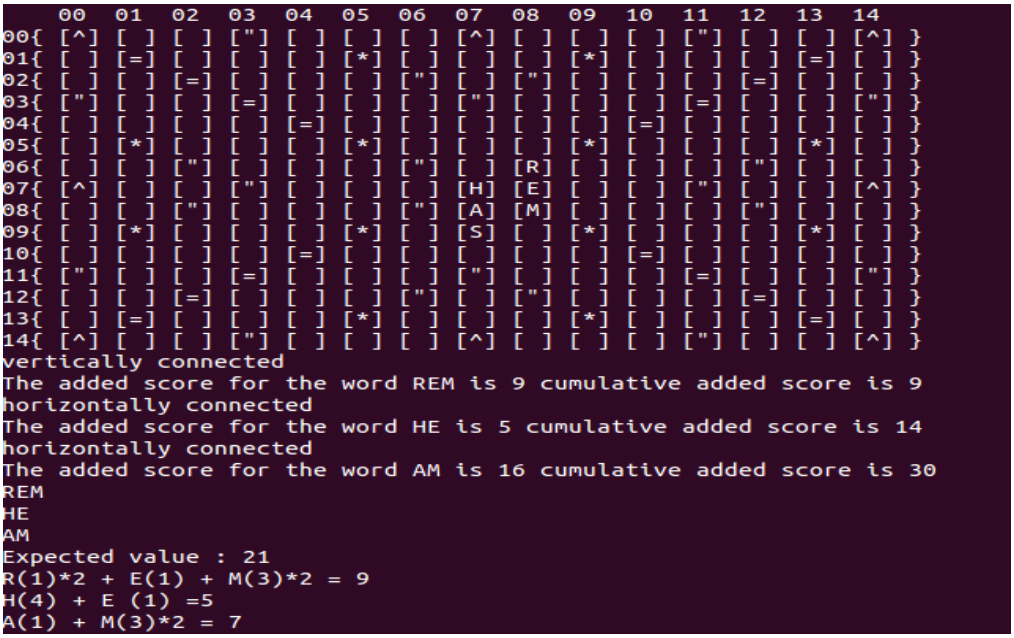

Fig 1

Fig 1, is a screenshot of a test case for the second play where the word “AM” was to be updated with the score 7 but instead updates the score of “AM” with a 16 which is invalid.

Testing 2nd Play with four words

In the 2nd play, we also had an issue updating the score correctly with the word placed on the board. All new words are identified correctly but the score is not correctly updated.

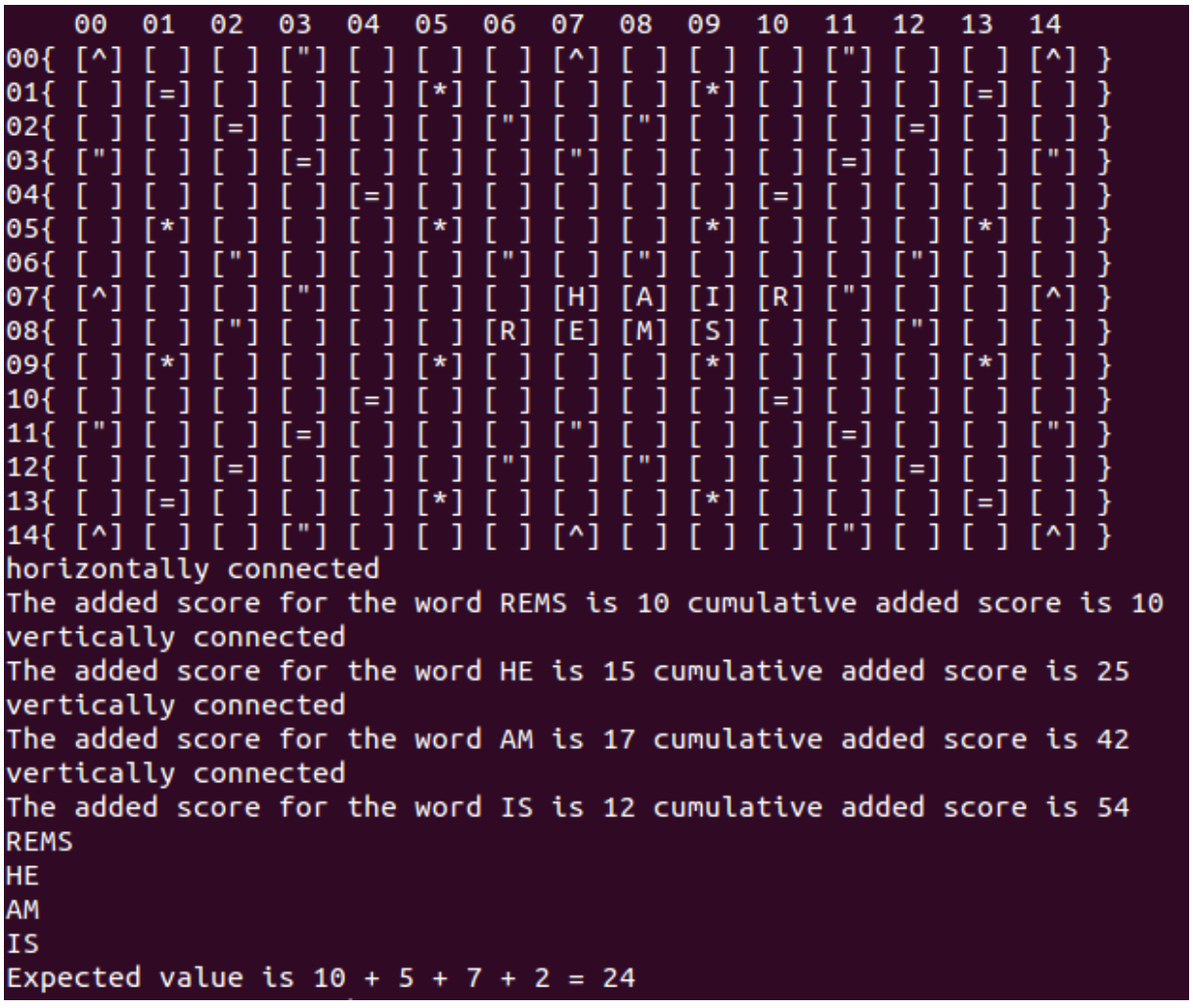

Fig 2

Fig 2 , shows the challenge of updating the of score of “HE”, “AM” and “IS” correctly as these words were to be update with 5 , 7 and 2 respectively. We have the score being updated as 15, 17 and 12 for these three (3) words respectively making it invalid.

Place tile Test case

In the test case to place a letter on the board, we noticed an unexpected behaviour after placing the first (1st) letter on the board. A blank letter is added to the bag in hand of the user. Other letters from the second (2nd) position to seventh (7th) behave as expected. However this unexpected behaviour is not experienced in the main scrabble game play.

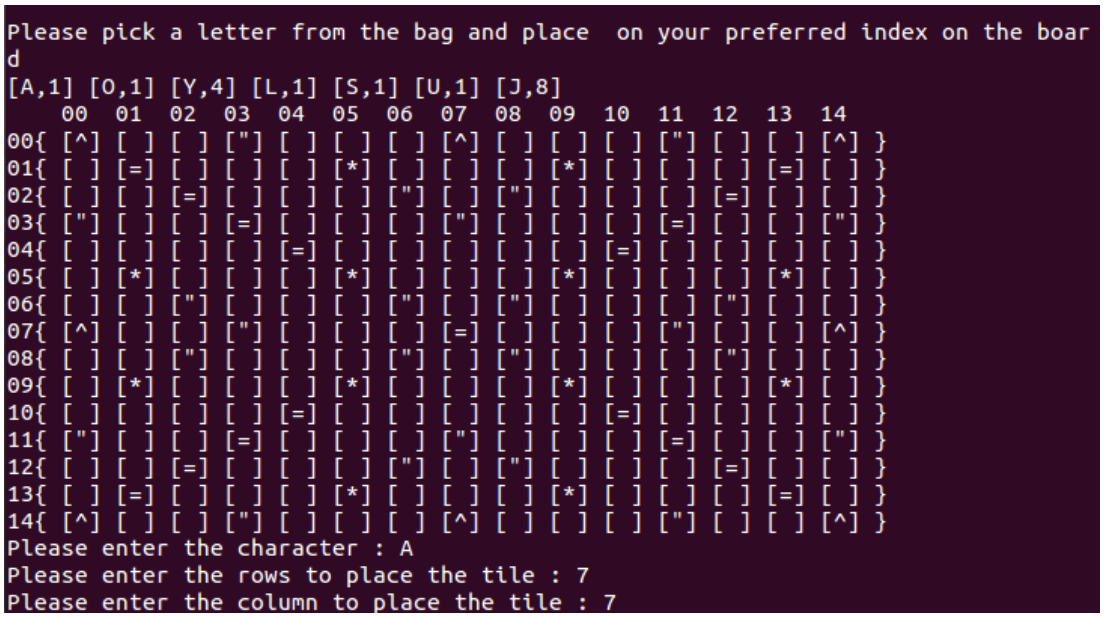

Fig 3

Fig 3, shows the state of the board and bag in hand (contains letters for the user) and a choice made to place A in index row: 7 and col: 7 on the board.

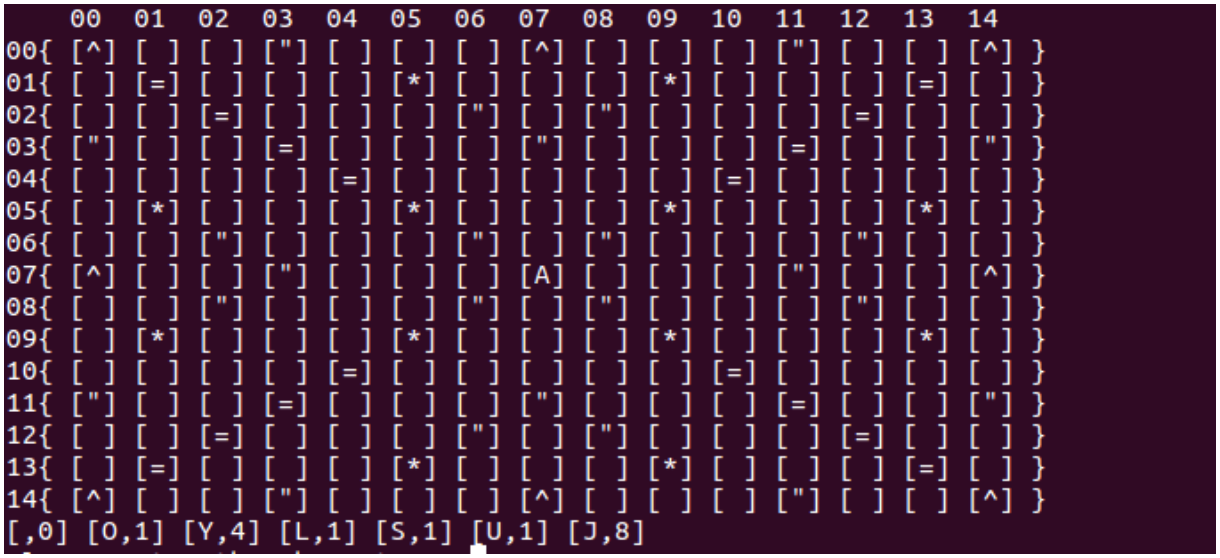

Fig 4

Fig 4, shows the state of the board and bag in hand (contains letters for the user) after placing the letter A on the board. It can be observed that an extra letter with a point value of 0 (meaning a blank tile) has been added to the bag in hand instead of the bag displaying 6 letters remaining.

References:

http://en.wikipedia.org/wiki/Scrabble_letter_distributions#English

https://www.youtube.com/watch?v=swlg3vQXboE

http://www.tutorialspoint.com/uml/