Bilkent University

Department of Computer Engineering

CS319 Project - Risk

Analysis Report

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1. Introduction

Risk is a strategic board game that represents diplomacy, conflict, and conquest that is played by two to six players. The game is played on a map that contains 6 continents that include 42 territories, with real-life geographical borders and political regions [1]. The game was first introduced in France in 1957, with the name La Conquête du Monde (The Conquest of the World), which was invented by Albert Lamorisse, a French film director [1]. In 1959, the game's rules were modified by the Parker Brothers and were released as *Risk: The Continental Game,* then as *Risk: The Game of Global Domination* [1]. The board game is composed of the map, the army troops, including infantry, cavalry, artillery pieces, 5 - 6 dice, and risk cards, that are composed of cards that represent each territory, mission cards, and wild cards. Players play in turns, using the army pieces to try to conquer other player's territories. The main aim of the player is to attack and occupy other player's territories and eliminate them from the game. The last standing player, who conquered all territories, is the winner of the game.

2. Overview

The Risk game we are going to implement will be an online version of the classical board game, that can be played by 3 - 5 players and on different screen sizes. The general rules of the board game will be implemented. Our version of the game is going to be implemented using React.js and Redux for the frontend, firebase for data management, like storing the game's data including players' scores and information, and saved games to be able to load them in the future again. The game will contain different maps that players can select between, including the original map of the risk board game. The players will have the option to save and load games if they want to stop the game and continue it later. Besides, high scores and previous players' scores will be tracked and saved.

2.1. Gameplay

The gameplay will be very simple for the players to use. The main player at first would log in if he has an account or sign up if he does not have an account. After the login is

successful, the player will be asked to enter the number of players, which can be 3 – 5 players inclusive. After the number of players has been selected, each player will start by rolling only one dice, which can be done by pressing the roll button that appears for each player. The player that receives the highest dice number will start by deploying one troop in a country of his/her choice, then moving counterclockwise the players will deploy one troop each until all the countries on the map are occupied. To deploy troops the players, in turn, would click on the country that they want to occupy. After all the countries are occupied, the number of troops for each player will be calculated. Starting with the first player, who was decided earlier by the highest dice roll, and moving counterclockwise, the players, in turn, will start by deploying the troops they received in the countries that they occupy after the player finishes deploying his/her troops, the player would have two buttons to choose between, either to pass or to attack. If the player decides to pass, the next player repeats the process starting from deployment and then choosing either to attack or pass.

On the other hand, if the player decides to attack a country, he/she can only attack the bordering countries to his/her country that he is attacking from and must leave at least one troop behind in the country that the attack is coming from. For the player to attack a neighboring country, he/she will press on the country they want to attack. The player attacking and the player being attacked both receive dice. Both players will roll the dice by pressing on the roll button and the highest dice from each player will be compared, and accordingly the winning and losing player will be decided. If the attacking player wins, he/she must move troops to the country conquered and receive a risk card. The player can decide to attack again or to pass. After collecting the number of cards required, the player may trade them in for additional troops by clicking on the trade button. In the end, the winner is the one who conquered all countries on the map. The players can stop playing at any time, saving the game's progress and loading it later when they want to continue playing.

2.2. Risk Play Pieces and Their Use

This version of the game will include 3 different maps, including the original map of the board version. There will also be 5 different colors for the armies to be chosen from. The

army pieces will be similar to the board game, in which there will be 3 different pieces. The army pieces include the infantry, the cavalry, which is counted as 5 infantry, and the artillery that is counted as 10 infantry or 2 cavalries. Besides, the game will include risk cards that will only contain the territory cards. And Finally, 5 – 6 dice that will include 2 colors 3 dice for each.

At the start of the game, the players will be able to choose between different map versions to play on. The army pieces will be used for attacking and conquering the countries. The number of infantries at the start per player will be decided using the formula 50 – 5n, where n is a number between 3 and 5 inclusive. Later in each turn, the players will receive x / 3, disregarding the remainder, pieces of troops, where x is the number of countries owned by the player. The players can receive additional troops by trading in cards they have. The players will deploy the troops they received, and they can decide either to attack or pass. In attack, the attacking player receives 3 dice of one color and the defending player receives two dice of the other color. The players roll the dice and the lowest dice roll by the attacking player is set aside and the highest dice roll of the attacking player is matched with the highest dice roll of the defending player and the second dice is matched with the second die. If the dice of the attacking player is higher than the defending player one of the defending player's troops is removed per dice, but if the dice of the defending player is higher than or equal to the dice of the attacking player, the attacking player loses one troop per dice.

3. Functional Requirements

1. Log in or sign up

At the beginning of the game, the players will either login if they already have an account or sign up if they do not have an account.

2. Choose number of players to play the game

The user would be able to choose the number of players to play the game.

3. Choose between different armies

The player can choose between different colors that will be set as the army pieces' color.

4. Choose different maps

There will be different maps including the original map of the classical board game that the players can choose between.

5. Deploy armies in the conquered countries.

At the start of the game each of the players will have a certain number of troops, and each player, in turns, will start to deploy one troop per turn. Besides, in the turn of each player, the player would be able to add new pieces to the countries he/she conquered, the number of pieces that the player receives to deploy will be decided according to the game rules.

6. Attack neighbouring countries or pass

After the player has deployed the armies in the countries, he/she can either attack other neighboring countries or skip attacking and moving on to the next player.

7. Win a new card for every new country conquered

If the player succeeded in conquering a new neighboring country, he will receive a card for every new country he/she conquered, after collecting a certain number of cards the player can substitute the cards with a certain number of army pieces to deploy in his/her countries.

8. Trade cards after having a certain number of cards

After the player receives a certain number of cards as defined by the rules of the game, the player can trade them in for new troops to deploy in his/her countries. In addition, the number of troops received depends on the number of trades the player has done until he/she reaches a certain number of trades in which the number of received troops will be constant starting from that point and forward on.

9. Save and load the game

The players would be able to save the game to the point they stopped at and can later on load it again.

4. Non Functional Requirements

1. Performance

The game will be built to work smoothly for a user. At any time, the frame rate will not drop below 30 frames per second so as to be noticed by the players.

2. Accessibility

The screen at all times will have no more than 4 buttons to ensure that the player is able to easily access them. The icons for the buttons will be used purposefully to allow the user to interact with them easily.

3. Experience

The player who is going to take a turn will be presented with guidance arrows and popups to guide them towards possible moves. This will increase the user experience.

4. Maintainability

The codebase will be written to ensure that in the future if the number of players who can play the game is to be updated, it can be done with the minimest possible changes. Reusable components will be used to make sure that no duplication of functionality occurs to prevent any future corruptions.

4.1 Pseudo Requirements

The game will be implemented with React.js and JavaScript for the frontend and google firebase for data management.

The game drawings such as the maps will be drawn using Adobe illustrator.

5. System Models

5.1 Use case Model

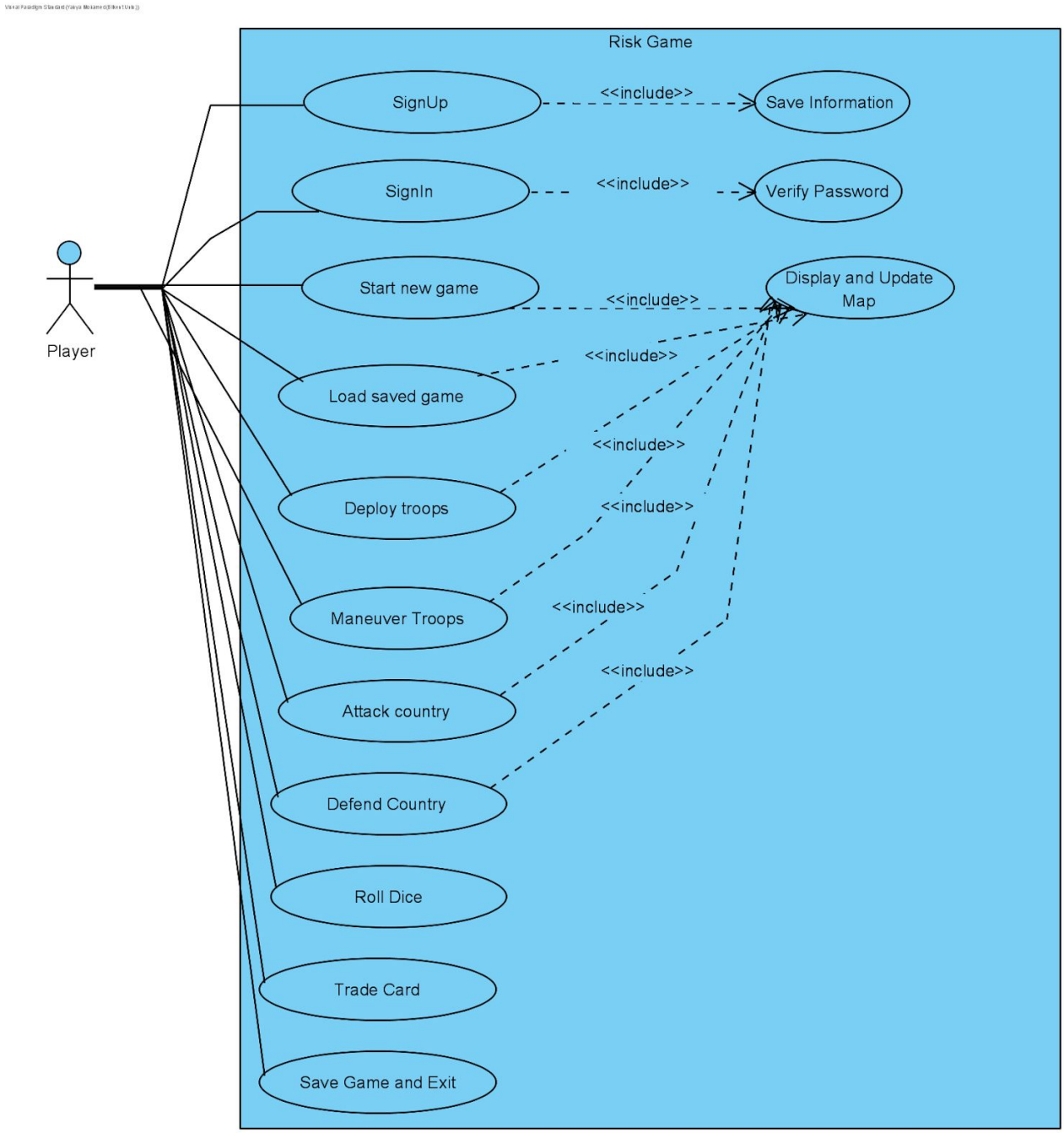

Figure 1 (Use Case Diagram)

5.1.1 Use Case Descriptions

1. **SignUp:**

   Name: SignUp

   Participating Actor(s): Player

   Entry Condition(s): The player opens the game

   Exit Condition(s): The Player enters his information to SignUp.

   Flow of events:

   a. The player opens the game
   b. The SignUp/SignIn window shows up.
   c. Player clicks on “SignUp”
   d. Player enters his information and they get saved in the game’s DataBase.

   Special Requirement(s): None

2. **SignIn:**

   Name: SignIn

   Participating Actor(s): Player

   Entry Condition(s): The player should have an account in the game.

   Exit Condition(s): The Player enters his username and password and they are validated by the server.

   Flow of events:

   a. The player opens the game
   b. The SignUp/SignIn window shows up.
   c. Player clicks on “SignIn”
   d. Player enters his information and they get validated by the game server.
   e. **Special Requirement(s):** None

3. **Start New Game:**

   Name: Start new Game

Participating Actor(s): Player

Entry Condition(s): The player should have an account in the game and be signed in.

Exit Condition(s): The Player starts playing and conquering countries.

Flow of events:

a. The player opens the game
b. The SignUp/SignIn window shows up.
c. Player clicks on “SignIn”
d. Player enters his information and they get validated by the game server.
e. The Player starts playing and conquering counties

Special Requirement(s): None

4. Load Saved Game:

Name: Load saved Game

Participating Actor(s): Player

Entry Condition(s): The player should have an account in the game and be signed in and have a saved game in his account.

Exit Condition(s): The Player starts playing and conquering countries.

Flow of events:

a. The player opens the game
b. The SignUp/SignIn window shows up.
c. Player clicks on “SignIn”
d. Player enters his information and they get validated by the game server.
e. The player selected one of his saved games
f. The Player starts playing and conquering counties

Special Requirement(s): None.

5. Deploy Troops:

Name: Deploy troops

Participating Actor(s): Player

Entry Condition(s): The player should have troops to be able to add them to the countries he/she owns

Exit Condition(s): All troops the player has in the turn are deployed.

Flow of events:

a. Player will receive certain number of troops in each turn
b. Player will click on owned country by him/her that wants to deploy troops in
c. Specify number of troops to be added out of the troops the player has

Special Requirement(s): None

6. Maneuver Troops:

Name: Maneuver troops

Participating Actor(s): Player

Entry Condition(s): The player should have at least 2 troops to be able to move one of the troops and leave one behind

the countries he/she owns

Exit Condition(s): Troop is placed in the territory wanted.

Flow of events:

a. Player will select one of his/her countries to move troops to
b. Specify number of troops to be moved

Special Requirement(s): None

7. Attack Country:

Name: Attack Country

Participating Actor(s): Player

Entry Condition(s): The player should have at least two troops in the territory he/she is attacking from to leave at least one behind in the territory.

Exit Condition(s): The player defeated all the troops and won the country or lost the battle and can't attack anymore.

Flow of events:

a. The player clicks on attack button
b. The player selects a country to attack
c. The player selects the number of troops to attack with
d. The attacking player and defender player rolls the dice and winner is decided

Special Requirement(s): At least one troop is left behind when attacking. The player must attack only neighbouring countries.

8. Defend Country:

Name: Defend Country

Participating Actor(s): Player

Entry Condition(s): The player should be the owner of a country with at least one troop.

Exit Condition(s): The player lost all the troops, losing the territory or the attack on the player is stopped and there are troops of the defending player.

Flow of events:

a. The player rolls dice and the winner is decided

Special Requirement(s): none

9. Roll Dice:

Name: Roll Dice

Participating Actor(s): Player

Entry Condition(s): The player should be attacking or defending

Exit Condition(s): Dice rolled and winner decided

Flow of events:

a. Player chooses to attack a neighbouring territory
b. Attacking player and defending player dices will be rolled depending on what was decided by player or automatically
c. The dices are compared and winner per dice comparison is decided

Special Requirement(s): None

10. Trade Card:

Name: Trade Card

Participating Actor(s): Player

Entry Condition(s): The player should have cards to trade them in for troops

Exit Condition(s): The player trades in the cards for troops.

Flow of events:

a. The player clicks on trade cards
b. The player specifies the number of cards to trade
c. Player receives additional troops

Special Requirement(s): The player must have at least 5 cards to be able trade them in for troops

11. Save game and exit:

Name: Save game and exit

Participating Actor(s): Player

Entry Condition(s): The player should be signed in.

Exit Condition(s): The game is saved

Flow of events:

a. The player clicks on exit button
b. The player will confirm saving the game if he/she wants to

Special Requirement(s): none

5.2. Dynamic Models

5.2.1 Activity Diagrams

Configure Game Diagram

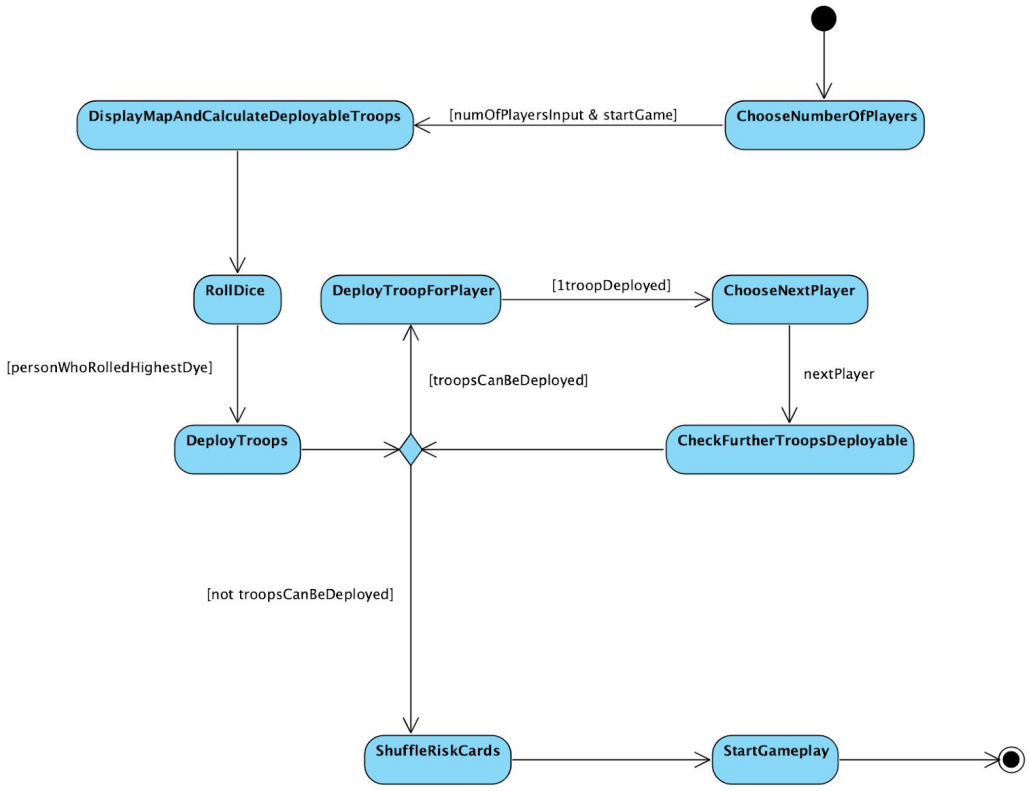

Figure 2 (Configure Game Activity Diagram)

This activity diagram represents the flow of activities during initial fame setup. The main player inputs the number of players that can play the game. This number can range from 3 to 5 inclusive. Upon choosing the number of players, the main player has to start the game using a button. This will trigger the start of the activity 2. Activity DisplayMapAndCalculateDeployableTroops displays the map to the players and calculates the number of troops that can be deployed per person. Upon completion, a dice is rolled as indicated by the RollDice activity, and the activity DeployTroops chooses the first player using the result of the RollDice activity to deploy troops. The rest of the players get turns in a counterclockwise manner. A

decision node is reached after this activity. If troops can be deployed, we transition to the DeployTroopForPlayer activity. Initially, this will be the player who rolled the highest dice number. Since we already know by now who rolled the highest dice number, we do not need to check the player. After the player has deployed 1 troop, we transition to the activity that chooses the next players, namely ChooseNextPlayer. Upon choosing, we transition to the activity CheckFurtherTroopsDeployable. This activity checks if the player is able to deploy troops. We again reach the decision node and carry on the sequence of activities as mentioned above until troops can not be deployed. In the latter case, we transition to the activity ShuffleRiskCards. This activity shuffles the risk cards, as indicated by its name. After shuffling the Risk cards, we reach the activity StartGameplay, which triggers the start of the game. The final activity node is reached.

Game Logic For a Player's Full Turn Diagram

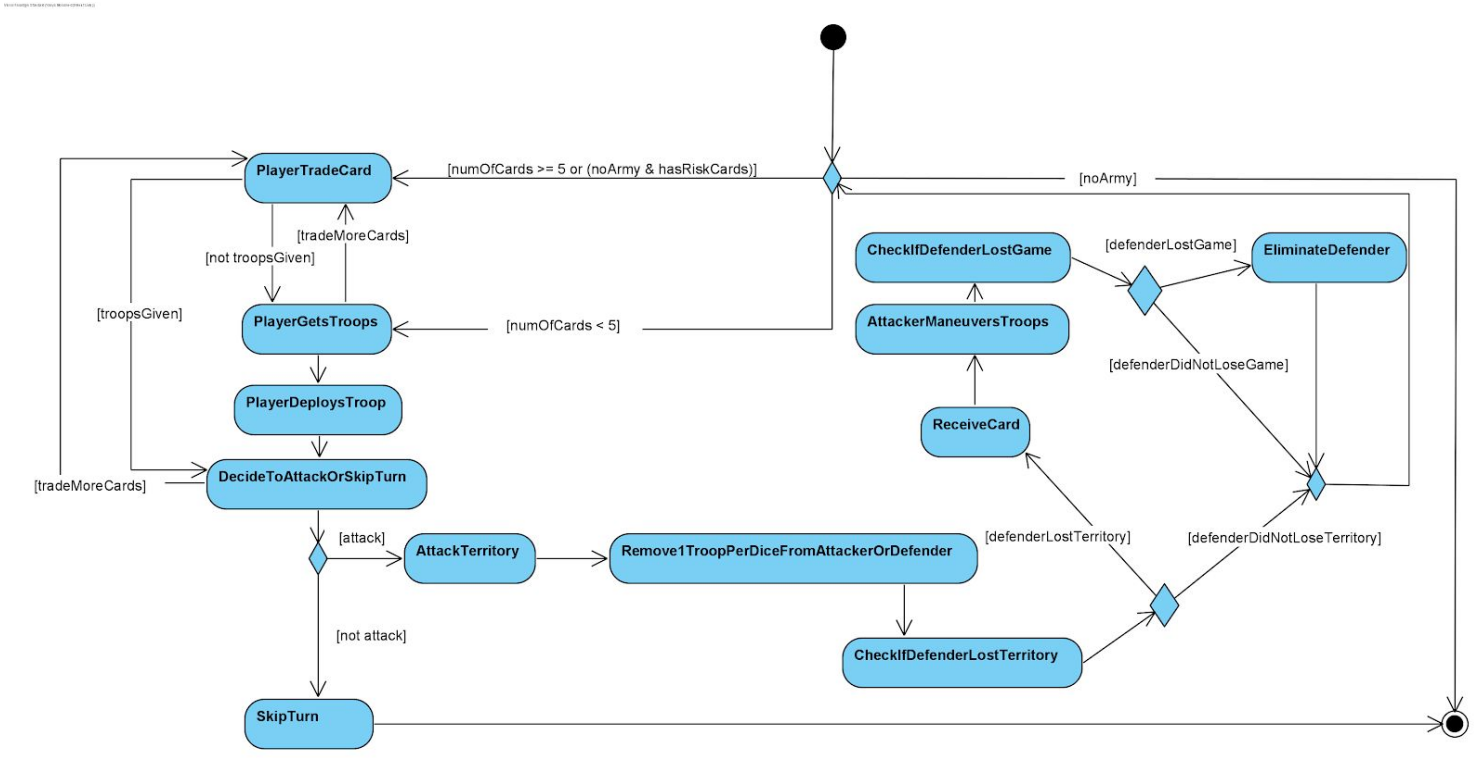

Figure 3 (Game Logic For a Player's Full Turn Activity Diagram)

The game logic for a player's full turn activity diagram is the sequence of activities for the activities triggered upon a player getting a turn. This diagram indicates activities for one player and it is the same for every other player. Upon entering the activity diagram, a decision node is reached where if a player has a number of Risk cards greater than or equal to 5 Risk cards, which he/she has to trade his/her set of Risk cards, or if he has no army. After PlayerTradeCard activity, we transition to the PlayerGetsTroops activity in which the player gets troops according to the rules of the game. After getting troops, we move to the next activity which is PlayerDeploysTroops, where the player starts deploying the received troops in his/her territories. After this activity, we transition to the DecideToAttackOrSkipTurn activity. This activity is also reached if originally the number of Risk cards is less than 5. The player can go back and trade more cards after which the player will transition back to the DecideToAttackOrSkipTurn Activity again. During this activity, the player decides if he wants to attack or not to attack. Upon reaching the decision node, if the player chooses not to attack, he transitions to the SkipTurn activity, which means that the player skips his turn and reaches the final activity. However, if the player decides to attack, he reaches the AttackTerritory activity. In this activity, the player decides on the territory to attack according to the rules of the game. A decision node is reached according to the result of the attack.The result of attack is comparing between the dice, where two dice from the attacker is compared with two dice from the defender and then we move to the activity Remove1TroopPerDiceAttackerOrDefender, where the per comparison 1 troop is removed either from defender (higher roll number than defender) or 1 troop is removed per comparison from attacker (tie roll or lower number than defender). Then we got to the next activity to CheckIfDefenderLostTerritory, where we check if the defending player has no troops left in the territory which means he/she lost the territory. If the defending player didn't lose his/her territory we move to the merging node going to the first decision node. If the defending player loses his/her territory, we move to the activity ReceiveCard where the attacking player receives a risk card and has to maneuver his/her troops, as indicated by AttackerManeuverTroops activity. After that we check if the defending player has any territories left, which is done in CheckIfDefenderLostGame activity. If the defending player has territories we move to the merging node going to the first decision node, but if the defending player has no territories left we move to the next activity which is EliminateDefender. If the player loses the attack, the player reaches the Remove1TroopFromOwnTerritory activity, where the player loses one troop per dice comparison lost, the attacking player at most can lose 2 troops per attack. If the player runs out of troops meaning he/she lost the game, or the player skips his turn, he reaches the final activity.

5.2.2 Sequence Diagrams

Player Turn Diagram

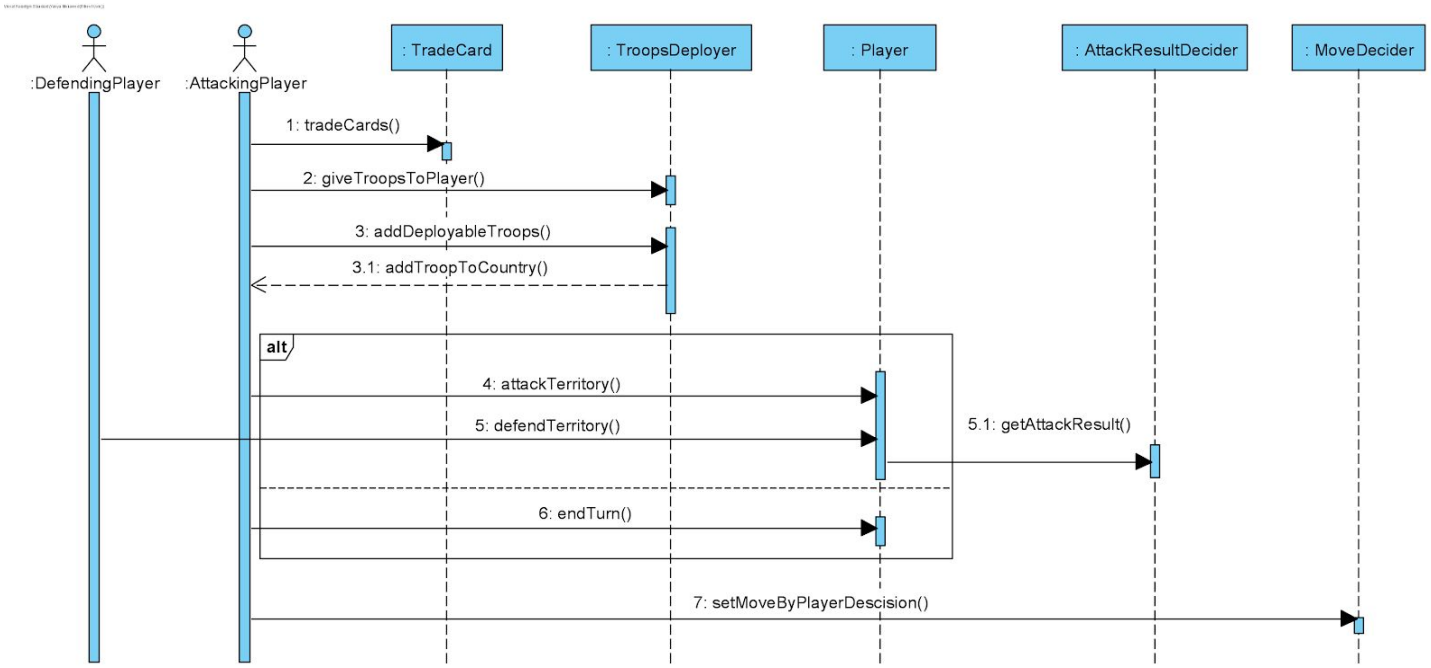

Figure 4 (Player Turn Sequence Diagram)

Scenario:

One player's gameplay is depicted and it is the same for every player. The player is required to trade a card according to the rules of the game. The player gets troops for their turn. The player then decides the move he/she is going to make. If the player chooses to attack another territory, the result of the attack dictates the game view. The player can then pick the next move. If the player is unable to make a next move, according to the rules of the game, the player then loses the turn and the next player takes his turn. If the player loses and is still in a position which allows him/her to attack, he/she can choose his next move. If the player wins, he/she can decide whether to attack another territory or skip his/her attack. In case the player skips his/her attack, the player's turn is ended and the next player gets the turn.

Explanation:

GamePlayer represents a player and triggers the tradeCards() method in the TradeCard class. Troops Deployer class manages both giving troops to the player and allowing the player to deploy troops. GamePlayer also triggers the giveTroopsToPlayer() method in the TroopsDeployer object and the number of troops as calculated by the game rules are given to the player. The player starts deploying the troops given triggering the addDeployableTroops(). The Player then decides his/her move and accordingly triggers either attackTerritory() and defendTerritory() or skipAttack(). If endturn() method is triggered, the MoveDecider class finishes the turn and gives the turn to the next player. If, however, attackTerritory() and defendTerritory() is triggered, a territory is attacked by the attacking player and the defending player the owner of the territory defends and the AttackResultDecider's getAttackResult() is triggered. Then react.js is responsible for updating the map display to show the player's troops, and the player's troop maneuvering. Once this is completed, the setMoveByPlayerDecision() method is triggered which causes the player to choose the next move, which can either be end turn or attack as dictated by the game rules. This cycle repeats, and upon termination, the next player has a similar cycle.

5.2.3 State Diagrams

Trade Card Diagram

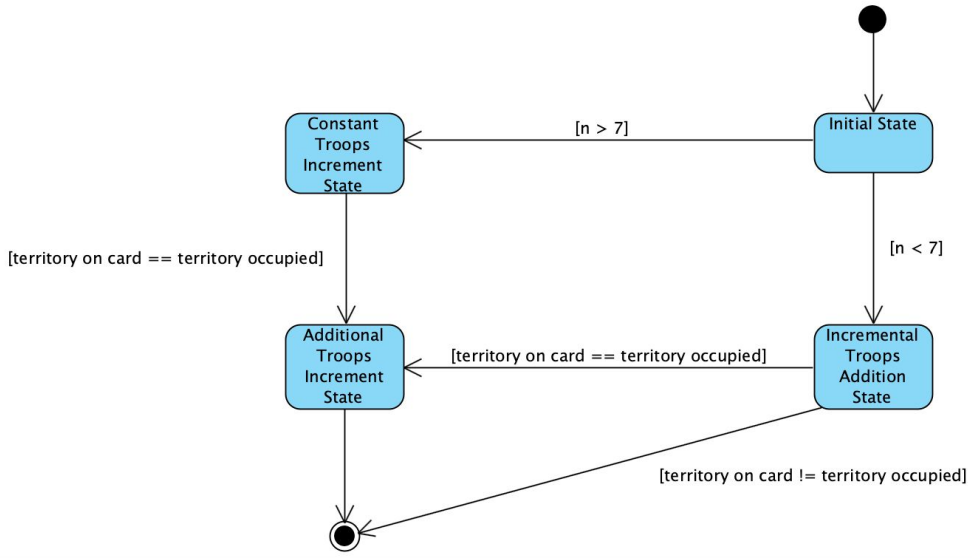

Figure 5 (Trade Card State Diagram)

When trading a Risk card, the number of times cards were traded previously affect the number of troops gained from the trade. In the state diagram above, n represents the number of times cards were traded previously by all the players. If n is less than 7 the state transitions to Incremental Troops Addition State, and the number of troops the player is allowed to add is calculated by the formula 2n + 2. If n is greater than 7 the state transitions from the initial state to the Constant Troops Increment State, and a number of troops 5 greater than the previous trade can be added. If the territory on the card is exactly the same as the one the player occupies, the state transitions to Additional Troops Increment State. Here the player is allowed to add 2 troops in addition to the addable number of troops previously calculated in previous states. However, if the territories do not match, the state transitions to the final state.

Setup Phase According to Number of Players Diagram

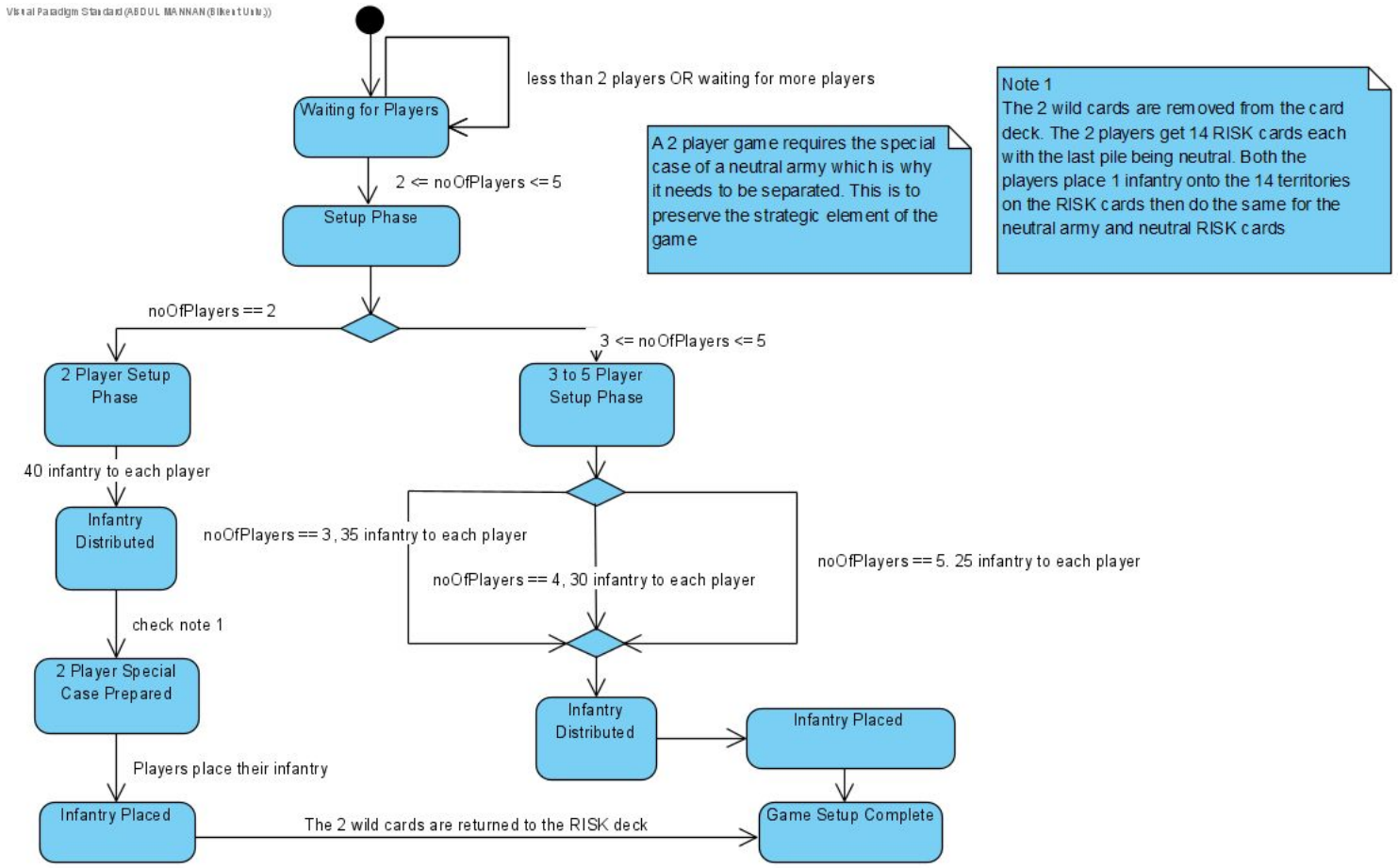

Figure 6 (Setup Phase State Diagram)

When a game is first started, the game will enter the Waiting for Players state. If the number of players are less than 2, the option to advance is not given to the joined player. Up to 5 players can play the game together. When the number of players, 2 to 5, have all joined, players can advance and the game will enter the Setup Phase state. Here we have a split, if we enter the 3 to 5 Player Setup Phase state, then infantry is distributed according to the number of Players. If there are 3 players, each player gets 35 infantry. If there are 4 players, each player gets 30 infantry and if there are 5 players, each player gets 25 infantry. After this the game will enter the Infantry Distributed state. These players will then distribute their infantry one by one until all

42 territories have been claimed. Once the infantry has been placed by all the players, the game will enter the Infantry Placed state after which it will proceed to the Game Setup Complete state. However, if the game enters the 2 Player Setup Phase state at the choice, the rules for the setup are a little different. First each player is given 40 infantry and 40 infantry is allocated to a neutral army, after which the game enters the Infantry Distributed state. At this point the special case for a 2 player game is prepared, the 2 wild cards are removed from the RISK deck and 14 cards are given to each player and the neutral army, 1 infantry is then placed on each of the territories on the RISK cards distributed, for both the players and the neutral army. The game then enters the 2 Player Special Case Prepared state. The players then place their remaining infantry one by one on the territories they already own and the game enters the Infantry Placed state, the 2 wild cards are then returned to the deck and the deck is shuffled, after which the game enters the Game Setup Complete state.

5.3 Object and Class Model

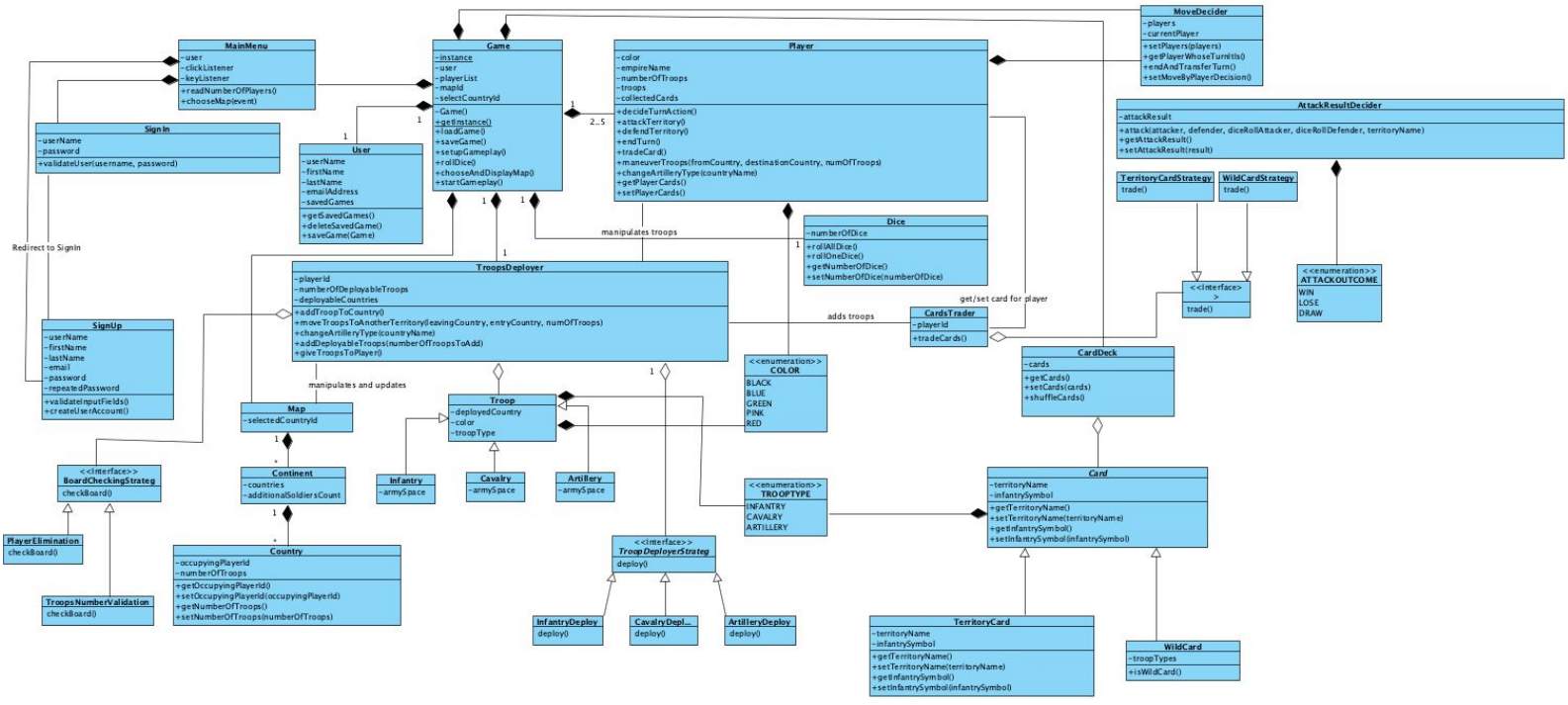

Figure 7 (Object and Class Model)

This diagram explains the class structure of the game and the components used in the game. The main class that controls everything in the game is the Game class. This diagram assumes that constructors, getters, setters, and destructors are present for every class.

The Game class is the main class controlling the program. It will get initialized when the game starts and it will let the player start a new game. It will be responsible for rolling the dice, saving the game, and setting up the gameplay.

The Troops deployer class is responsible for deploying troops in a country, moving the troops to another country, and changing the artillery type.

The MainMenu class is responsible for getting the initial user feedback on what kind of game they want to play. It also serves as the initial place for the user to signIn or signUp.

The Map class houses all the countries and the continents of the game.

The Land class is the parent class for a continent and a country. Every land has a name. Every Continent has an additionalSoldiersCount which is the number of troops to be given to the user when this land is concurred

The User class is the main class responsible for user management. It will validate the user's information when signing in and store them.

The Player class houses the players information, their empireName and their color. And is responsible for ending the players turn and trading cards

5.4 User Interface

Figure 8 (Main Menu UI Design)

Adapted from Source [2]

This is the main menu of the game which will be initially presented to the user. The user will be required to press the login button to proceed.

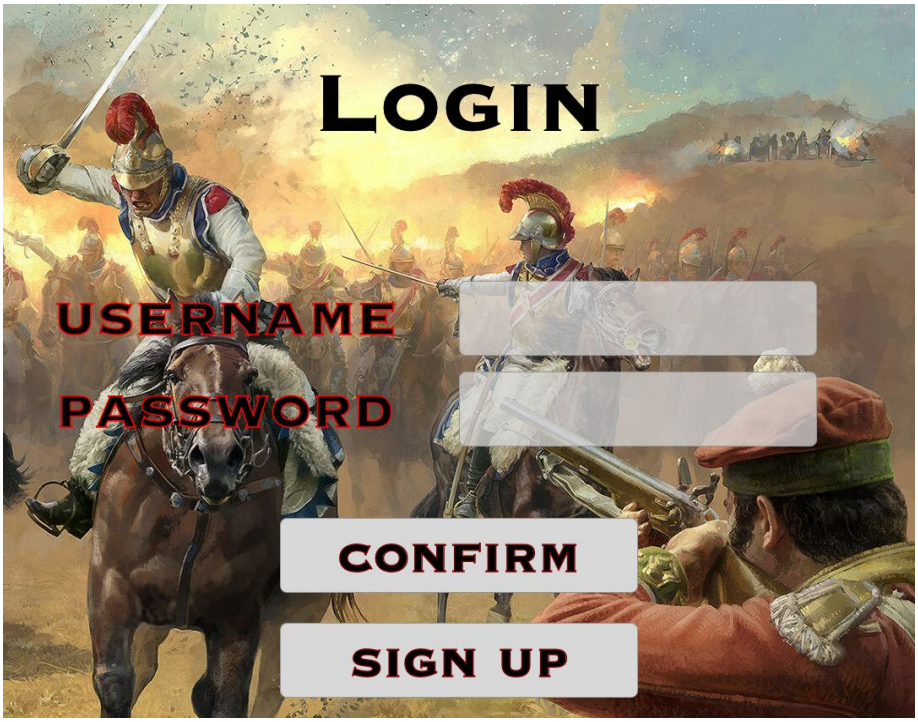

Figure 9 (Login Screen UI Design)

Source: Adapted from [2]

The login screen will prompt the user to enter his/her username and passcode in order to play, or will allow the username to sign up and create a new account.

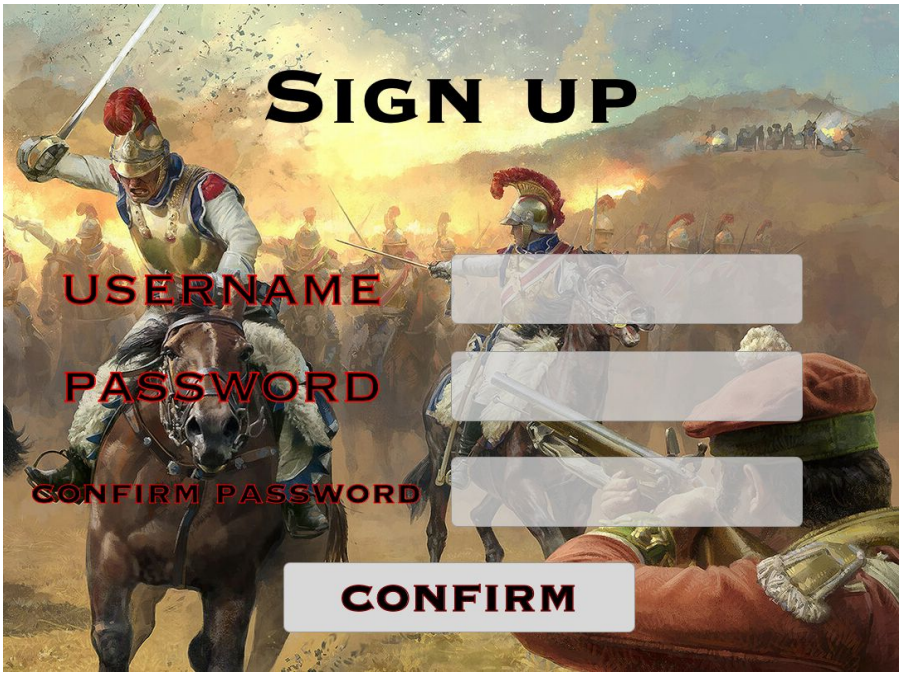

Figure 10 (Signup Screen UI Design)

Source: Adapted from [2]

The sign up screen will allow the user to create and save a new account. The user will be asked to enter his/her password twice in an attempt to avoid mistakes while typing.

Figure 11 (Launch Game Screen UI Design)

Source: Adapted from [2]

Once the user has logged in, he/she will be given the option to either start a new game or continue a previously saved game.

Figure 12 (Saved Games Screen UI Design)

Source: Adapted from [2]

Saved games screen will hold the data of previously saved and played games.

Figure 13 (Game Options Screen UI Design)

Source: Adapted from [2]

In case the user decides to start a new game, he/she will be prompted to enter the number of players to play with. The number of players ranges from 3 to 5 inclusive.

Figure 14 (Map Options Screen UI Design)

Source: Adapted from [2]

Once the number of players have been set, the user will be prompted to choose a map from a plethora of options. Some default options will consist of a general map, the map of a few countries (e.g Turkey).

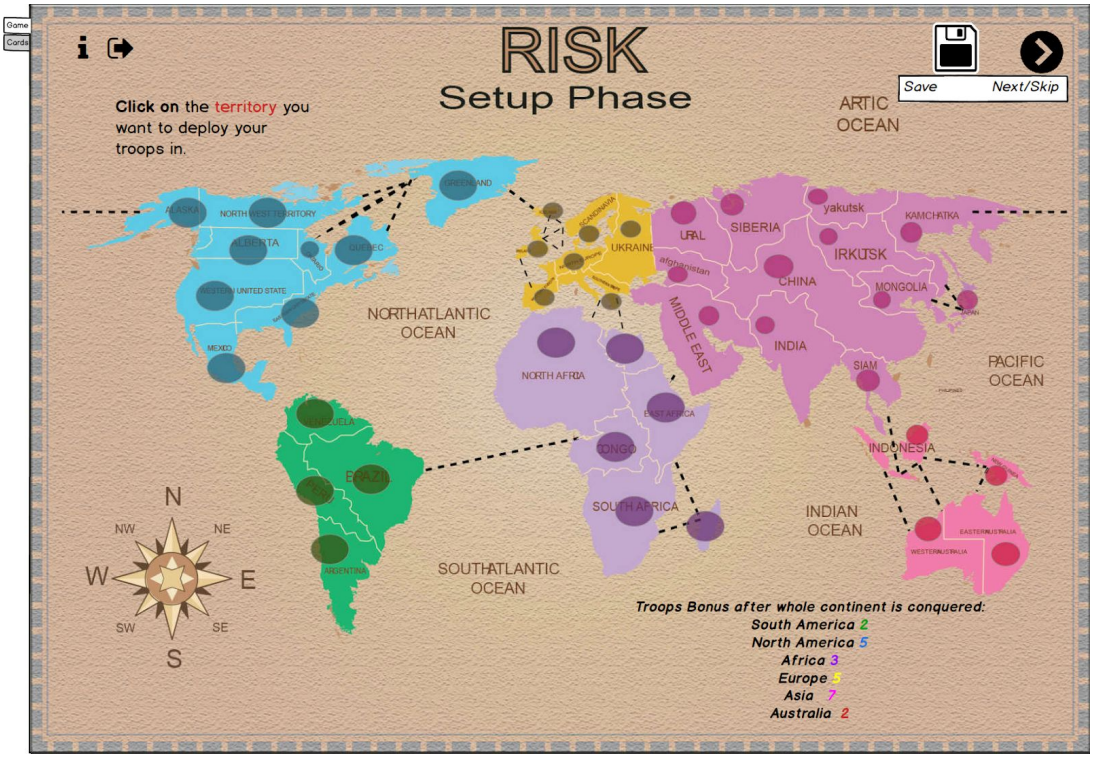

Figure 15 (Main Game Screen UI Design)

Upon choosing the general map option, the players will be required to deploy their troops. The deployable regions are indicated by dark circles of the respective color. This will be applicable for all players. The dark circles will be dynamic hence helping the players choose regions. The save and next/skip buttons on top-right of the screen would save the game and skip the player's turn respectively. The 2 tabs on the top-left, Game and Cards, are 2 screens of the game. The Game tab will present the game while the Cards tab will show the collection of cards for each player.

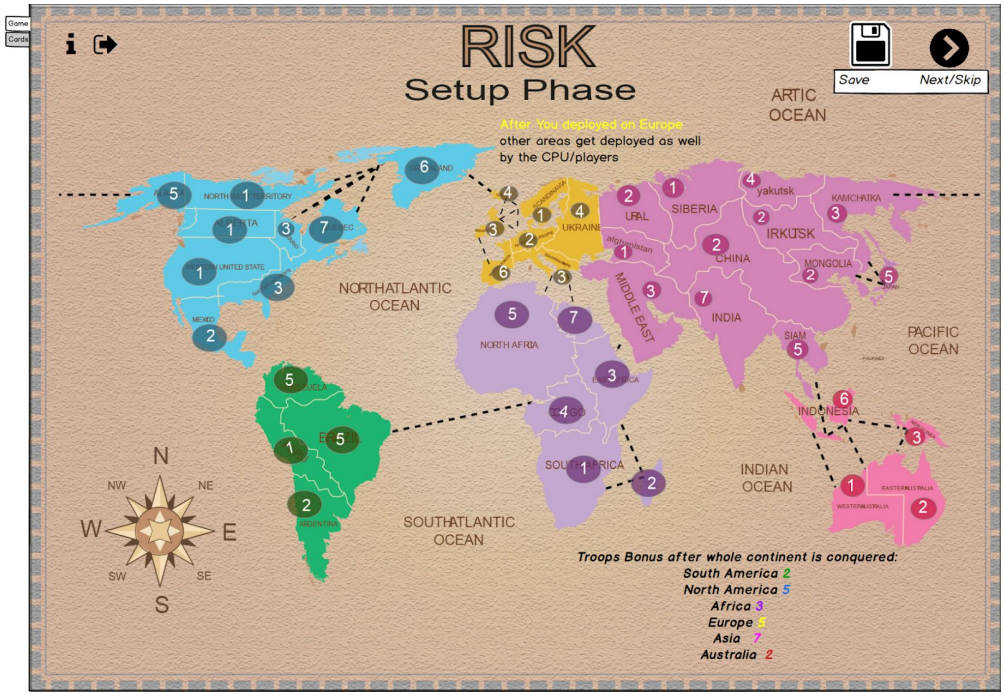

Figure 16 (Map with Troops Screen UI Design)

This is the map after troops have been deployed by each player.

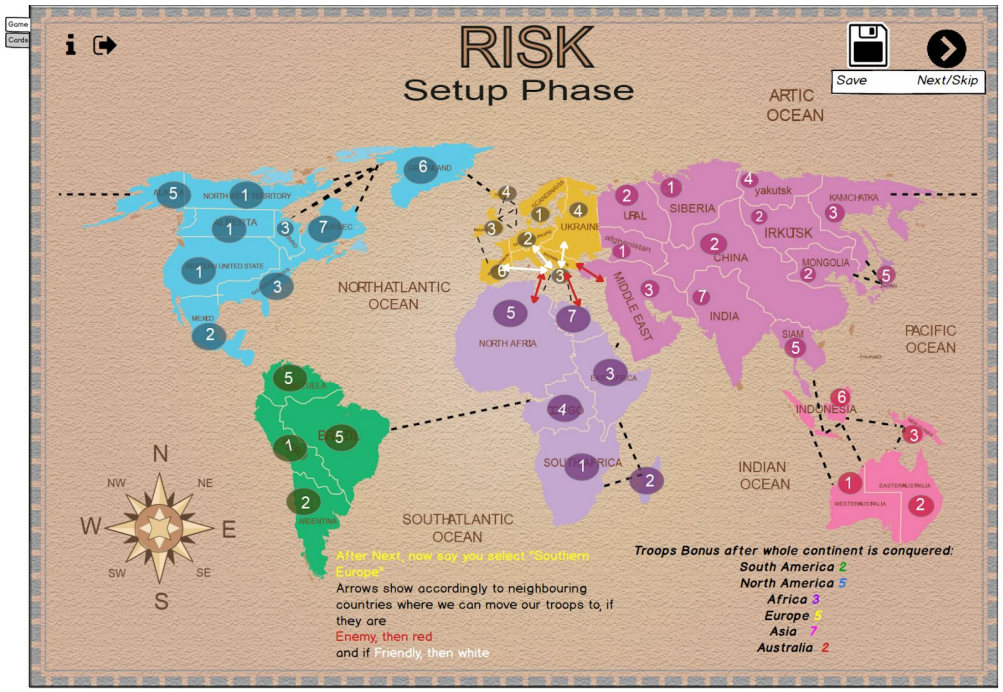

Figure 17 (Map with Player Turn Screen UI Design)

When it is a player's turn, the player selects one of his/her territories. Upon this selection, the player will be presented with options for movement. The red arrows indicate a region to attack while the white ones indicate the region where a player can maneuver his/her troops.

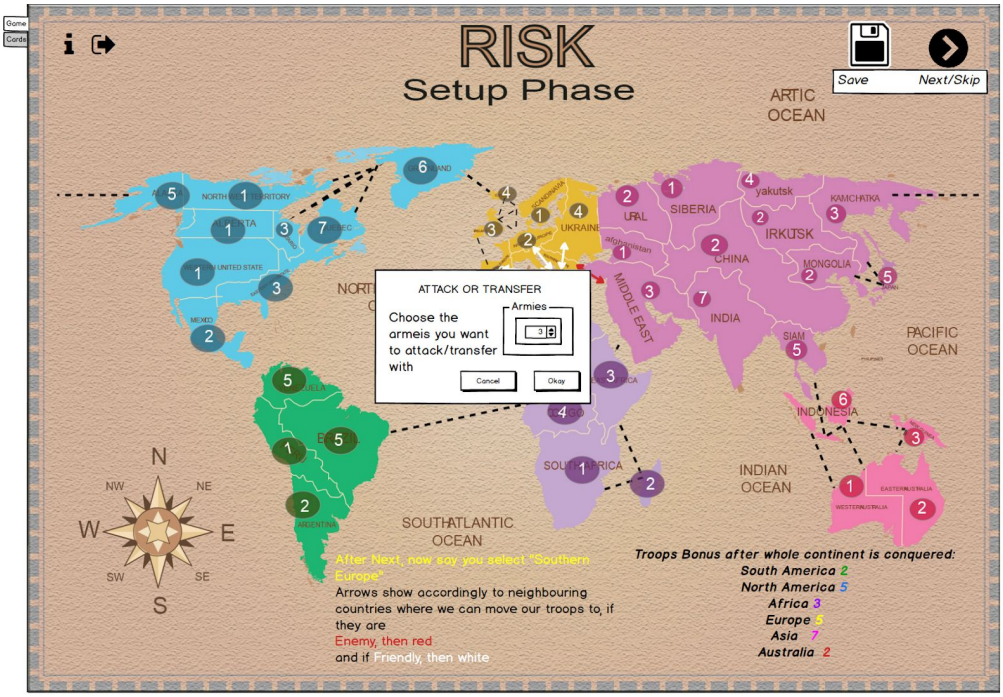

Figure 18 (Attach Screen UI Design)

When the player chooses an option, he/she will be presented with a popup to choose the number of troops he wants to use while attacking or moving.

Figure 19 (Dice Screen UI Design)

After choosing, if the player decides to attack, 2 sets of dice will be rolled according to the situation of the attack. Red dice are rolled for the attacker and the white for the defender.

Figure 20 (Card awarding Screen UI Design)

If the dice roll results in the win of the attacker, the attacker is awarded a card.

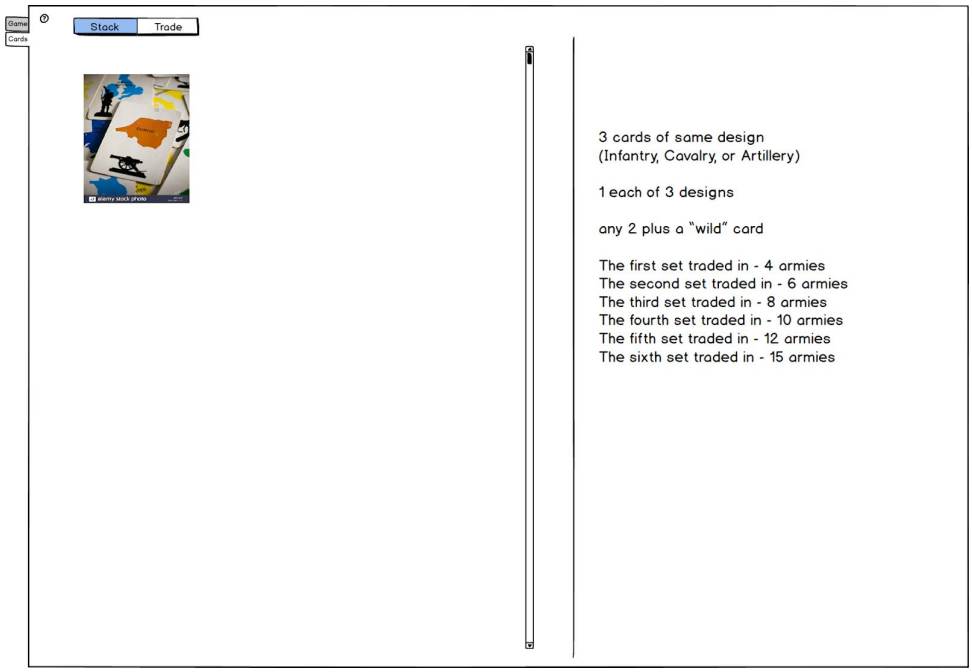

Figure 21 (Card Description Screen UI Design)

The awarded card is shown up in the Cards tab on the top-left of the screen. The player is also presented with a set of instructions of the cards that can be traded.

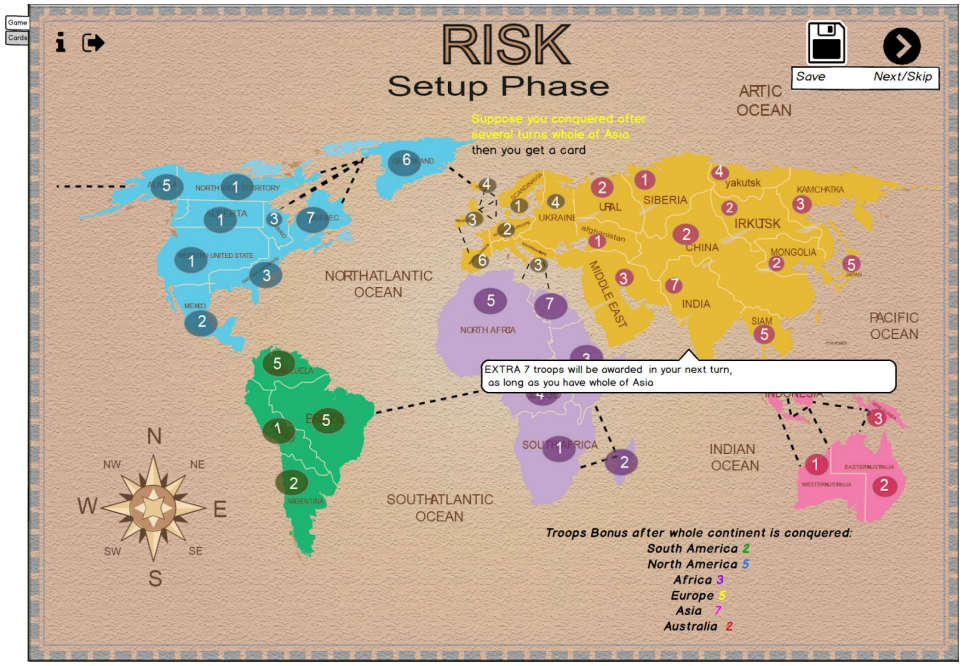

Figure 22 (Conquered Continent Screen UI Design)

In this case, a continent is conquered.

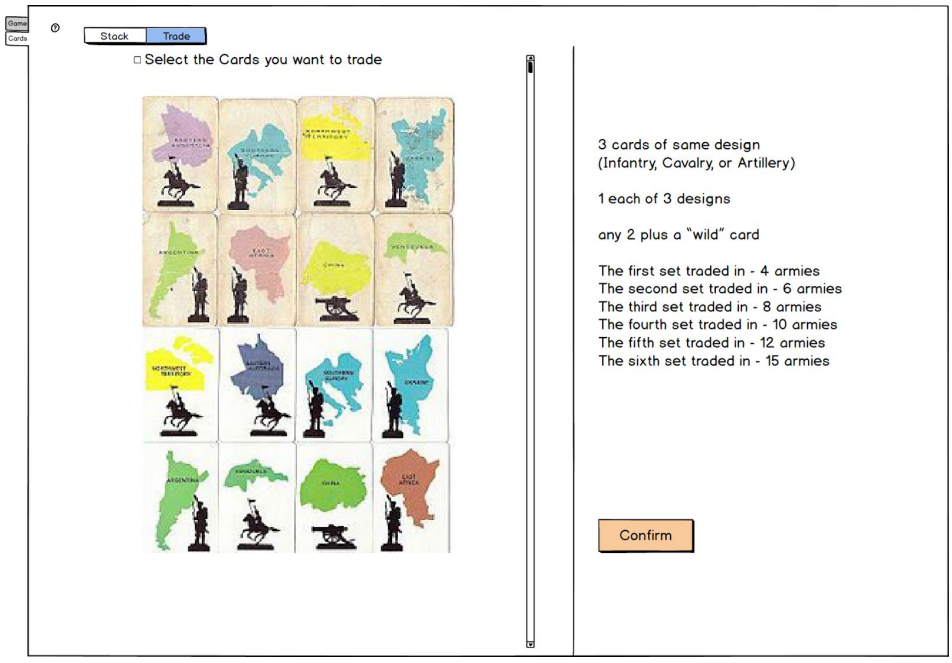

Figure 23 (Cards Description Screen UI Design)

This is the screen where the player will be able to trade a set of cards.

Figure 24 (Save Game Screen UI Design)

Source: Adapted from [2]

In case the top-right pause button is pressed during the gameplay, this screen will show up and will prompt the user to save the game. In case the user chooses yes, the game's data will be recorded in previously saved games.

6. Improvement Summary

The UML diagrams have been modified according to the necessary requirements. Since the use case diagram was missing a few use cases, it has been updated to include them all. This consists of defending, maneuvering troops and roll dice. For dynamic models, we previously used all types of diagrams to represent each phase of the game. This created a lot of repetition in our report. We have revised that and selected only a single type that best encapsulates the state of the game. For example, game configuration and full player turn diagrams are now only supported by activity diagrams. Sequence diagrams have been chosen to represent a single player-turn since

they clearly represent each stage of the player's turn. Similarly, state diagrams were chosen to be the best fit to portray trading cards and the set-up phase according to the number of players. The set-up phase has also been modified to include different gameplays depending on the number of players since the rules of the game are different in case 2 players are playing, and vary when 3-6 players are playing. The object and class model has also been updated to include more classes that weren't included like AttackResultDecider and MoveDecider, also 3 design patterns were used Strategy, MVC, and Singleton design patterns. We discuss the design patterns in detail in our design report.

7. Glossary and References

[1] "Risk (game)", *En.wikipedia.org*, 2020. [Online]. Available: https://en.wikipedia.org/wiki/Risk_(game). [Accessed: 30- Oct- 2020].
[2] S. Beliaev, *Cavalry Horse*. 2020.