Design and Analysis of a Game of Monopoly

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Abstract

The aim of this project is to design a game of monopoly using an Object-Oriented approach and following the Agile Scrum framework. This paper will outline the research required for the design of monopoly and will begin with an analysis of the requirements, classes and use cases needed for the design of the game. The product will be designed with the use of object diagrams and user interface mockups as well as state machines. Classes will be modelled using a collection of diagrams to portray the structure of the project, these will include collaboration and sequence diagrams. Finally, the source code will be written and provided to the reader based on the designs.

Introduction

This paper will seek to analyse, design and structure a game of monopoly with an Object Oriented Approach. The project is split into stages which include Analysis, Product Design, Class Design and finally the implementation. Source code for the game of monopoly will be provided and this will incorporate the designs and structure as outlined in the different stages.

Analysis

The first stage of this project is the Analysis Stage. Here, the requirements will be defined, the scenarios will be described, a primary class list determined, class diagrams and use case diagrams will be created and the results of a structured walkthrough will be provided.

Requirements

These requirements outline what the game will and will not do. They will highlight the scope of the project and give light to how the game will be developed. Below is the requirements specification of the game of monopoly.

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Requirements Specification

1. Allowing 2-8 players to join a game session.
2. Permitting each player to pick a game piece from a choice of 8.
3. Allocating €1500 to players at the start of the game.
4. Enabling the player to navigate around the board by rolling two dice and moving the game piece.
5. Giving €200 to a player when they pass the ‘Go’ square.
6. Allowing player to take another turn if a double is rolled.
7. Permitting players to purchase property if it is unowned.
8. Validating that property is unowned.
9. Placing Title Deed Cards in players’ inventories when they have purchased a property.
10. Requiring a player to pay rent to another player if they land on their unmortgaged property.
11. Doubling the rent price for a set of properties once the complete set of properties is owned by one player.
12. Raising the rent price for a property when the property is improved with houses or hotels.
13. Auctioning a property if a property landed on by a player is unwanted and unowned.
14. Permitting players to mortgage property according to the property’s worth as specified on the Title Deed Card.
15. Enforcing that a property has no improvements before being mortgaged.
16. Receive payment for a mortgaged property with 10% interest when a player wishes to unmortgage it.
17. Preventing the player from collecting rent on a mortgaged property.
18. Allowing players to purchase up to four houses on a property when they own the full set of properties of the same colour.
19. Validating that houses are being built evenly on a property grouping.
20. Allowing the player to purchase hotels once four houses have been purchased on all properties in a grouping.
21. Enforcing that only one hotel may be built on a given property.
22. Preventing players to build improvements on a property if any of the properties in the grouping are mortgaged.
23. Auctioning buildings in the case of a building shortage when more than one player wishes to purchase the same building.
24. Allowing the player to receive a chance or community chest card when landing on the relevant space and permitting to user to follow the instruction given.
25. Putting a player in jail when the player lands on ‘Go To Jail’, rolls three doubles or receives a card instructing them to do so.

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26. Enforcing a player in jail to stay in jail unless €50 is paid, the player waits three turns and pays €50, rolls a double on one of their three turns or the player has a ‘Get Out Of Jail Free’ card and wishes to use it.
27. Collecting taxes and fines from players.
28. Buying properties and buildings back from the player when the player wishes to sell.
29. Validating that a player’s buildings are sold back evenly.
30. Allowing players to make deals with each other which can include trading money, property, or ‘Get Out Of Jail Free’ cards.
31. Eliminating a player from the game when they can no longer pay what they owe and declare bankruptcy.
32. Enforcing a bankrupt player to give their mortgaged properties and ‘Get Out Of Jail Free’ cards to the other player that they are in debt to.
33. Requiring that the player who receives assets from a bankrupt player to pay 10% interest on any received mortgaged properties at time of receiving.
34. Auctioning a player’s mortgaged properties at full (unmortgaged price) and returning ‘Get Out Of Jail Free’ cards to the relevant decks when that user is bankrupt and in debt to the bank.
35. Allowing the last player left in the game to win.

Scenarios

Below is a brief list of scenarios describing a sample monopoly game play using players A,B,C and D.

1. Players A, B, C and D join a game together. They each choose their pieces and colours. The system sets up a wallet for each player and deposits €1500 in each wallet.
2. Each player clicks to roll the dice. Player A rolls the highest sum so Player A has the first go, clicks to roll again and moves their piece by the amount shown on the dice.
3. Player A lands on a property and the system gives the player the option to buy or auction the property as the property is unowned. The player clicks to purchase the property. The system deducts the cost of the property from the player’s wallet and deposits the money in the bank. The system places the title deed card in Player A’s inventory.
4. Player B clicks to roll the dice and lands on a property. The property is unowned so the System gives the player the option to purchase or auction the property. Player B decides to auction the property and types in €200 as the initial bidding price to start the auction. Players A,C and D click to bid and enter a bidding price greater than the current one. This continues until Players A and C click to exit the bid. Player D is the last bidder and purchases the property for €310. The System deducts the money

from Player D's wallet and deposits it in the bank, the title deed card is placed in Player D's inventory.

5. Player C clicks to roll the dice and lands on a property. The property is owned by Player A. The System prompts player C to pay the rent specified on the title deed card owned by Player A. The rent is deducted from player C's wallet and placed in Player A's wallet.
6. Player D clicks to roll the dice and they land on a Community Chest square. Player D opens the card menu and selects a random card from the deck. The System turns the selected card over and the player reads the card and it says it is a 'Get Out Of Jail Free' card. The card is placed in Player D's inventory.
7. Player A clicks to roll and lands on a tax square. The system deducts the money specified on the square from Player A's wallet and places it in the bank.
8. Player B rolls the dice and lands on the 'Go To Jail' square. The System moves their piece to the jail square. The System gives the player the option to pay €50 to get out of jail, to roll the dice to try and get a double on their next turn or to use a Get Out Of Jail card if they have one. Player B decides to pay 50e. Their game piece is moved to 'Just Visiting' and €50 is deducted from their wallet and placed into the bank.
9. Player C has two properties of the same grouping. The player clicks to roll the dice and lands on the third property in that grouping. The property is unowned so the player decides the purchase it. The money is deducted from their wallet and placed in the bank. Player C now has all three properties from the same grouping so can collect more rent as specified on the title deed card from other players who land on the properties. Now Player C can also access the housing menu.
10. On their next turn, Player C decides to buy a house for their property group. They click to open the house menu and click to purchase a house. They System shows the player the available places to build and Player C chooses where to place the house. The cost of the house as shown on the title deed card is deducted from their wallet and moved into the bank.
11. On Player D's turn, the player clicks to roll the dice. They move their piece the amount specified by the dice roll and they pass Go. The System adds €200 to their wallet and deducts €200 from the bank.
12. It is Player C's turn. They have four houses on each property and the system will not allow the player to buy another house for those properties. The System now makes hotels available to the player and Player C chooses to buy a hotel. The System shows the player the available spaces to build the hotel and Player C clicks on the space to build. The System replaces the houses on that space with a hotel. Player C is deducted the cost of the hotel as shown on the title deed card from their wallet and the money is put in the bank.
13. Player A lands on Player C's property and does not have enough money in their wallet to pay the rent. Player A checks the value of their assets but still does not have enough to cover the debt. Player A clicks to declare bankruptcy and the System gives their mortgaged properties and 'Get Out Of Jail Free' cards to Player C. Player C

pays 10% interest on the mortgaged properties to the bank. The System transfers Player A's money back to the bank. The System offers Player A the option to quit the game or to watch. Player A clicks to watch.

14. Player D lands on a tax square and owes the bank €100 but Player D does not have €100 in their wallet and has no unmortgaged properties to mortgage. Player D clicks to declare bankruptcy. The System begins to auction Player D's mortgaged property at their unmortgaged value and returns player D's 'Get Out Of Jail Free' card to the bottom of the card deck. Player D is offered the option to watch or quit the game and the player quits the game.
15. It is player B's turn and they mortgage three of the properties they own. The System puts the money in Player B's wallet with the amount based on that stated on the title deed card. Player B can no longer collect rent on these three properties and The cards are turned over in their card deck.
16. It's Player C's turn and they want to do a deal with Player B. Player C wants to buy a property from Player B. Player B has two houses on this property so before Player B can sell the property they need to sell the two houses back to the bank. Once player B has done this then Player C enters their proposal to buy the property for 1 'Get Out Of Jail Free' card, a Utility and €60. The System gives player B the option to click Accept or Decline and Player B accepts. The assets are transferred to each respective inventory and wallet.
17. It is Player B's turn and they wish to purchase a property from Player C. The property Player B wishes to buy is mortgaged and so once the two players agreed on a deal, Player B is given the option to pay the price of unmortgaging the property now or must pay 10% of the list price on the card and keep the card mortgaged. Player B chooses to repay the bank the mortgaged price and the System deducts the money from Player B's wallet and puts it in the Bank.
18. Player C lands on Player B's property which has a hotel on it. Player C checks the value of their assets but cannot pay off the rent. Player C clicks to declare bankruptcy. Player B is the only player left so the game ends and Player B wins. A success screen appears with Player B as the winner.

Primary Class List

Below is a list of our primary domain-based classes.

1. Player
2. Bank
3. Board
4. Card
5. Property
6. Game

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7. Square
8. Piece
9. Die
10. Inventory

CRC Descriptions

Class Name: Player	**ID:** 1	**Type:**
Description: Represents a user playing the game		**Associated Use Cases:** Player joins a game session Player buys property Player buys buildings Player sells property Player sells buildings Player bids in auction Player goes to jail Player declares bankruptcy Player does a deal Player picks up a card Player pays rent
Responsibilities	**Collaborators**	
Maintains data about the user	Game Piece	
Keeps track of the user's money	Wallet	
Keeps track of the user's inventory	Property, Card	
Retains the user's location on the board	Board, Square	
Attributes		
Name		
Colour		
Piece		

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Wallet	
Inventory	
Position	
Relationships	
Generalisation (a-kind-of)	
Aggregation (has-parts)	
GamePiece	
Inventory	
Other Associations	**Collaborators**
'Is on'	Square
'Buys', 'Sells', 'Bids'	Property, Card, Bank
'Joins'	Game
'Goes to'	Jail
'Picks Up', 'Keeps'	Card

Class Name: Bank	**ID:** 2	**Type:**
Description: Holds all the money, properties and buildings		**Associated Use Cases:** User allocated money User buys property User buys buildings User sells properties User sells buildings User mortgages property User unmortgages property Property up for Auction
Responsibilities	**Collaborators**	
Maintains money		
Maintains properties	Property, Cards	

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Maintains buildings	Property
Gives out money	Player
Sells property	Property, Player
Sells buildings	Property, Player
Buys property	Property, Player
Buys buildings	Property, Player
Gives out mortgages	Property, Player
Holds Auctions	Property, Player
Attributes	
Money	
Houses	
Hotels	
Properties	
Relationships	
Generalisation (a-kind-of)	
Inventory	
Aggregation (has-parts)	
Property	
Other Associations	**Collaborators**
‘Sells to’, ‘Buys from’, ‘Allocates to’, ‘Gives mortgage to’	Player
‘Sells’, ‘Buys’, ‘Auctions’	Property

Class Name: Board	**ID:** 3	**Type:**
Description: Maintains information about the game board		**Associated Use Cases:**

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and is what users will navigate around in the game play.	
Responsibilities	**Collaborators**
Maintain information about squares on the board	Square
Maintains information about the dimensions of the board	
Attributes	
Title Deed Card	
Purchase Cost	
Mortgage Value Price	
Grouping	
Name	
Location	
Colour	
Relationships	
Generalisation (a-kind-of)	
Aggregation (has-parts)	
Square	
Other Associations	**Collaborators**
‘Is bought by’, ‘Is sold by’, ‘Is bidded on by’	Player

Class Name: Card	**ID:** 4	**Type:**
Description: This represents a game card and can be a chance, community chest or title deed card.		**Associated Use Cases:** Player picks up a card

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	Player buys a property Player sells a property Player does a deal Player declares bankruptcy
Responsibilities	**Collaborators**
Maintains information about each card	
Gives information about properties	Property
Attributes	
Type	
Description	
Keep	
Relationships	
Generalisation (a-kind-of)	
Aggregation (has-parts)	
Other Associations	**Collaborators**
‘Is linked to’	Property
‘Sold to’, ‘Bought by’, ‘Picked up by’, ‘Orders’	Player
‘Is kept in’	Inventory

Class Name: Property	**ID:** 5	**Type:**
Description: Represents a property that can be owned by a player.		**Associated Use Cases:** Player purchases a property Player sells a property Property goes up for auction Player pays rent

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Responsibilities	**Collaborators**
Maintains information about the cost of each property	Card
Holds information about the property grouping	
Attributes	
Type	
Description	
Keep	
Relationships	
Generalisation (a-kind-of)	
Aggregation (has-parts)	
Card	
Other Associations	**Collaborators**
'Is bought by', 'Is sold by', 'Is bid on by', 'Collects rent on'	Player
'Is landed on by'	Piece

Class Name: Game	**ID:** 6	**Type:**
Description: This represents the actual game.		**Associated Use Cases:** Player joins game session Player wins game Player loses game
Responsibilities	**Collaborators**	
Keeps track of players in the game	Player	
Keeps the game running		

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Initialises the board	Board
Initialises the cards	
Shows success screen for winner	Player
Shows the user menu	
Allows players to choose their game pieces and colours	Game Piece, Player
Ends the game	
Eliminates players from the game	Player
Attributes	
Players	
Winner	
Running	
Relationships	
Generalisation (a-kind-of)	
Aggregation (has-parts)	
Player	
Other Associations	**Collaborators**
‘Initialises’, ’	Board, Card, Bank

Class Name: Square	**ID:** 7	**Type:**
Description: Is a space on the board that can hold properties, jail, ‘Go’, tax, utilities, cards and stations.		**Associated Use Cases:** Player lands on a property Player lands on a card space Player passes Go

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	Player goes to Jail Player lands on tax square
Responsibilities	**Collaborators**
Holds information about each space	Card, Property
Attributes	
Location	
Type	
Name	
Relationships	
Generalisation (a-kind-of)	
Aggregation (has-parts)	
Property	
Other Associations	**Collaborators**
‘Player lands on’	Player

Class Name: GamePiece	**ID:** 8	**Type:**
Description: Represents a game piece which the player uses to navigate around the board		**Associated Use Cases:** Player makes a move
Responsibilities	**Collaborators**	
Keeps track of player’s location on the board	Player, Board, Square	
Attributes		
Name		
Position		
Image		

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Relationships	
Generalisation (a-kind-of)	
Aggregation (has-parts)	
Other Associations	**Collaborators**
‘Is moved by’	Player
‘Moves around’	Board
‘Lands on’	Square

Class Name: Die	**ID:** 9	**Type:**
Description: Represents a die that is used to determine the number of spaces the player navigates around the board.		**Associated Use Cases:** Player rolls the dice
Responsibilities	**Collaborators**	
Determines the amount of spaces a user moves around the board	Player	
Attributes		
Numbers 1 - 6		
Relationships		
Generalisation (a-kind-of)		
Aggregation (has-parts)		
Other Associations	**Collaborators**	
‘Is rolled by’	Player	

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Class Name: Inventory	**ID:** 10	**Type:**
Description: Is a collection of properties and cards that a user owns		**Associated Use Cases:** Player purchases property Player sells property Player gets a 'Get Out Of Jail' card Player does a deal
Responsibilities	**Collaborators**	
Holds a player's property and 'Get Out Of Jail Free' cards	Player, Property, Card	
Attributes		
Property		
'Get Out Of Jail Free' cards		
Relationships		
Generalisation (a-kind-of)		
Aggregation (has-parts)		
Property		
Card		
Other Associations	**Collaborators**	
'Owned by'	Player	
'Items are places in by'	Bank	

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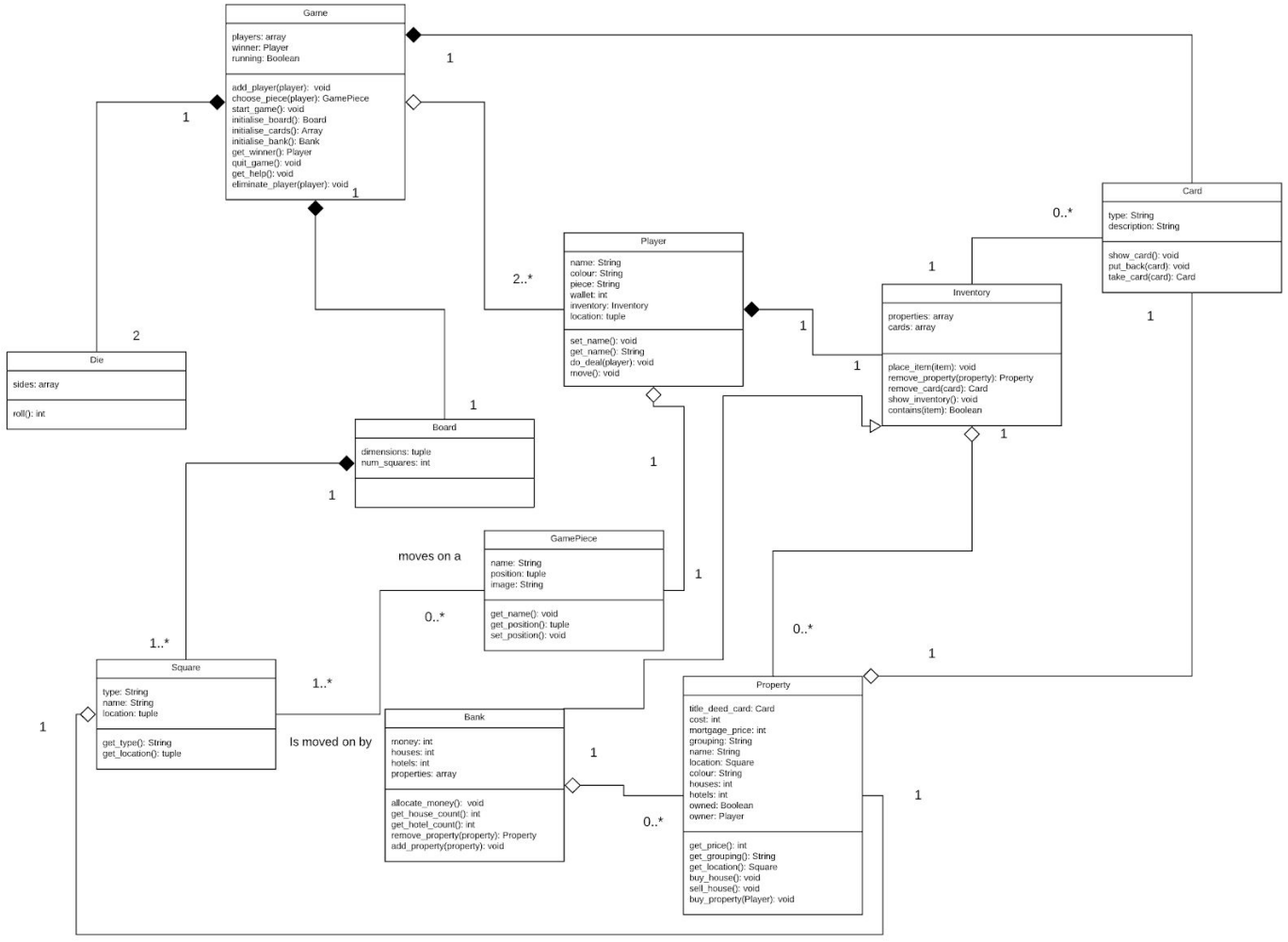
Class Diagram



Use Case Diagrams

Use Case 1	Buying property
Goal In Context	Purchasing a property from a user or the bank
Scope and Level	Low Level
Preconditions	Property is unowned, user has adequate funds to purchase property.

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Success End Condition	Player purchases property
Failed End Condition	Player does not purchase property
Primary, **Secondary Actors**	Player Bank, Other Players
Trigger	Player lands on a property.
Description **Step**	**Action**
1	Player lands on a property
2	Player checks if property is unowned
3	Player decides if they want to purchase the property
4	Player checks if they have adequate funds to purchase property
5	System takes money from players wallet and deposits the money in the bank
6	The player receives the title deed card
Extensions **Step**	**Branching Action**
2a	If property is owned, player pays rent on property
3a	Player doesn't wish to purchase property so the property goes up for auction
4a	Player cannot purchase property and property goes up for auction
6a	If the player now owns all properties in a grouping, they can begin purchasing houses for those properties
Variations	**Branching Action**
1	Player purchases property through auction or deals with another player.

Use Case 2	Going to Jail
Goal In Context	Player gets locked in jail
Scope and Level	Low Level
Preconditions	Player lands on 'Go To Jail' square
Success End Condition	Player goes to jail
Failed End Condition	Player does not go to jail

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Primary, **Secondary Actors**	Player 'Go To Jail' Square
Trigger	Player lands on 'Go To Jail' Square
Description **Step** **1** **2** **3**	**Action** Player lands on 'Go To Jail' Square Player navigates to the jail Player remains in jail for three turns
Extensions **Step** **2a**	**Branching Action** Player cannot collect €200 if they pass Go.
Variations	**Branching Action**
1 **3a** **3b** **3c**	Player gets a chance or community chest card which orders them to go to jail. Player rolls three doubles in a row which means they must go to jail immediately. Player uses a 'Get Out Of Jail Free' card and moves into 'Just Visiting'. Player rolls a double on their next turn and moves into 'Just Visiting'. Player pays €50 on their next turn and moves into 'Just Visiting'.

Use Case 3	Player declares bankruptcy
Goal In Context	Player declares bankruptcy when they no longer have adequate funds to pay off debt.
Scope and Level	
Preconditions	Player is in debt and does not have adequate funds
Success End Condition	Player declares bankruptcy
Failed End Condition	Player does not declare bankruptcy
Primary, **Secondary Actors**	Player Other players, Bank
Trigger	Player owes money and cannot pay off the debt

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Description	**Step**	**Action**
	1	Player owes money
	2	Player pays with their leftover money
	3	Player checks the value of their assets
	4	Player declares bankruptcy
	5	Player must give away their assets
	6	Player is eliminated from the game
Extensions	**Step**	**Branching Action**
	1a	Player can owe money to the bank or to another player
	4a	Player declares bankruptcy when the value of their assets is not sufficient to pay off the debt
	5a	Assets include properties and 'Get Out Of Jail Free' cards
	5b	If the player is in debt to the bank, the player's properties go for auction unmortgaged and 'Get Out Of Jail Free' cards are returned to the card piles
	5c	If the player is in debt to another player, the bankrupt player must give the other player all their mortgaged properties and ''Get Out Of Jail Free' cards. The player receiving the mortgaged properties must pay 10% interest on them
	6a	The player can choose to quit the game or to watch the game play
Variations		**Branching Action**

Use Case 4	Property Auction for unwanted, unowned property
Goal In Context	Unwanted, unowned property is being auctioned and the player with the highest bid can purchase the property
Scope and Level	Low Level
Preconditions	Player has sufficient funds for each of their bids, a player landed on the property being auctioned, the property being auctioned is unowned
Success End Condition	Property up for auction is purchased by highest bidder
Failed End Condition	Property being auctioned is not purchased as no bids

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	are made
Primary, **Secondary Actors**	Bidders Auctioneer
Trigger	Player lands on an unowned property and does not wish to purchase it.
Description **Step** **1** **2** **3** **4** **5** **6** **7**	**Action** Player lands on property Player checks if property is owned Player decides not to purchase property Property goes up for auction First player to bid decides the initial bidding price Other players bid on the property The highest bidder purchases the property
Extensions **Step** **4a** **5a** **7a**	**Branching Action** The player who lands on the property cannot participate in the bidding process The initial bidder can make the initial bid for as low as €1 The highest bidder must purchase the property at their last bid value
Variations	**Branching Action**
1a	Properties can go up for auction when a player declares bankruptcy and is in debt to the bank

Use Case 5	Purchasing a hotel
Goal In Context	Player improves on their property by building a hotel on it
Scope and Level	Low Level
Preconditions	Player has sufficient funds to purchase the hotel, the player has all the properties in the grouping they are

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	building on, the player has four houses on the property.
Success End Condition	Hotel is purchased
Failed End Condition	Hotel is not purchased
Primary, **Secondary Actors**	Player Bank
Trigger	It is the player's turn and they wish to build a hotel on their property
Description **Step** **1** **2** **3**	**Action** Player decides to build a hotel on a property System takes money from player's wallet and deposits it in the bank The system replaces the houses on the property with a hotel
Extensions **Step** **1a** **1b** **1c** **1d** **2a** **3a**	**Branching Action** Player must have four houses on each property of the same grouping before they can purchase a hotel Player can only have one hotel per site The property must be unmortgaged to build a hotel on it If no hotels are available, the player must wait until one becomes available The cost of the hotel is specified on the title deed card for the property The property is now worth the amount as specified on the title deed card
Variations	**Branching Action**
1a	Players can purchase hotels in an auction in the occasion of a building shortage

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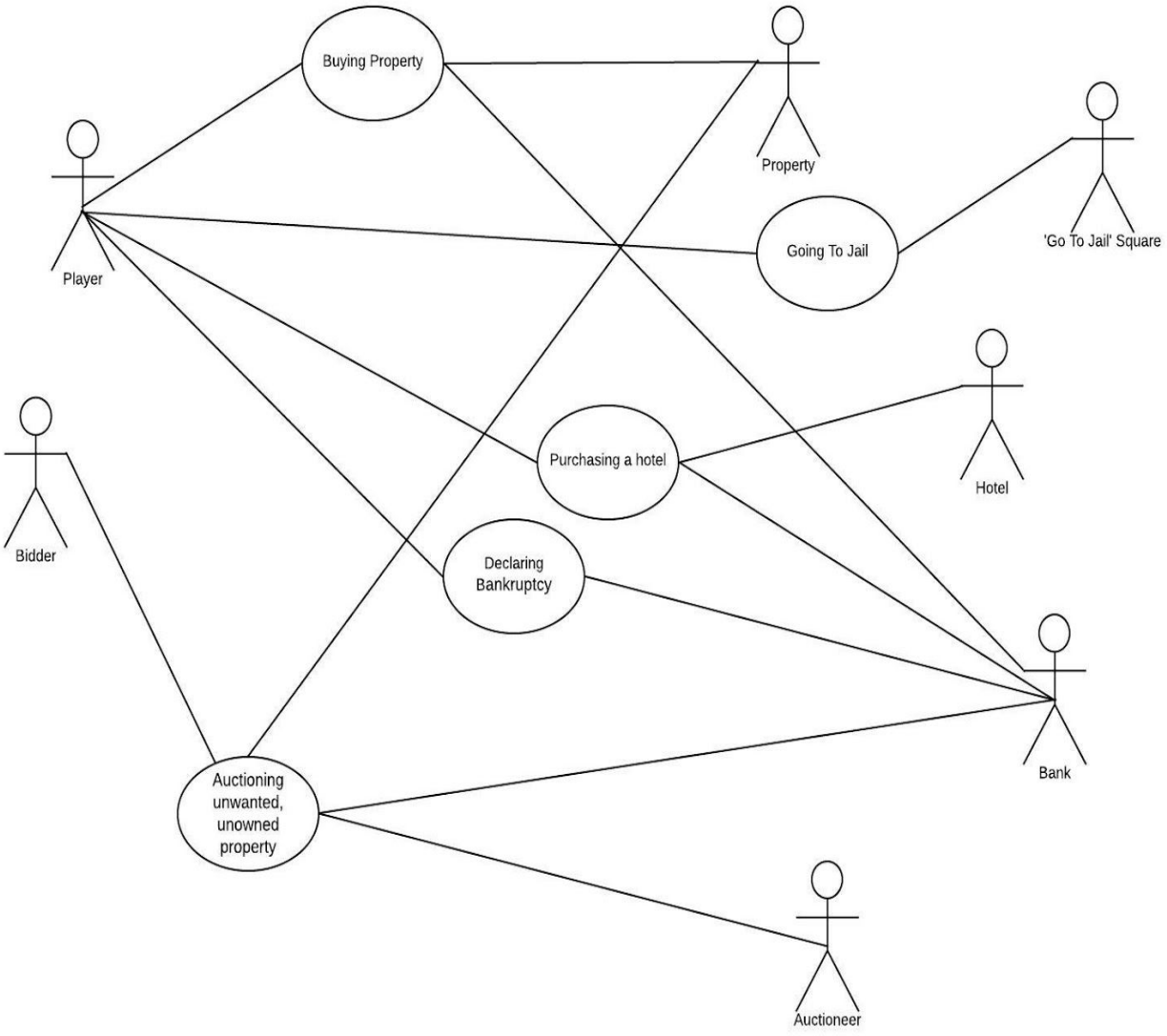
Use Case Diagram



Result Of Structured Walkthrough

Blah blah blah…

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Appendix

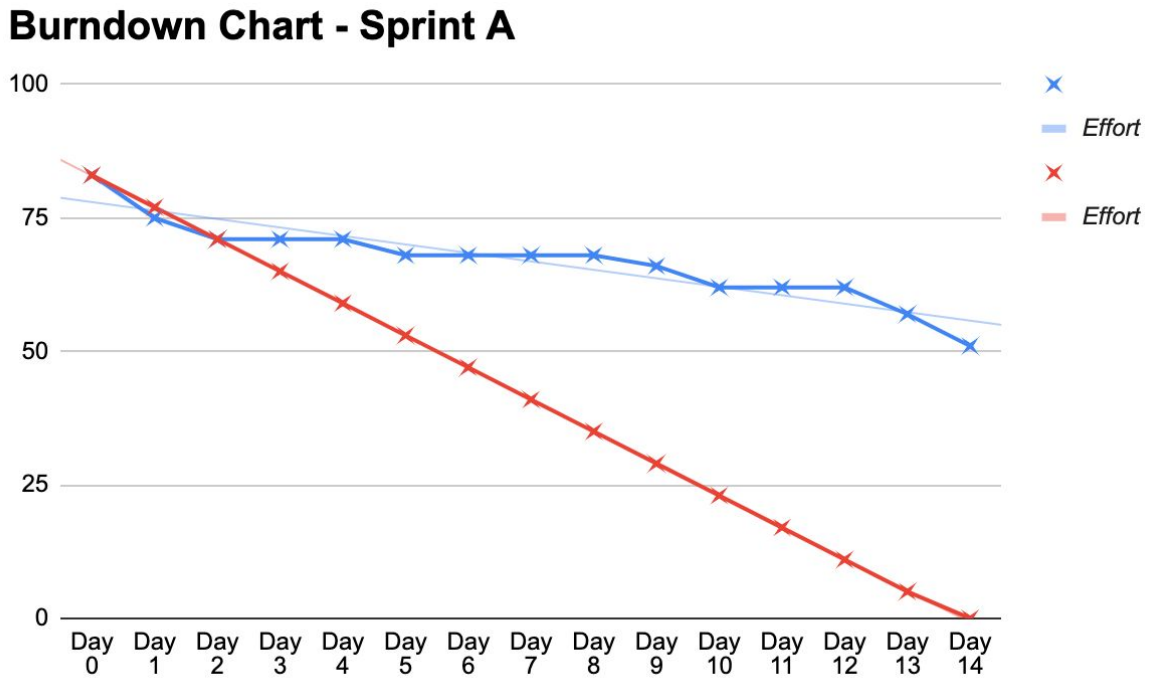
Notes of Team Meetings

Meeting 1

Blah blah blah…

Sprint Burndowns

Colour	Meaning
Blue	Actual Effort
Red	Estimated Effort



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Use Case Diagram: https://www.tutorialspoint.com/uml/uml_use_case_diagram.htm