Bilkent University

Department of Computer Engineering

CS 319 Term Project: Monopoly

Section 01

Group 1A

DESIGN REPORT

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1. Introduction

1.1. Purpose of the System

Monopoly is a board game where players buy and trade properties to play. Monopoly is normally played interactively on the board. There are many digital versions available for the Monopoly game. The purpose of this project is to create a digital version of Monopoly using virtual money, property, and financial operations. The proposed game will be played locally on one computer. It can be played multiplayer or single-player against computer-created players. There will be new features added to extend the enjoyability of the game. These features include each token having its own buff, putting a thief in the game to steal money, and so on.

1.2. Design Goals

Dependability

***Reliability*:** Constructing a game with a minimum number of mistakes and bugs is a crucial design goal. The operations should perform and produce expected results. There should not be any bugs that will affect players. Applying this design goal may require implementing several more functions to the game, and may lower readability. Besides, the game should not allow the players to input incorrect values such as putting words in places where number input is required. When adding a new map to the game the format of the file will be checked if it is adaptable to the game.

Maintenance

***Extensibility*:** The game should allow new functionalities, such as the addition of new tokens or flexible rules that change the dynamic of the original Monopoly game. The system is divided into parts so that each part can be extended easily because they will not have big effects on other components. JavaFX library provides a modifiable interface for the UI components. Besides, the purpose of this project is to allow UI components to change.

***Portability*:** Portability is significant for games. Our system will be implemented in Java so any computer that has the suitable Java Runtime Environment can be used to play the game.

End User

***Usability*:** The players should easily be able to understand how the game is played and they should not be confused by external factors. That is to say, the game should be user-friendly. Each operation will require simple user interaction. Each operation will be divided into subparts to help the user. For example, operations like auction, trade, and build will have more than one step to complete. This design goal was favored over others because the user experience is the most important factor when designing a game.

2. High-level Software Architecture

2.1. Subsystem Composition

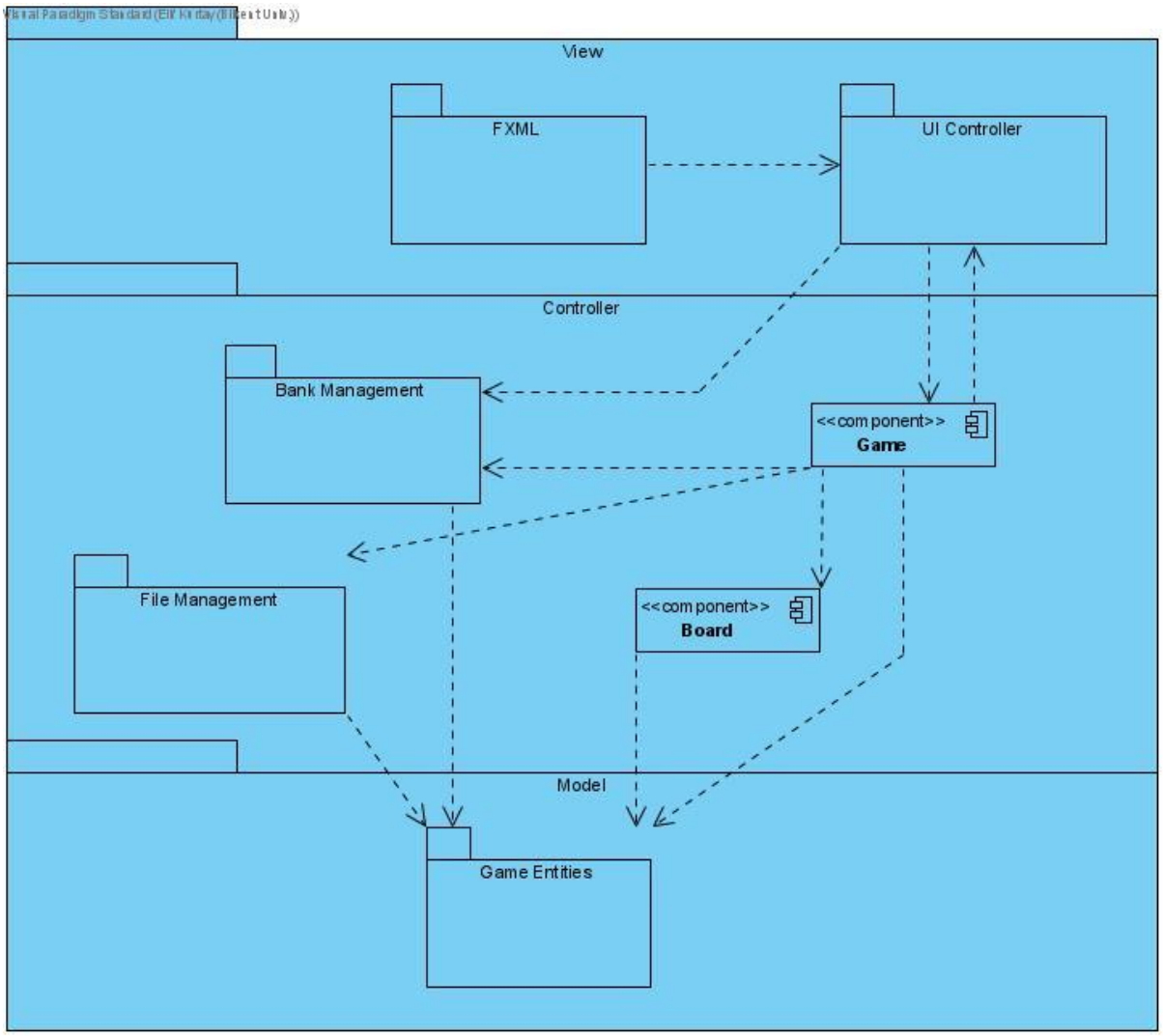


Figure 1. Subsystem Decomposition for the Monopoly game.

The system of the game is decomposed into smaller subsystems. The purpose of this decomposition is to reduce the complexity of the system. With this decomposition, it is easier to divide work, understand where the problem lies, and modify required subsystems. Figure 1 presents the subsystem decomposition for the monopoly game. We chose a three-layer architectural design in our system and decided to have a Model-View-Controller (MVC) design pattern. This system design pattern is suitable for our game software because the system has three distinct subsystems: a subsystem for the user interface, called *View*, a subsystem for game objects, called *Model*, and a subsystem for the game dynamics, functionality, and management called *Controller*. Dividing the system into these three subsystems increased coherence and lowered coupling of the system when compared to a system without decomposition. In this design pattern, packages and components that perform similar tasks that are related to each

other are in the same subsystems, and a change in one component usually affects the other packages or components inside the same subsystem.

The View subsystem consists of two packages named FXML and UI Controller. FXML includes the files for different screens for the user to interact with. UI Controller includes classes that manage the inputs from the user and the game controls. UI Controller forms a dependency with the Game class and Bank package in the Controller subsystem. In addition, Game class forms a dependency with UI Controller as well. Therefore, any interaction between View and Controller needs to be done in the UI Controller package. This provides a convenient and easy way when solving bugs related to user input, or user interface.

The Controller subsystem manages the game loop and controls game entities. It is divided into `Game` class, `Board` class, `Bank Management` package, `Smart Systems` and `File Management` package. The `Game` class has the game loop and it forms a dependency with all other subsystem components, UI Controller package and the Model subsystem. The `Board` class has board-related functions and controls. The `Smart Systems` package includes classes that has the control system of smart components in the application such as computer players and thief player. The `Bank Management` package includes different control mechanism classes for Bank, Auction, and Trade that are affected by the user interface. The `File Management` package includes classes to control the file-based database system for saving and loading data. By collecting most interactions in one component (`Game` class), the game becomes easily modifiable, easy to solve bugs, and extendable.

The Model subsystem includes a single package name `Game Entities` that has game objects such as Player, Property, and Space. These entities are affected by the components in the `Controller` subsystem. To have entities in one place adds to the writability and modifiability of the system.

This subsystem decomposition will be assisting the organization of the project and bring the project closer to our design goals.

2.2. Hardware/Software Mapping

The game will be implemented in Java, so a computer that has a Java Runtime Environment 8 or a newer version will be needed for execution. Other than the Java Runtime Environment there are no system requirements for the computer to be chosen. The game will run on the computer, so the hardware allocation will only consist of one device which is the computer itself. The game does not have any online dependency so an internet connection is not needed.

As the game does not include online multiplayer play, there will be no need for a server containing different players. That being said, there will not be a need for multiple nodes, meaning the game does not require functionalities being divided into nodes. It also implies that there will not be any communication between nodes as there will only be one node.

In summary, it can be said that the version of Monopoly will be executed on one hardware, which is a computer.

2.3. Persistent Data Management

As our game is played from one computer, there is limited persistent data. The persistent data includes game data. The game data consists of entity data which consists of player information, map, property and cards. Maps will be stored in JavaScript Object Notation (JSON) format and the images that are needed will be stored in Portable Network Graphics (PNG) format.

The game data will be saved when the user saves through the save button or in exceptional conditions like the crash of the program. The game can be loaded later on to continue or view the scores of the players even if the game is finished. If the game is not finished, the loaded game has elements such as where the players are positioned, how much money they possess, and which properties they own. There will be a separate subsystem called File Management for data storage.

These data sets will be stored locally in different modifiable flat files. These data sets are quite small and have low information density. In general, flat files can lead to problems when there is concurrent access. However, there will not be a significant amount of concurrent accesses and no finer levels of detail in this software. There will be only one writer and one reader at an execution. Similarly, there is no far-reaching use of associations to retrieve data, nor there is the need to have associations between among objects. For these reasons, flat files were selected to store our persistent data as the other two types (relational databases and object-oriented databases) would only slow down the storage of data.

2.4. Access Control and Security

The only actor in our version of the Monopoly game is a player. A player can play a game, change the settings, load a previous game, or read the credits. However, the player is not able to change any attributes, like how much money players own, or their properties. It can be said that there is a minor limitation over access at that part.

The player can access UI controller classes through the interface. They can create a new game, load a game, change the settings, read the credits, or exit through the main menu. In the new game screen, users can add or remove players, choose or load a map, start the game or turn back to the main menu. On the game screen, they have access to all the operations required by the game and the system options like save, restart, and settings. In the settings menu, the user can go back to the main menu or the game screen. In the credits menu, the user can turn back to the main menu.

The system is not a multi-user system, therefore there is no need for the creation of accounts or a login system for authentication, as the game will automatically start after execution. There may be more than one player in one game, but since they all access the game from the same computer, the actor remains singular. Together with the fact that we will not be using a database, the game can be said to be secure in terms of the distribution of private user information and there won’t be any need to make major efforts to secure access control.

Users can modify the contents of a saved file or find a way to cheat while playing the game. We are not taking any action towards unfavorable actions done by players because the game is an offline game.

2.5. Control Flow

When a game is started through the user interface a Game object will be initialized and the `gameLoop` method will be called. The game loop will wait for user input. The game is a turn-based game, therefore, every activity has a preceding and a next activity, until the game ends. The turn process consists of the acts that the player does before the turn advances to the other player. Accordingly, the turn processes are event-driven.

When a player provides input, such as the dice rolling or participating in the bidding, an event will be fired to advance to the next stage of the turn. Similar action will happen when a player finishes his turn. As there are not many concurrent events and more than one user interaction only happens through the act of engaging in an auction, there is no need for threads.

The control flow will be centralized. The dynamic behavior will be controlled by the Game object. We chose a centralized design because modifying the control structure will be easy in the future.

2.6. Boundary Conditions

***Configuration*:** There are two ways to configure this game. The first way is to create a new game through the new game screen. The users will add the players' names and choose a map. The second way is to configure by loading a previous game. The persistent data will be created upon the exit of a game. When the game is saved with the save game option, the game closes and all its persistent data will be saved into the flat files. For example, when the game is closed, the game object that has information on the players' positions, wealth, and possessions will be recorded in the file. A new game can be configured using that previous game. The settings will be created with default values when the game starts and will be updated with every change that the user makes for that execution. For any configuration of the game, the settings will be set to default values.

***Start-up*:** The game starts upon the running of the executable file. When the user creates a new game through the main menu, The game will be configured as described above. The image of the monopoly board and the players' UI are loaded at this point.

***Shutdown*:** The player can terminate the game by clicking the exit button in the main menu.

***Exception handling*:** The game will be automatically saved periodically after the completion of each three laps. In the case of a program crash, the players might lose the last lap that was being played as the previous version of the game that starts from the last lap will be automatically saved. These automatic saves will be available on the load game screen in case of a crash. During a normal termination of the game, if the user chooses not to save the game, automatically saved game data will be deleted.

Errors will be saved in a log file to keep track and permit future solutions of bugs.

3. Subsystem Services

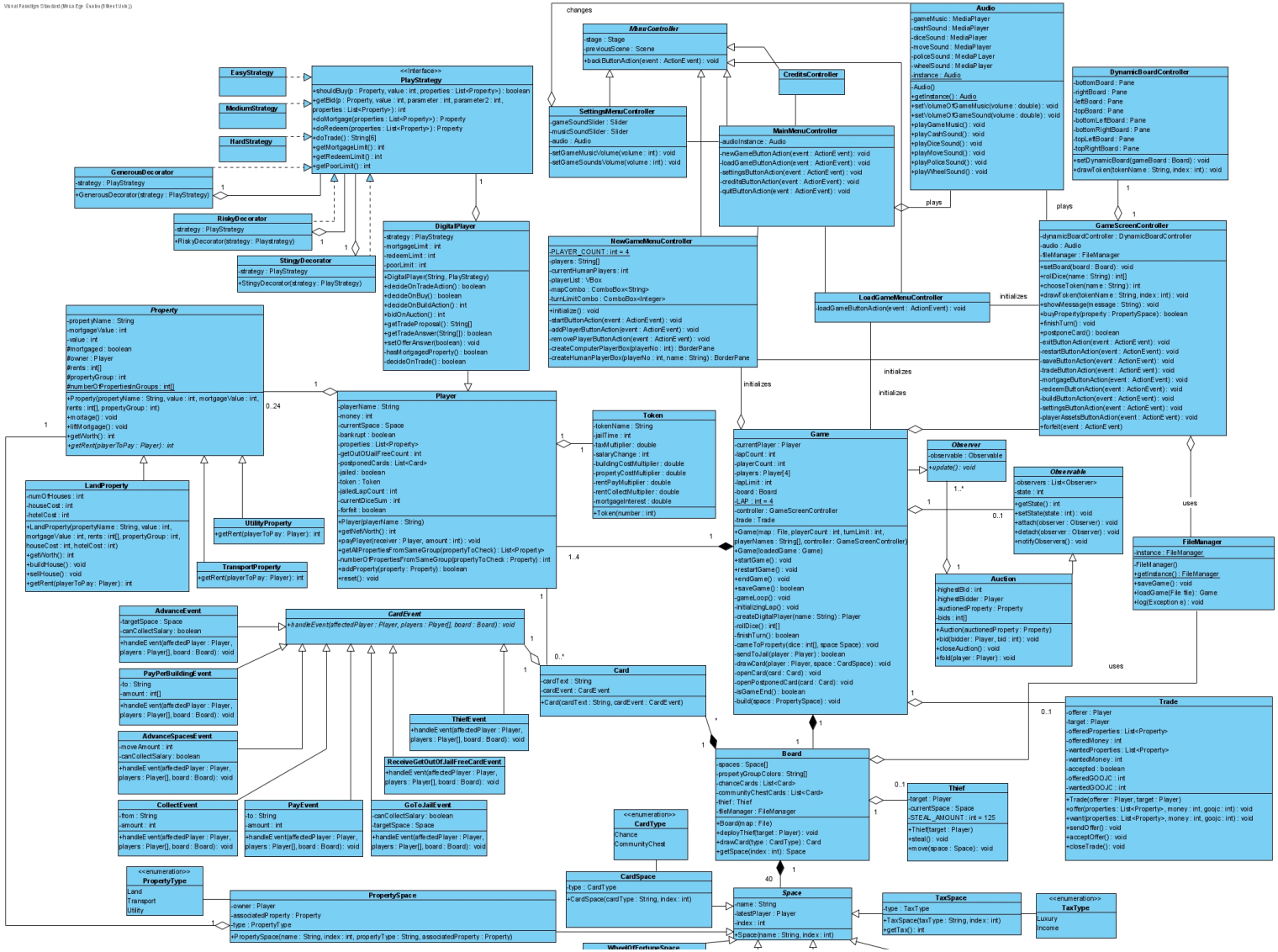
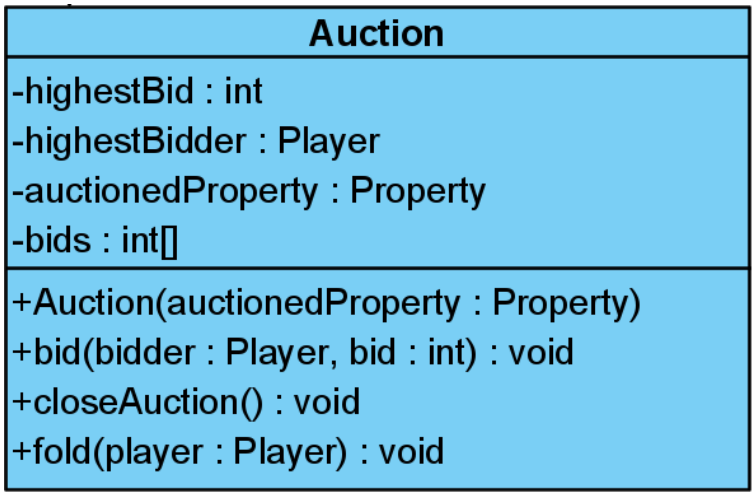


Figure 2 UML Class Diagram.

3.1. Bank Management

Auction Class



Attributes:

- **private final Property auctionedProperty:** This attribute is an instance of Property class that is auctioned.
- **private int highestBid:** This attribute is used to determine the winning amount in the auction.
- **private Player highestBidder:** This attribute is used to determine the winning player in the auction.
- **private int[] bids:** This attribute holds the bids given by each player.

Methods:

- **public void bid(Player bidder, int bid):** This method updates the winning bid if a new bid is higher than the previous highest one.
- **public boolean closeAuction():** This method ends the auction and the winner of the auction buys the property.
- **public void fold(Player player):** This method is used when a player folds, and retreats from the Auction.

Trade Class

Attributes:

- **private final Player offerer:** This attribute is an instance of Player class that is the offerer of the trade.
- **private final Player target:** This attribute is an instance of Player class that is the target of the trade.
- **private List<Property> offeredProperties:** This attribute is a List of Property class that is offered as part of the trade.
- **private int offeredMoney:** This attribute is the amount of money offered as part of the trade.
- **private List<Property> wantedProperties:** This attribute is a List of Property class that is wanted as part of the trade.
- **private int wantedMoney:** This attribute is the amount of money wanted as part of the trade.
- **private int offeredGOOJC:** This attribute is the number of the Get Out Of Jail Cards offered as part of the trade.
- **private int wantedGOOJC:** This attribute is the number of the Get Out Of Jail Cardswanted as part of the trade.
- **private boolean accepted:** This attribute is true if the offer is accepted.

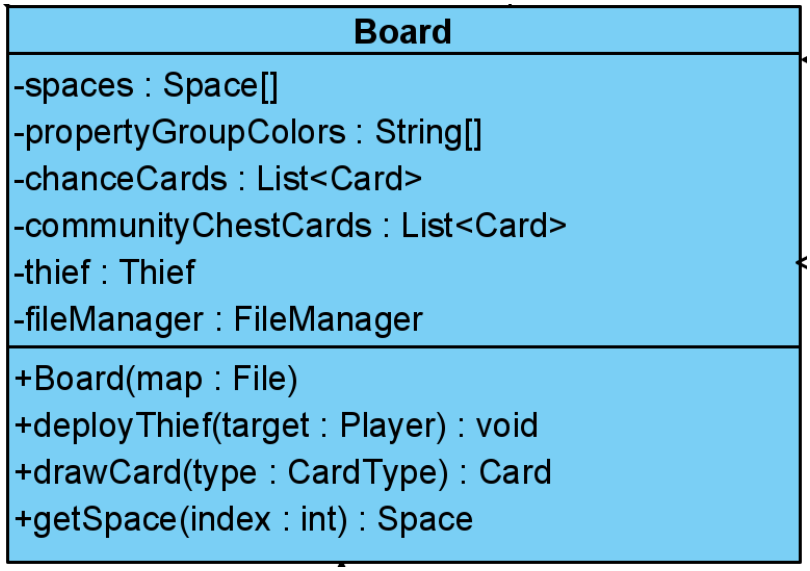
Methods:

- **void offer(List<Property> properties, int money, int goojc):** This method is used to edit the offered part of the trade.
- **void want(List<Property> properties, int money, int goojc):** This method is used to edit the wanted part of the trade.

- **void sendOffer():** This method sends the offer to the target.
- **void acceptOffer():** This method accepts the offer.
- **boolean closeTrade():** This method closes the trade. Returns true if the offer is accepted.

3.2. Board

Board Class



Attributes:

- **private Space spaces[]:** This attribute is an array of the Space class that is part of the board in the game. By default, it should hold 40 instances of Space.
- **private String propertyGroupColors[]:** This attribute is an array of the String class that denotes the property group colors.
- **private List<Card> chanceCards:** This attribute is an List of the Card class that makes up the Chance cards.
- **private List<Card> communityChestCards:** This attribute is an List of the Card class that makes up the Community Chest cards.
- **private Thief thief:** This attribute is an instance of the Thief class. It is initialized when a thief card is played to deploy a Thief.

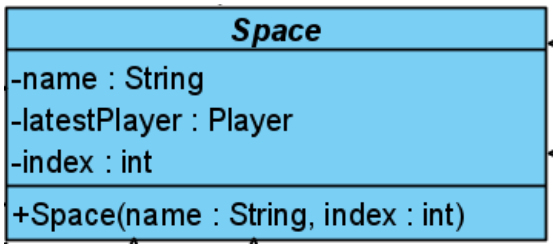
Methods:

- **public Space getSpace(int index):** This method returns the space on the specified index.
- **public void deployThief(Player target):** This method deploys the Thief by initializing the thief property with a target.

- **public Card drawCard(CardSpace.CardType type):** This method draws and returns a card from the top of the deck of the specified card type. It then adds the card back to the bottom of the deck.
- **private FileManager fileManager:** The FileManager singleton used for logging exceptions that happen when reading a map to an external file.

3.3. Game Entity

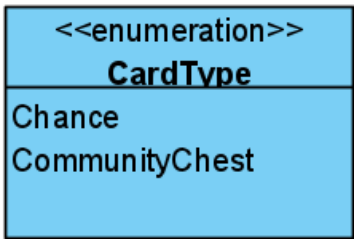
Space Abstract Class



Attributes:

- **private String name:** This attribute denotes the name of the space.
- **private Player latestPlayer:** This attribute is an instance of the Player Class that last stepped on the space.
- **private int index:** This attribute denotes the index number of the space on the board.

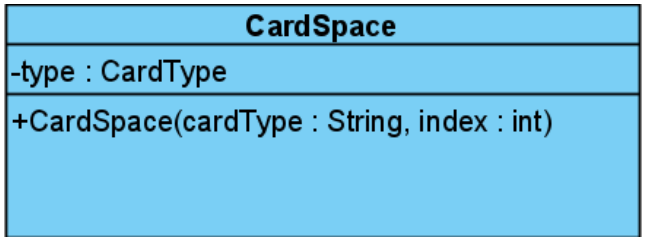
CardType Enum



Enumerations:

- **CHANCE:** Indicates the card's type is that of a Chance Card
- **COMMUNITY_CHEST:** Indicates the card's type is that of a Community Chest Card

CardSpace Class

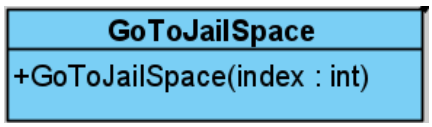


Attributes:

- **private CardType type:** This attribute is a CardType enumeration used to indicate if the card is a Chance Card or Community Chest Card

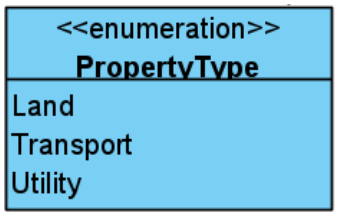
GoSpace Class

GoToJailSpace Class



JailSpace Class

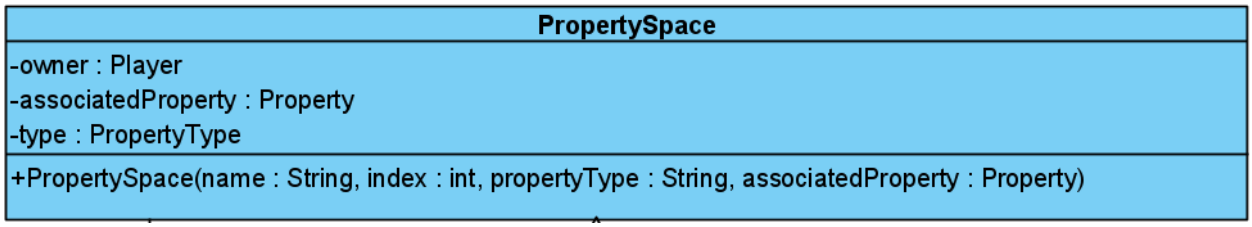
PropertyType Enum



Enumerations:

- **LAND:** Indicates the property's type is that of a Land Property.
- **TRANSPORT:** Indicates the property's type is that of a Transport Property.
- **UTILITY:** Indicates the property's type is that of a Utility Property.

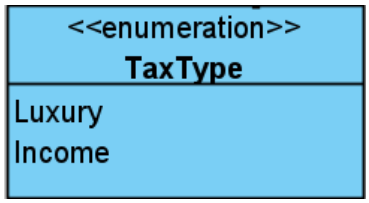
PropertySpace Class



Attributes:

- **private Player owner:** This attribute is an instance of Player Class that owns the property.
- **private int value:** This attribute denotes the value of the property to be used in trades, mortgages or in auctions.
- **private Property associatedProperty:** This attribute is an instance of Property Class that is associated with this particular Space.
- **private PropertyType type:** This attribute is a PropertyType enumeration used to indicate what type of property is on the Space.

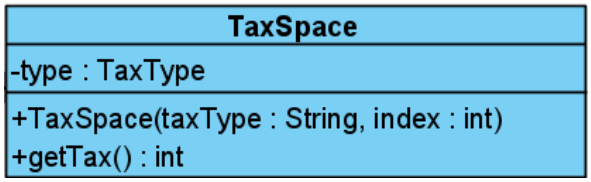
TaxType Enum



Enumerations:

- **LUXURY:** Indicates the tax's type is that of a Luxury Tax.
- **INCOME:** Indicates the tax's type is that of an Income Tax.

TaxSpace Class



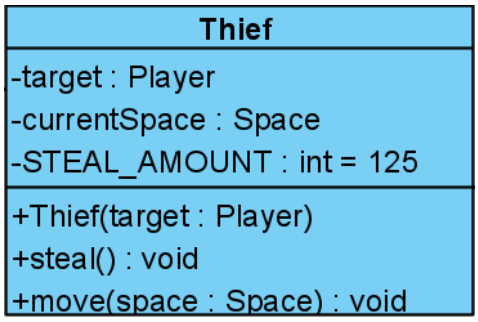
Attributes:

- **private TaxType type:** This attribute is a TaxType enumeration used to indicate what type of tax is applied to the Players that step on the Space.

Methods:

- **public int getTax():** This method returns the base tax according to the TaxType of the Space.

Thief Class



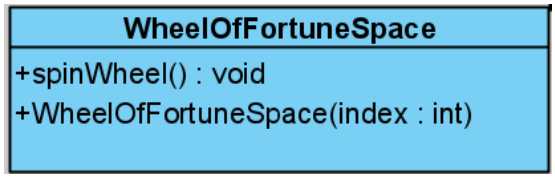
Attributes:

- **private Player target:** This attribute is an instance of the Player Class that is being targeted by the Thief.
- **private Space currentSpace:** This attribute is an instance of the Space Class that the Thief is standing on.
- **private final static int AMOUNT:** This attribute is the amount the thief steals from its target. The constant is set as 125.

Methods:

- **public void steal():** This method steals money from the target. It is called when the thief catches up to its target.
- **public void move(Space space):** This method moves the Thief on the Board.

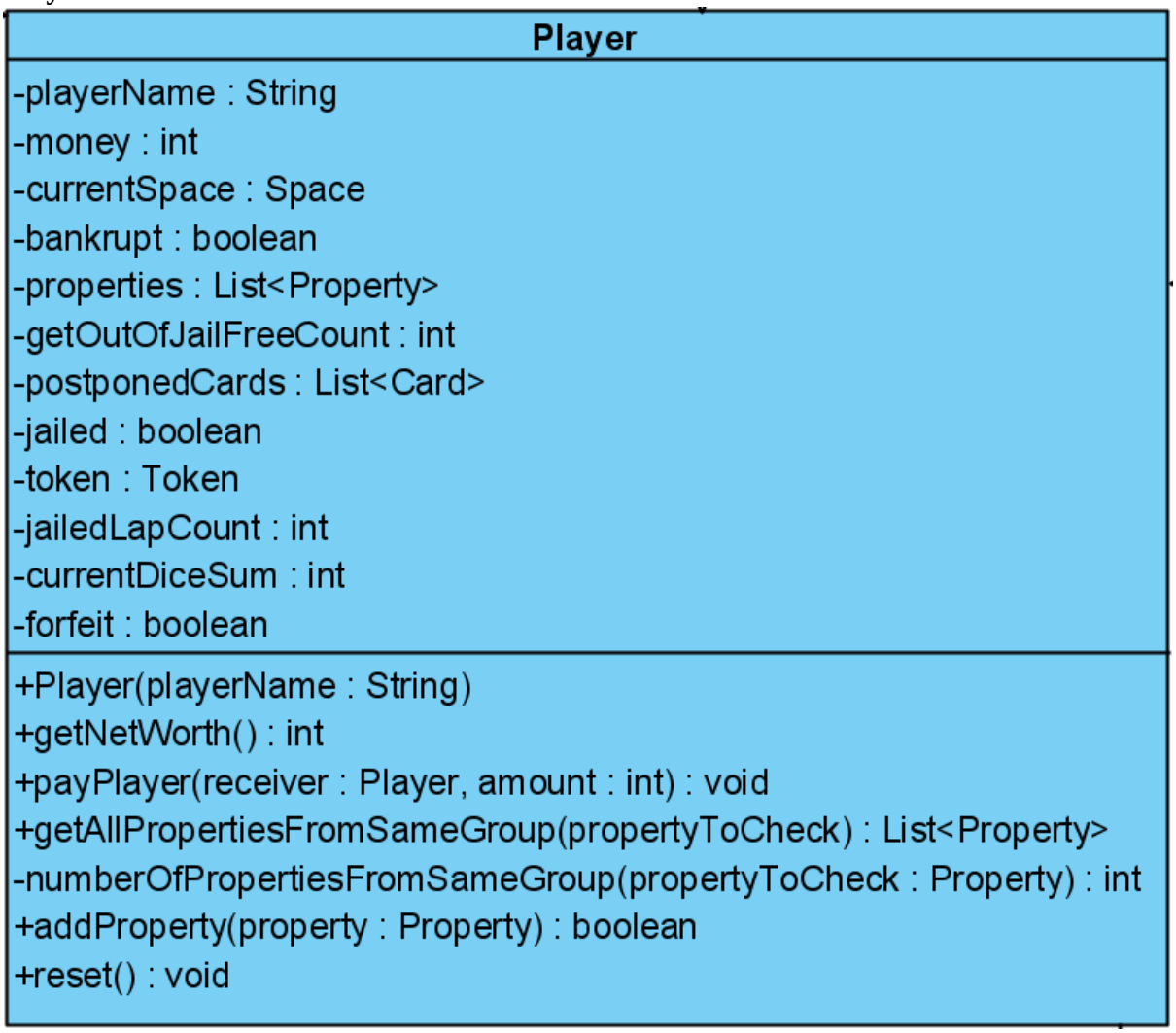
WheelOfFortuneSpace Class



Methods:

- **public int spinWheel():** This method spins the wheel and generates a random amount to be used as the reward.

Player Class



Attributes:

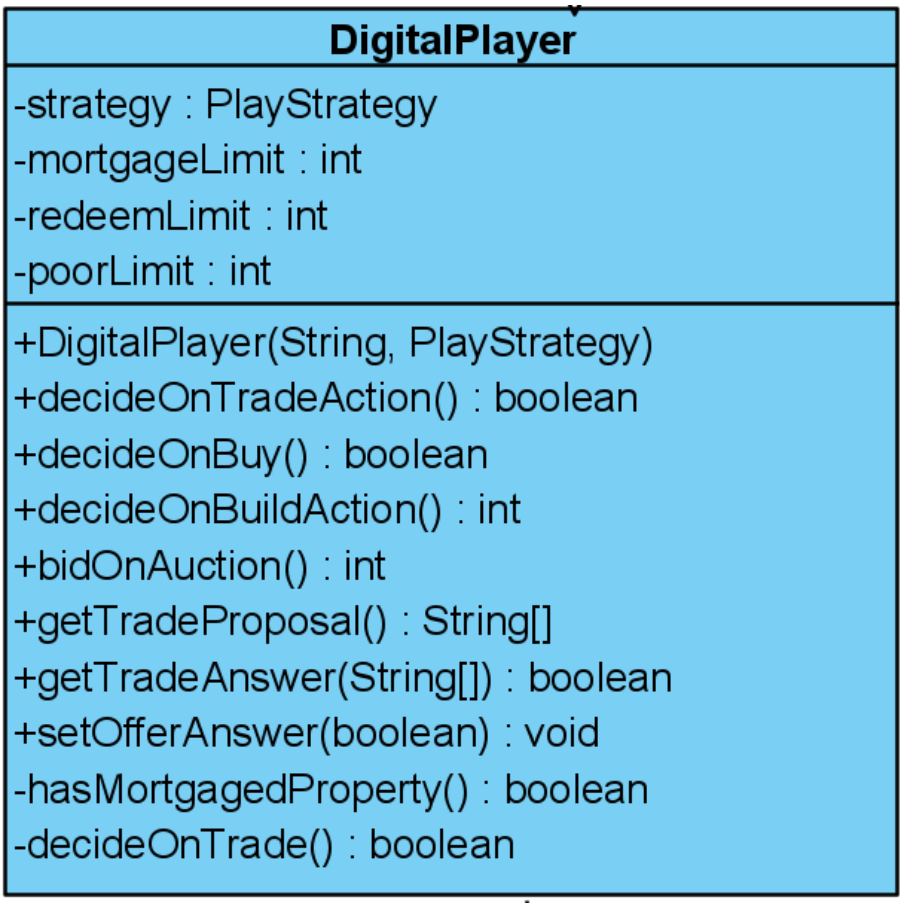
- **private String playerName:** This attribute denotes the name of the Player.
- **private int money:** This attribute denotes the amount of money the Player possesses.
- **private Space currentSpace:** This attribute is an instance of the Space class which is the current one the Player is standing on.
- **private boolean bankrupt:** This attribute denotes whether the Player has gone bankrupt or not.
- **private List<Property> properties:** This attribute is a List of the Property class which are the properties the Player owns:
- **private int getOutOfJailFreeCount:** This attribute denotes the amount of GetOutOfJailFreeCards the player owns.
- **private List<Card> postponedCards:** This attribute is a List of the Card class which are the cards the Player has drawn but not opened yet.
- **private boolean jailed:** This attribute denotes whether the player has been jailed or not.

- **private Token token:** This attribute is an instance of the Token class which is the Token that represents the Player.
- **private int jailedLapCount:** This attribute denotes the number of laps the Player has spent in jail.
- **private int currentDiceSum:** The current sum of the dice rolled by the player.

Methods:

- **public int getNetWorth():** This method calculates and returns the player's net worth.
- **public void payPlayer(Player receiver, int amount):** This method is used to pay money to another player.
- **public List<Property> getAllPropertiesFromSameGroup(Property propertyToCheck):** This method returns a List of the Property class which are in the same group as the propertyToCheck.
- **private int numberOfPropertiesFromSameGroup(Property propertyToCheck):** This method returns the amount of titles in the group of propertyToCheck.
- **public boolean addProperty(Property property):** This method adds the property to the Player's properties and returns true if the action is successful.
- **public void reset():** This method is used to reset a Player's attributes.

DigitalPlayer Class



Attributes:

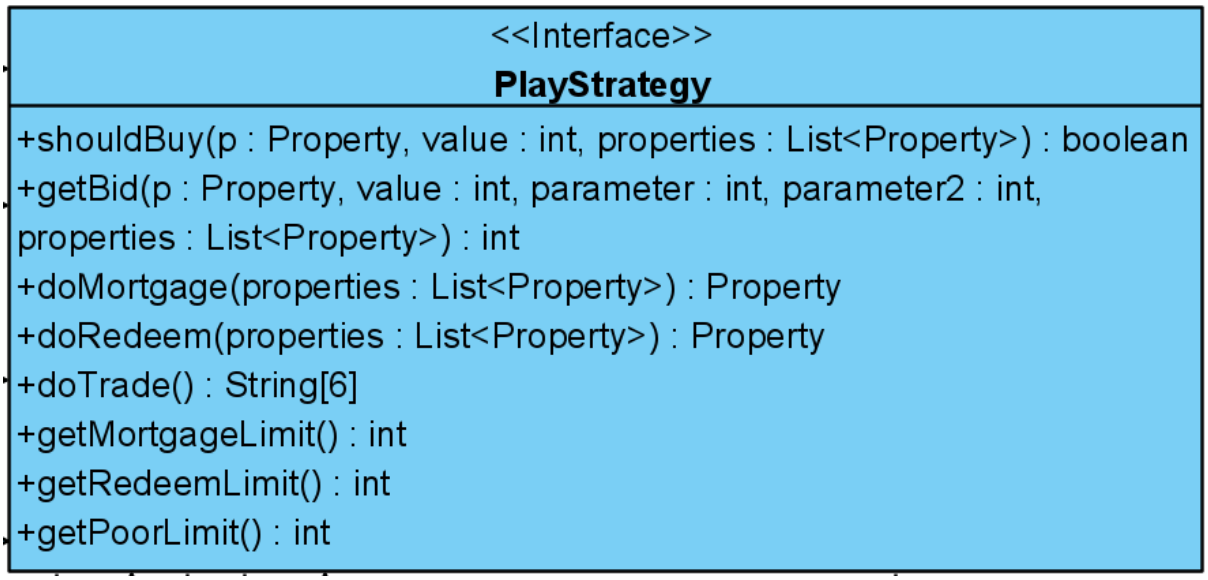
- **private PlayStrategy strategy:** This attribute holds a class that implements a PlayStrategy interface. The artificial decisions made on this class are controlled and affected by the strategy attribute.
- **private int mortgageLimit:** This is an integer value to determine whether the player needs to mortgage their properties. It is a lower limit. If Player's money drops lower than this amount, the digital player will need to mortgage if they have any property. This limit is decided by the strategy attribute.
- **private int redeemLimit:** This is an integer value to determine whether the player is ready to claim their mortgaged properties. It is an upper limit. If Player's money reaches higher than this amount, the digital player will be able to redeem if they have any mortgaged property. This limit is decided by the strategy attribute.
- **private int poorLimit:** This is an integer value to determine whether the player is in poor condition. It is a lower limit. If Player's money drops lower than this amount, the digital player might change its strategy in making decisions. This limit is decided by the strategy attribute.

Methods:

- **public boolean decideOnTradeAction():** This method will investigate if a trade action will be taken by the player this turn. This decision will be made according to the player's strategy and return the boolean answer to the Game class.
- **public boolean decideOnBuy():** This method will investigate if a buy or auction action will be taken by the player this turn. This decision will be made according to the player's strategy. If the return value is true, buy action will be performed; else auction action will be performed.
- **public int decideOnBuildAction():** This method will investigate if a build action will be taken by the player this turn. This decision will be made according to the player's strategy. The return value will indicate whether there will be a build action, how many properties and how many buildings to be built.
- **public int bidOnAuction():** This method will calculate the best bid amount to a property during an auction action. This decision will be made according to the player's strategy and return the amount of bid. A -1 in the return value will indicate a "fold" action.
- **public String[] getTradeProposal():** This method will calculate the best trade proposal during a trade action. This decision will be made according to the player's strategy and return value will include both the offered and requested assets in the proposal.
- **public boolean getTradeAnswer(String[]):** This method will send a trade proposal to the digital player. After being assessed according to its strategy, the return value will indicate an approval or rejection.
- **public void setOfferAnswer(boolean):** This method will return an answer to a trade proposal sent by the digital player. the parameter will indicate an approval or rejection.

- **private boolean hasMortgagedProperty():** This private method will return true if the digital player has mortgaged property. Else, it will return false. This method is used when redeem action is being evaluated.
- **private boolean decideOnTrade():** This method assesses whether a trade action should be taken by the player this turn. This decision will be made according to the player's strategy. The return value will indicate whether there will be a trade action.

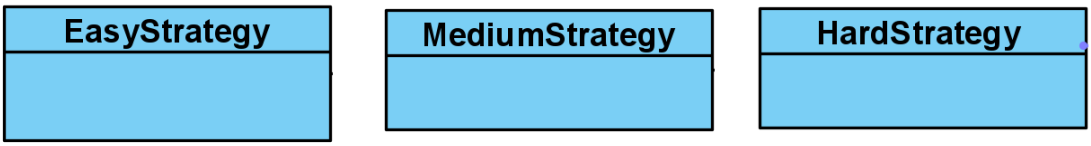
PlayStrategy Interface



Methods:

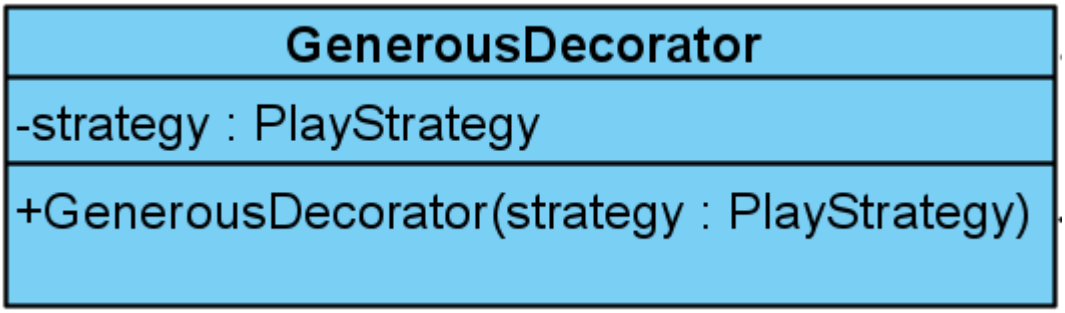
- **public boolean shouldBuy(Property p, int value, List<Property> properties):** This method will assess whether a Buy action should be taken according to its parameters.
- **public int getBid(Property p, int value, int parameter, int parameter2, List<Property> properties):** This method will calculate a bid amount for an auction action according to its parameters.
- **public Property doMortgage(List<Property> properties):** This method will assess which owned property will be mortgaged between the property list in its parameter. The return value will be the decided property.
- **public Property doRedeem(List<Property> properties):** This method will assess which owned mortgaged property will be redeemed between the property list in its parameter. The return value will be the decided property.
- **public String[] doTrade():** This method will calculate a trade proposal. The return value will be the proposal with both offered and required assets.
- **public int getMortgageLimit():** This method will return an integer value to determine whether the player needs to mortgage their properties. It is a lower limit.
- **public int getRedeemLimit():** This method will return an integer value to determine whether the player needs to redeem their properties. It is an upper limit.
- **public int getPoorLimit():** This method will return an integer value to determine whether the player is considered to be poor. It is a lower limit.

EasyStrategy, MediumStrategy & HardStrategy Classes



The EasyStrategy, MediumStrategy & HardStrategy Classes are implementing the PlayStrategy class with different algorithms. Each difficulty level assesses different parameters and qualities of the same methods to provide a different range of decisions. All methods present in the PlayStrategy interface are overridden in these classes.

GenerousDecorator Class



Attributes:

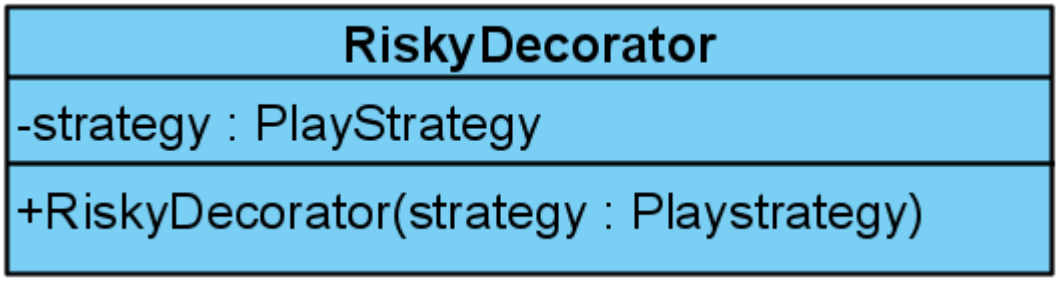
- **private PlayStrategy strategy:** This attribute holds a class that implements a PlayStrategy interface. The artificial decisions made by this strategy attribute are altered and modified in this class.

Methods:

- **public GenerousDecorator(strategy: PlayStrategy):** This is a constructor which only takes a PlayStrategy attribute. The modification of algorithm results are done on this strategy.

The GenerousDecorator class implements the PlayStrategy interface. Hence, each method in the PlayStrategy interface is overridden inside this class.

RiskyDecorator Class



Attributes:

- **private PlayStrategy strategy:** This attribute holds a class that implements a PlayStrategy interface. The artificial decisions made by this strategy attribute are altered and modified in this class.

Methods:

- **public RiskyDecorator(strategy: PlayStrategy):** This is a constructor which only takes a PlayStrategy attribute. The modification of algorithm results are done on this strategy.

The RiskyDecorator class implements the PlayStrategy interface. Hence, each method in the PlayStrategy interface is overridden inside this class.

StingyDecoratorClass

Attributes:

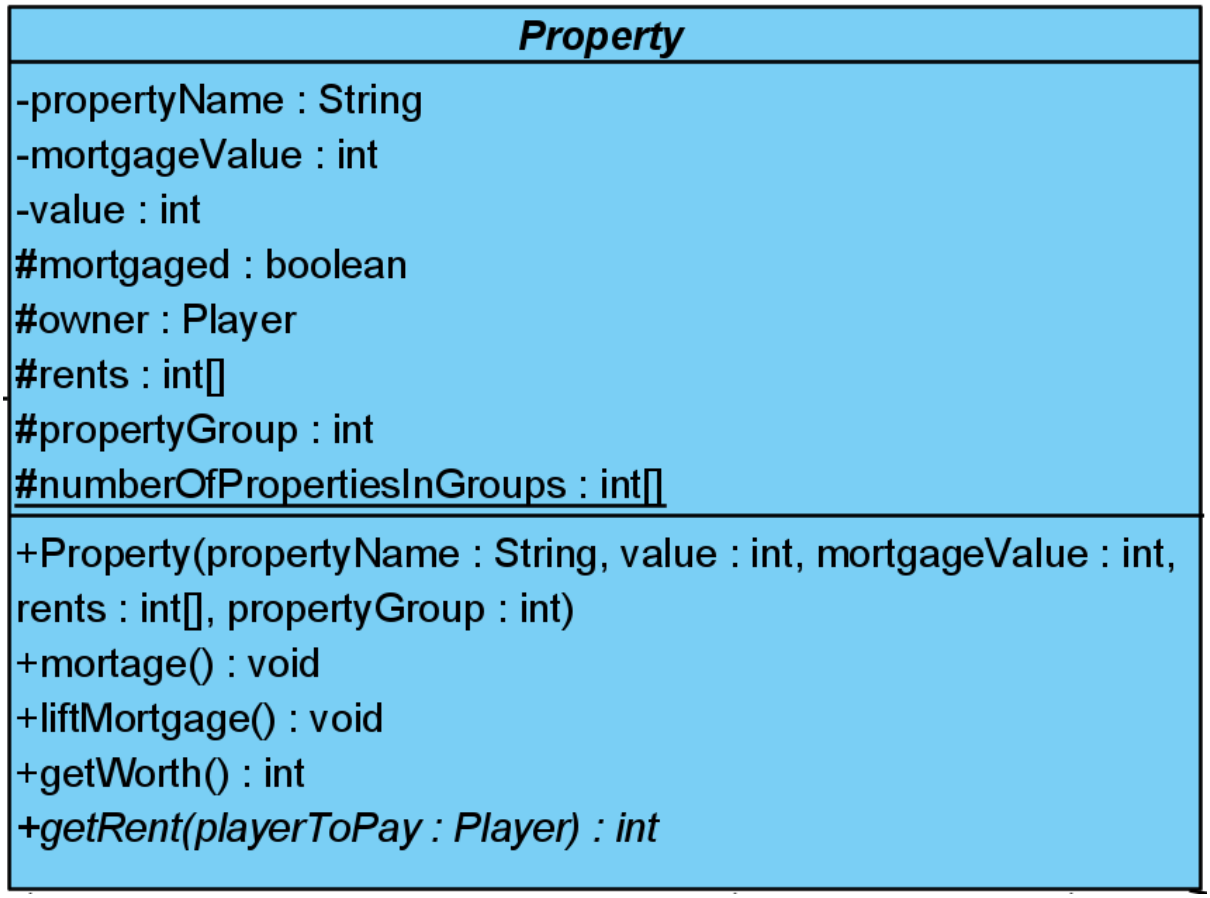
- **private PlayStrategy strategy:** This attribute holds a class that implements a PlayStrategy interface. The artificial decisions made by this strategy attribute are altered and modified in this class.

Methods:

- **public StingyDecorator(strategy: PlayStrategy):** This is a constructor which only takes a PlayStrategy attribute. The modification of algorithm results are done on this strategy.

The StingyDecorator class implements the PlayStrategy interface. Hence, each method in the PlayStrategy interface is overridden inside this class.

Property Class



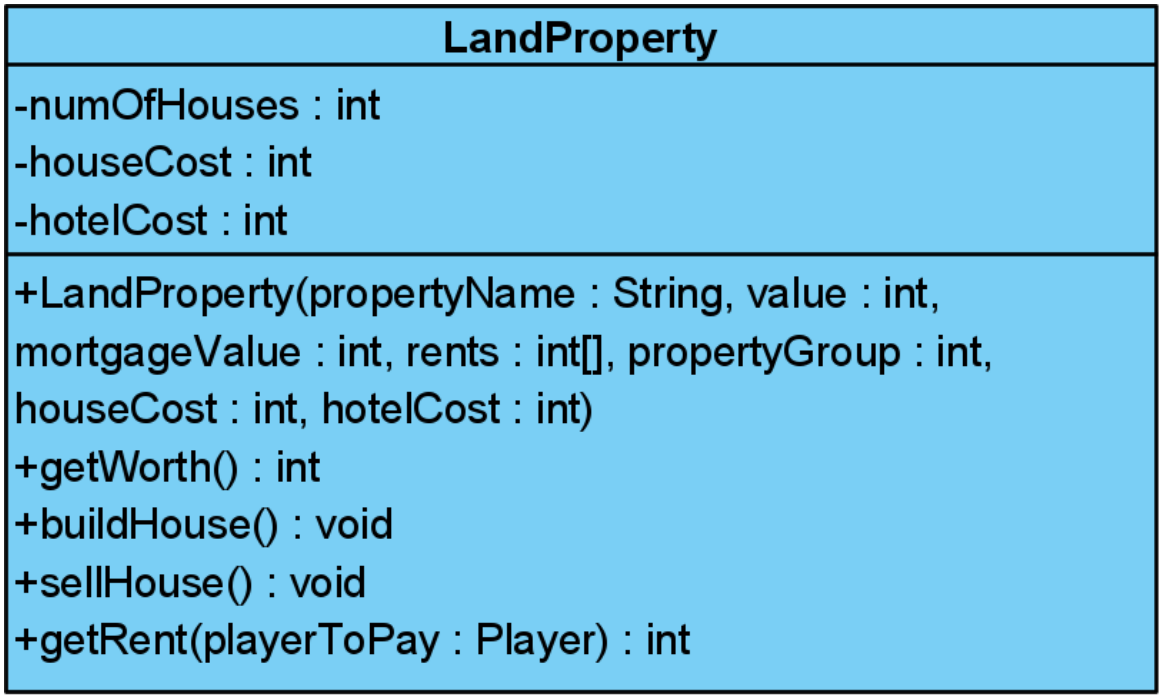
Attributes:

- **private String propertyName:** This attribute denotes the name of the property.
- **private int mortgageValue:** This attribute denotes the property's mortgage value.
- **private int value:** This attribute denotes the value of the Property.
- **protected boolean mortgaged:** This attribute denotes whether the Property is mortgaged or not.
- **protected Player owner:** This attribute denotes the owner of the Property.
- **protected int[] rents:** This attribute denotes the rents of the Property.
- **protected int propertyGroup:** This attribute denotes which property group the Property is in.
- **protected static int[] numberOfPropertiesInGroups:** This attribute denotes how many properties are in each property group.

Methods:

- **public void mortgage():** This method is used to mortgage the Property.
- **public void liftMortgage():** This method is used to lift the mortgage on the Property.
- **public int getWorth():** This method returns the worth of the Property
- **public int getRent(Player playerToPay):** Calculates the rent the given player would pay.

LandProperty Class



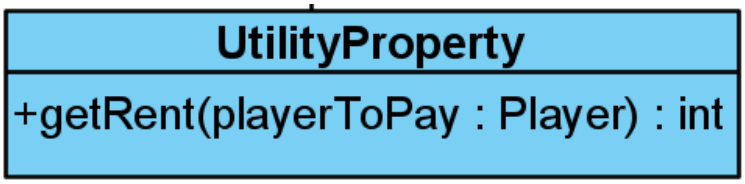
Attributes:

- **private int numOfHouses:** This attribute denotes the number of houses on the LandProperty.
- **private int houseCost:** This attribute denotes how much each house building action costs.
- **private int hotelCost:** This attribute denotes how much hotel building action costs.

Methods:

- **public void getWorth():** This method returns the worth of the LandProperty as the sum of the values of the land itself and any houses or hotel on it.
- **public void buildHouse():** This method is used to build a house on the Property.
- **public void sellHouse ():** This method is used to sell a house on the Property.
- **public void getRent():** Calculates the rent the given player would pay.

UtilityProperty Class



Methods:

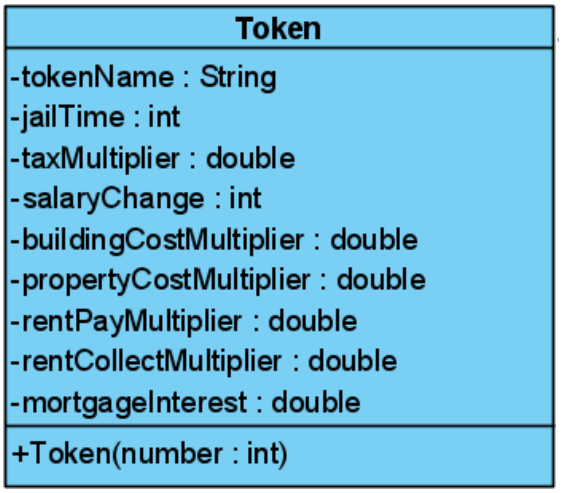
- **public void getRent():** Calculates the rent the given player would pay.

TransportProperty Class

Methods:

- **public void getRent():** Calculates the rent the given player would pay.

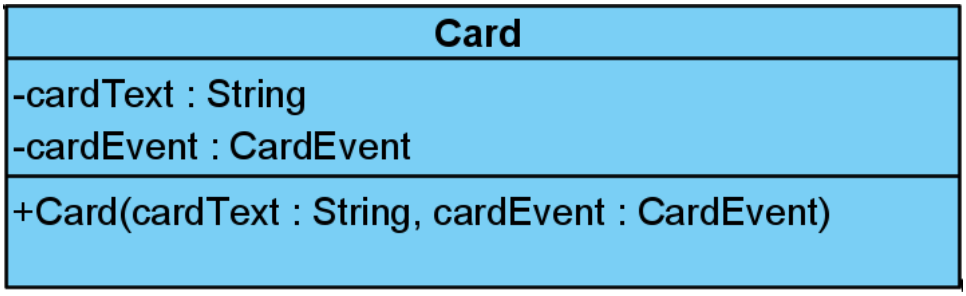
Token Class



Attributes:

- **private String tokenName:** This attribute denotes the name of the Token.
- **private int jailTime:** This attribute denotes the time in jail the owner of the Token has to spend.
- **private double taxMultiplier:** This attribute is used to determine how much tax the owner of the Token has to pay.
- **private int salaryChange:** This attribute is used to determine how much salary the owner of the Token receives.
- **private double buildingCostMultiplier:** This attribute is used to determine how much money the owner of the Token has to pay when building a house or a hotel.
- **private double propertyCostMultiplier:** This attribute is used to determine how much money the owner of the Token has to pay when purchasing a Property.
- **private double rentPayMultiplier:** This attribute is used to determine how much money the owner of the Token has to pay don rent.
- **private double rentCollectMultiplier:** This attribute is used to determine how much money the owner of the Token receives on rent.
- **private double mortgageInterest:** This attribute is used to determine how much money the owner of the Token has to pay when lifting a mortgage.

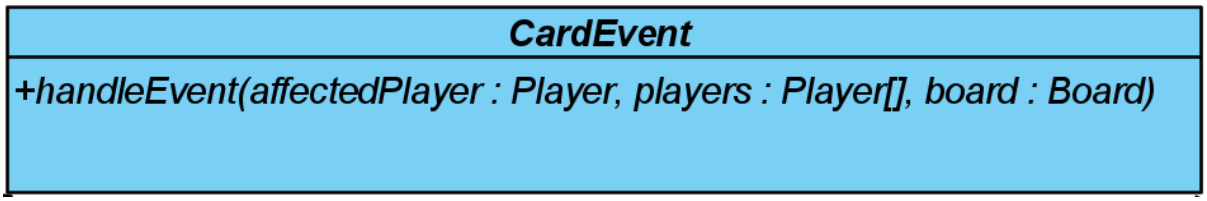
Card Class



Attributes:

- **private String cardText:** This attribute denotes the text of the Card.
- **private CardEvent cardEvent:** This attribute is an instance of CardEvent class that denotes the event to occur when the card is opened.

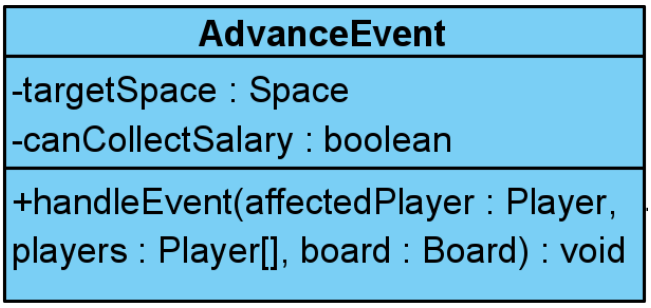
CardEvent Class



Methods:

- **public abstract void handleEvent():** Handles the associated event and makes the necessary changes to the affected entities.

AdvanceEvent Class



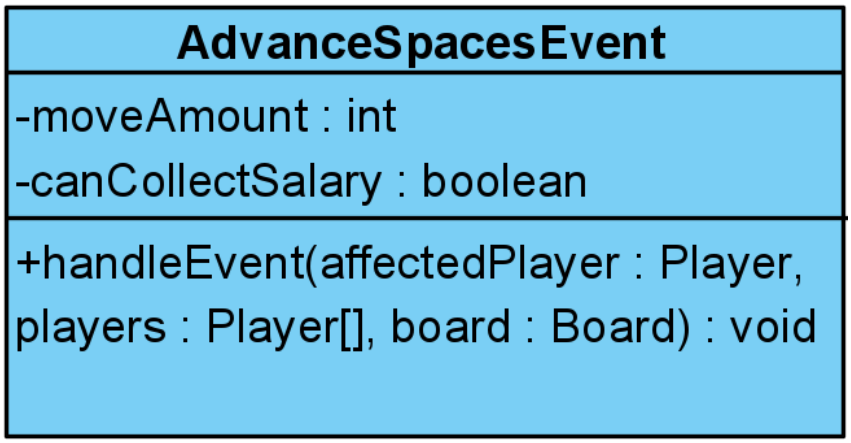
Attributes:

- **private Space targetSpace:** This attribute denotes the space the Player is going to advance to.
- **private boolean canCollectSalary:** This attribute denotes if the Player can collect salary while advancing.

Methods:

- **public abstract void handleEvent():** Moves the player to the given Space, if they pass "GO" and can collect salary, they will collect their salary

AdvanceSpacesEvent Class



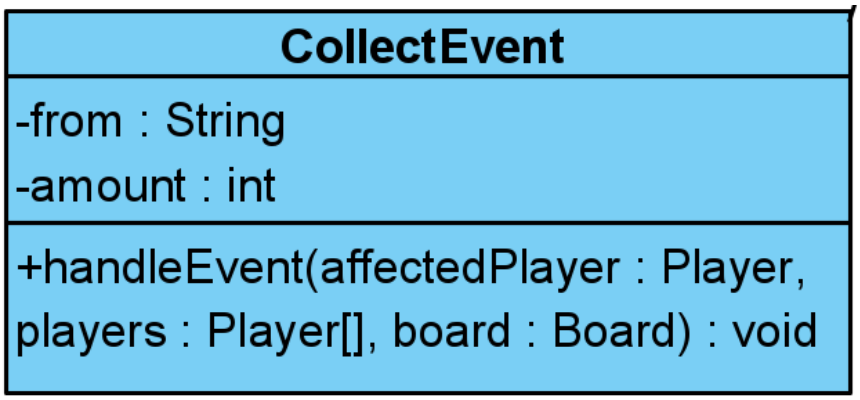
Attributes:

- **private int moveAmount:** This attribute denotes how many spaces the Player is going to advance, it can have both positive and negative values..
- **private boolean canCollectSalary:** This attribute denotes if the Player can collect salary while advancing.

Methods:

- **public abstract void handleEvent():** Moves the player by moveAmount spaces. The player can collect their salary if they are allowed, if they pass the "GO" space.

CollectEvent Class



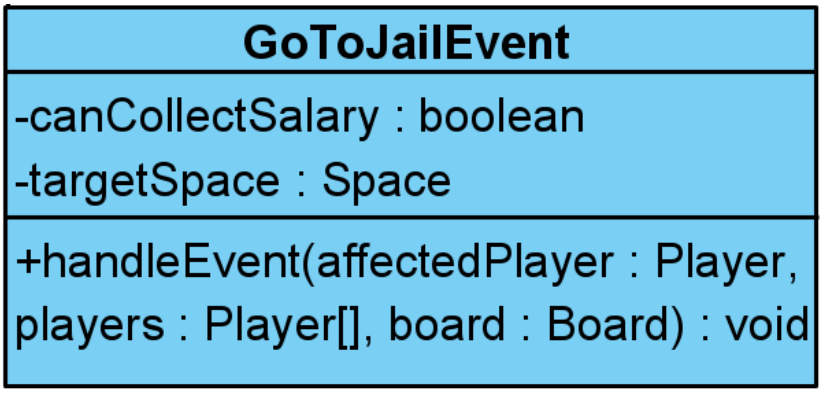
Attributes:

- **private String from:** This attribute denotes who the player is going to collect the money from..
- **private int amount:** This attribute denotes the amount to be paid to the Player.

Methods:

- **public abstract void handleEvent():** Collects the money from the specified sources and gives it to the affectedPlayer.

GoToJailEvent Class



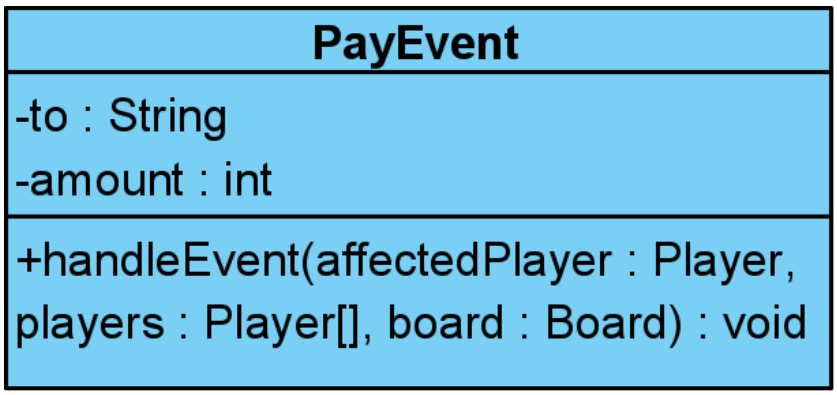
Attributes:

- **private boolean canCollectSalary:** This attribute denotes whether the Player can collect a salary while advancing to the jail.
- **private Space targetSpace:** This attribute denotes the space the Player is going to advance to, which is the JailSpace in this case.

Methods:

- **public abstract void handleEvent():** Sends the player to the jail. The player can collect their salary if they are allowed if they pass the "GO" space.

PayEvent Class



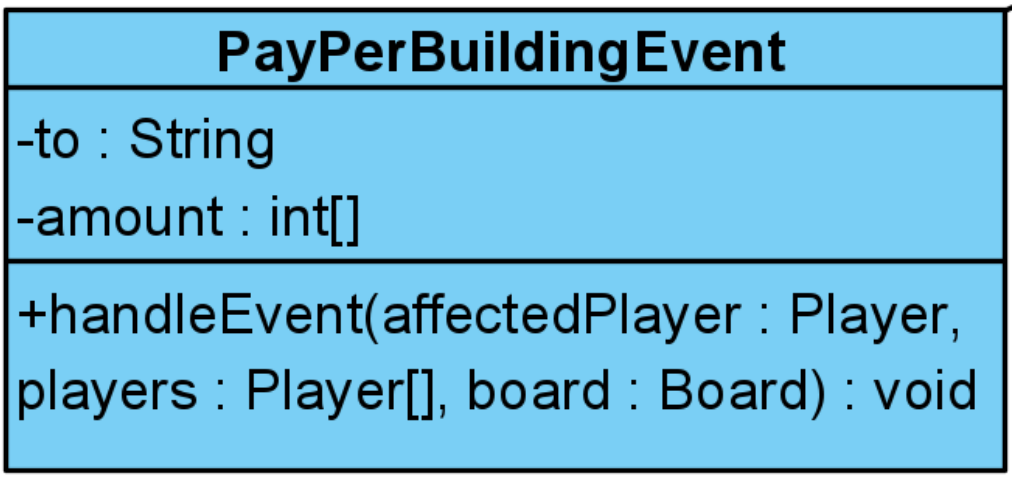
Attributes:

- **private String to:** This attribute denotes who the player is going to pay the money to.
- **private int amount:** This attribute is the amount the Player has to pay.

Methods:

- **public abstract void handleEvent():** Collects the money from the affectedPlayer and gives it to the recipients

PayPerBuildingEvent Class



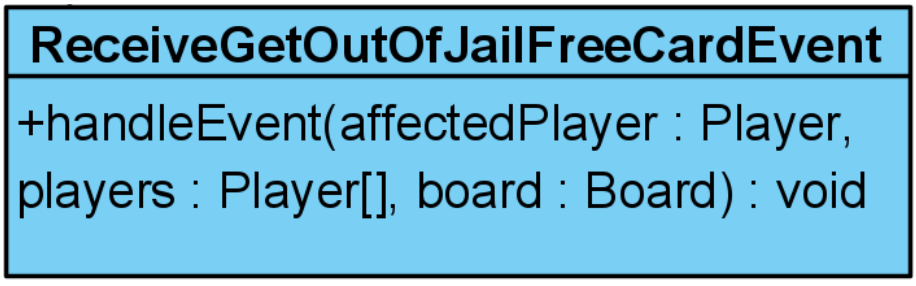
Attributes:

- **private String to:** This attribute denotes who the player is going to pay the money to.
- **private int[] amount:** This attribute denotes the amounts the Player has to pay for their buildings.

Methods:

- **public abstract void handleEvent():** Makes the player pay an amount of money, specified in amount, for each of their buildings (houses and hotel).

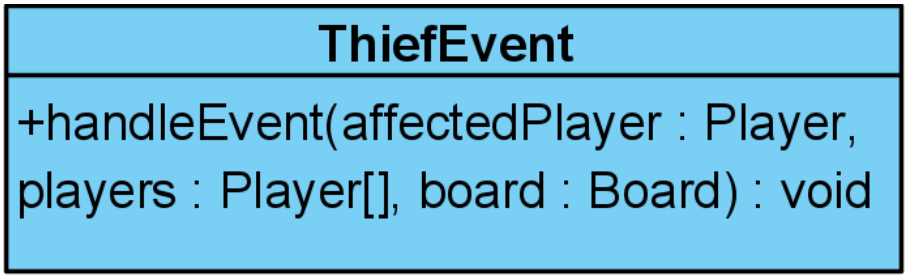
ReceiveGetOutOfJailEvent Class



Methods:

- **public abstract void handleEvent():** Increments the "Get Out of Jail Free" card count of the affectedPlayer by one.

ThiefEvent Class

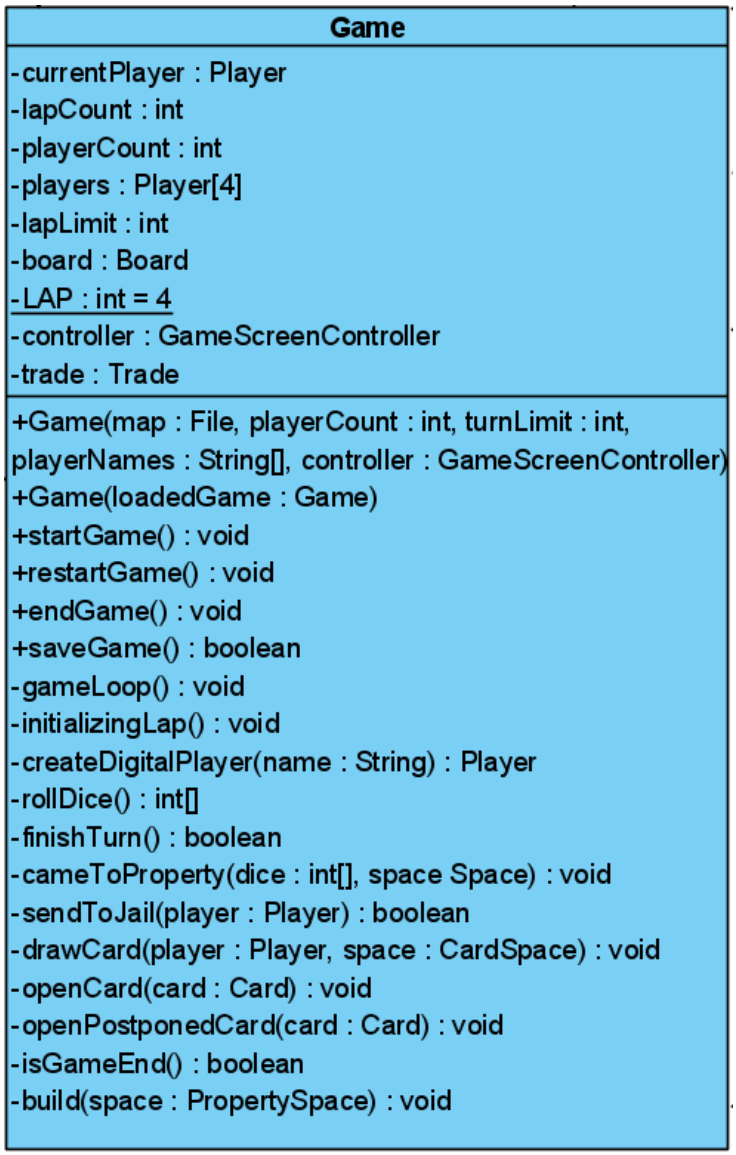


Methods:

- **public abstract void handleEvent():** Deploys a thief on the board with a random target.

3.4. Game

Game Class



Attributes:

- **private Player currentPlayer:** This attribute is an instance of the Player class which is the one that has the active turn.
- **private int lapCount:** This attribute denotes how many laps have been performed in the game.
- **private final int playerCount:** This attribute denotes the number of players in the game.
- **private Player[] players:** This attribute is an array of the Player class which are the players of the game.
- **private final int lapLimit:** This attribute denotes the lap limit for the game to end. It is -1 if there is no lap limit.
- **private final Board board:** This attribute denotes the Board the Game is played on.

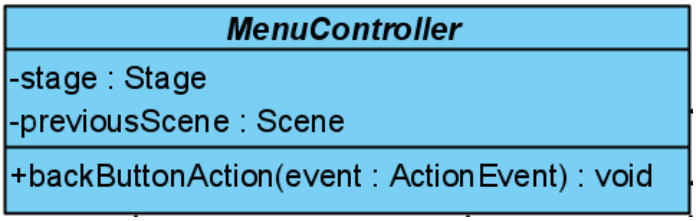
- **private static final int LAP:** This attribute denotes the number of turns needed to be played in a single lap. The constant's value is 4.
- **private GameScreenController controller:** This attribute is an instance of the GameScreenController class which handles the user interface of the game screen.
- **private Trade trade:** This attribute is an instance of Trade class, which handles trades between players.

Methods:

- **public void startGame():** This method is used to start the Game.
- **public void restartGame():** This method is used to restore the Game to its initial state and restart the game.
- **public void endGame():** This method is used to end the game and display the results.
- **public boolean saveGame():** This method is used to save the game state to a file to be able to continue later on.
- **private void gameLoop():** This method is used to start the gameplay loop and handle in-game events.
- **private void initializingLap():** This method is used to perform the actions of the initializing lap. This lap requires a specific method as actions such as token selections and player initializations are only done in the initializing lap.
- **private Player createDigitalPlayer(String name):** This method is used to create a DigitalPlayer to fill the game with 4 Players. The created DigitalPlayer is returned.
- **public int[] rollDice(String name):** This method rolls and returns the dice.
- **public boolean finishTurn():** This method is used to alert the user to finish their turn.
- **private void cameToProperty(int[] dice, Space space)**: This method is used to decide which Space the Player landed on according to its dice roll.
- **private boolean sendToJail(Player player):** This method is used to send the player to jail.
- **private void drawCard(Player player, CardSpace space):** This method is used to draw a Card for the Player depending on the Space the Player landed on.
- **private void openPostponedCard(Card card):** This method is used to open a card that the Player postponed.
- **private void openCard(Card card):** This method is used to open a Card.
- **private boolean isGameEnd():** This method returns whether the Game ended or not.
- **private void build(PropertySpace space):** This method handles build operations for a given space.

3.5. UI Controller

***MenuController* Class**



Attributes:

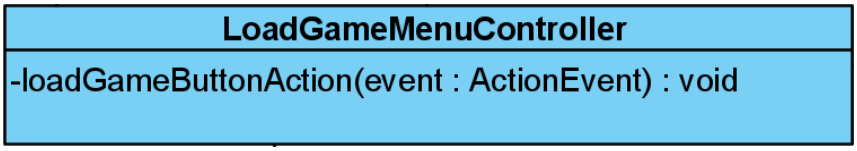
- **private Stage stage:** Holds the current JavaFX stage.
- **private Stage previousScene:** Holds the previous scene which will be displayed if the user presses the Back button.

Methods:

- **private void backAction(ActionEvent actionEvent):** This method is used to return to the previous page.

CreditsController Class

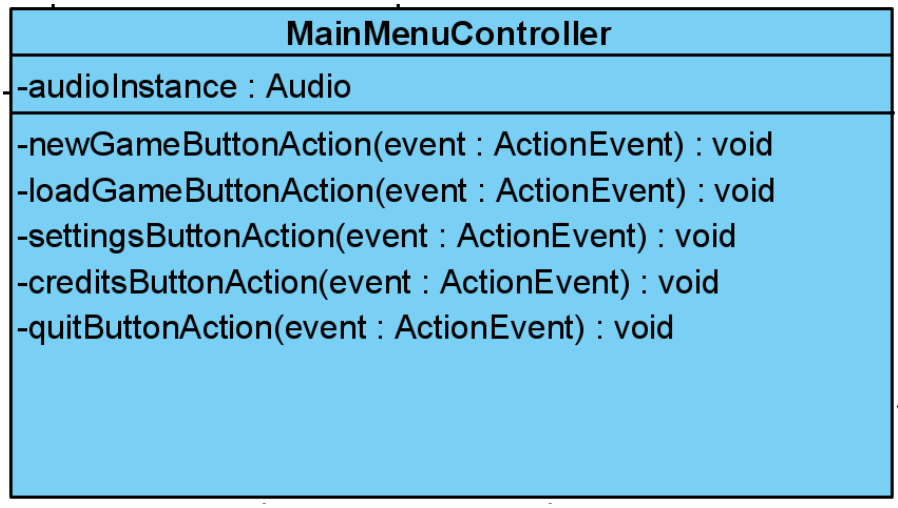
LoadGameMenuController Class



Methods:

- **private void loadGameButtonAction(ActionEvent event):** Loads the given game file and initializes the Game and GameScreenController objects with the loaded data.

MainMenuController Class



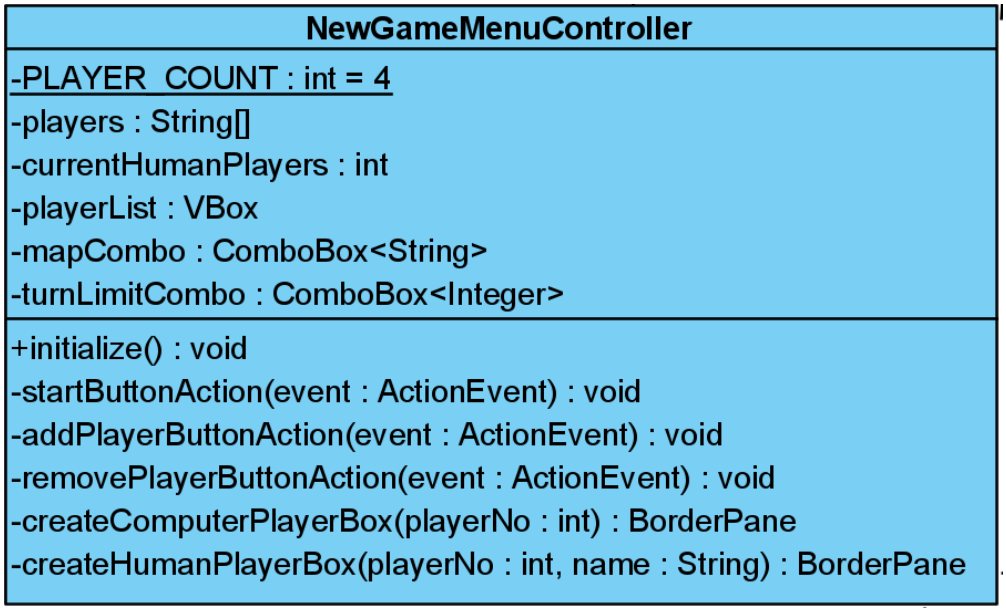
Attributes:

- **private Audio audioInstance:** The Audio singleton used for handling the game music and sounds.

Methods:

- **private void newGameButtonAction(ActionEvent event):** Navigates to the New Game menu screen.
- **private void loadGameButtonAction(ActionEvent event):** Navigates to the Load Game menu screen.
- **private void settingsButtonAction(ActionEvent event):** Navigates to the Settings menu screen.
- **private void creditsButtonAction(ActionEvent event):** Navigates to the Credits menu screen.
- **private void quitButtonAction(ActionEvent event):** Quits the application.

NewGameMenuController Class



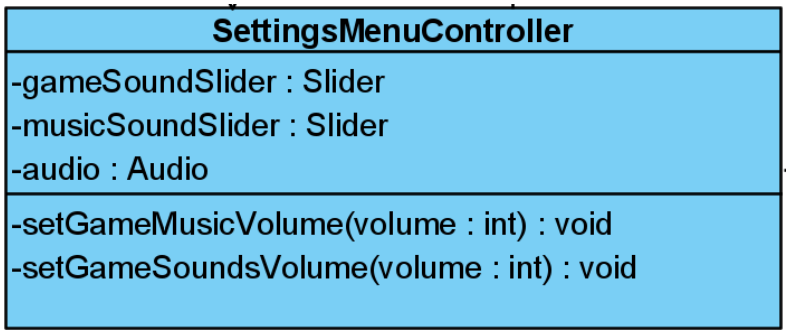
Attributes:

- **Private static final int PLAYER_COUNT = 4:** The maximum player count.
- **Private String[] players:** Holds the names of the current human players.
- **Private int currentHumanPlayer:** Holds the number of current human players.
- **Private Vbox playerList:** The VBox(JavaFX component) that holds the player cards.
- **Private ComboBox<String> mapCombo:** The ComboBox(JavaFX component) that the user interacts with to choose the map file.
- **Private ComboBox<Integer> turnLimitCombo:** The ComboBox(JavaFX component) that the user interacts with to choose the turn limit.

Methods:

- **public void initialize():** Creates the initial player boxes for the computer players, loads the map files from the maps folder, adds the maps to the mapCombo component and adds the turn limit options to the turnLimitCombo component.
- **private void startButtonAction(ActionEvent event):** Initializes the GameScreenController and Game objects when the user presses the start button in the new game screen.
- **private void addPlayerButton(ActionEvent event):** If there are fewer human players than the maximum number of players prompts the user to enter a player name, constructing a player box for that player and adding that player to the players list.
- **private void removePlayerButton(ActionEvent event):** Removes the player box, on which this method was invoked, and the player from the players list.
- **private BorderPane createComputerPlayerBox(int playerNo):** Creates a player box for the computer player with the given playerNo.
- **private BorderPane createHumanPlayerBox(int playerNo, String name):** Creates a player box for the human player with the given playerNo and name.

SettingsMenuController Class



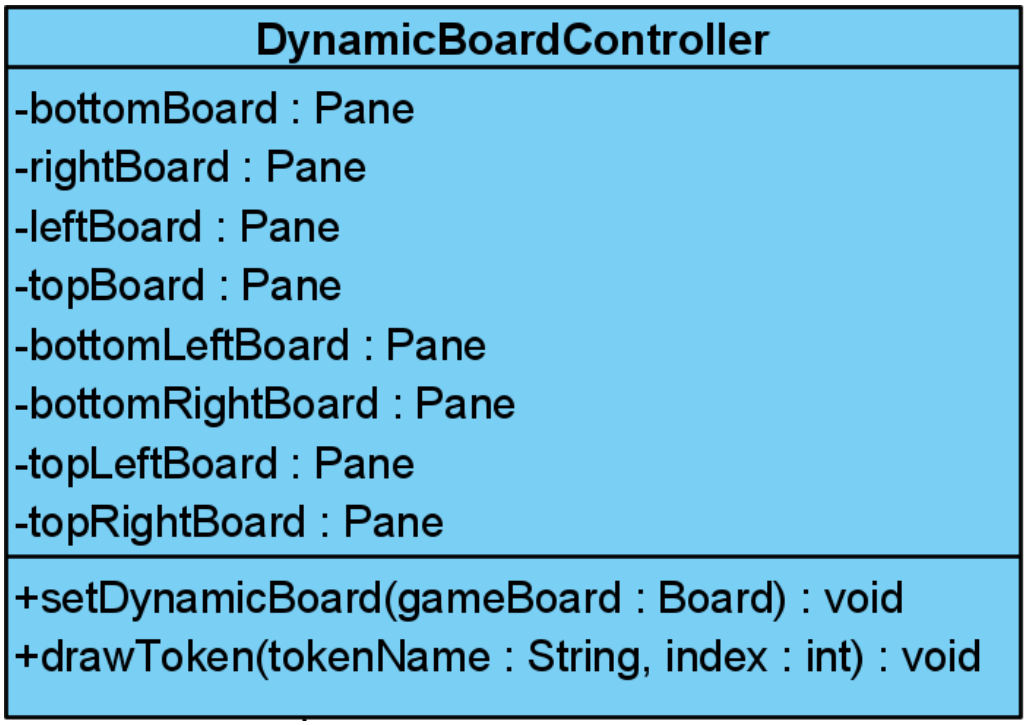
Attributes:

- **private Audio audio:**The Audio singleton used for handling the game music and sounds.
- **private Slider musicSoundSlider:** The JavaFX slider element used to set the volume of game music.
- **private Slider gameSoundSlider:**The JavaFX slider element used to set the volume of game sounds.

Methods:

- **private void setGameSoundsVolume(int volume):** Sets the game sound effects volume level to the given int.
- **private void setGameMusicVolume(int volume):** Sets the game music volume level to the given int.

DynamicBoardController Class



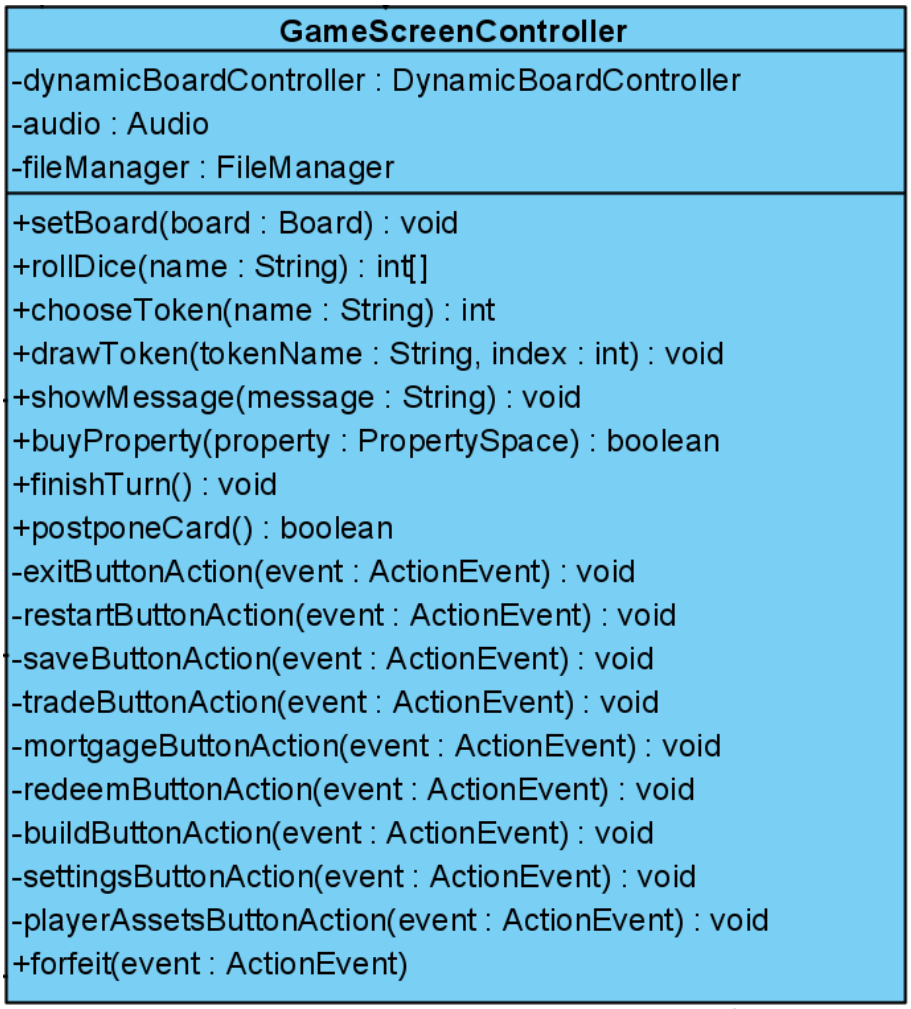
Attributes:

- **private Pane bottomBoard, rightBoard, leftBoard, topBoard, bottomLeftBoard, bottomRightBoard, topLeftBoard, topRightBoard:** All of these attributes correspond to the parts of the dynamic Monopoly board in the game screen.

Methods:

- **public void setDynamicBoard(Board gameBoard):** Draws the game board with the Space information it gets from the Board object. This allows us to draw different game boards.
- **public void drawToken(String tokenName, int index):** Draws the token corresponding to the given tokenName on the given index of the board. (0 == First Space, 39 == Last Space).

GameScreenController Class



Attributes:

- **Private DynamicBoardController dynamicBoardController:** Allows the GameScreenController to draw on the DynamicBoard through the methods of DynamicBoardcontroller.

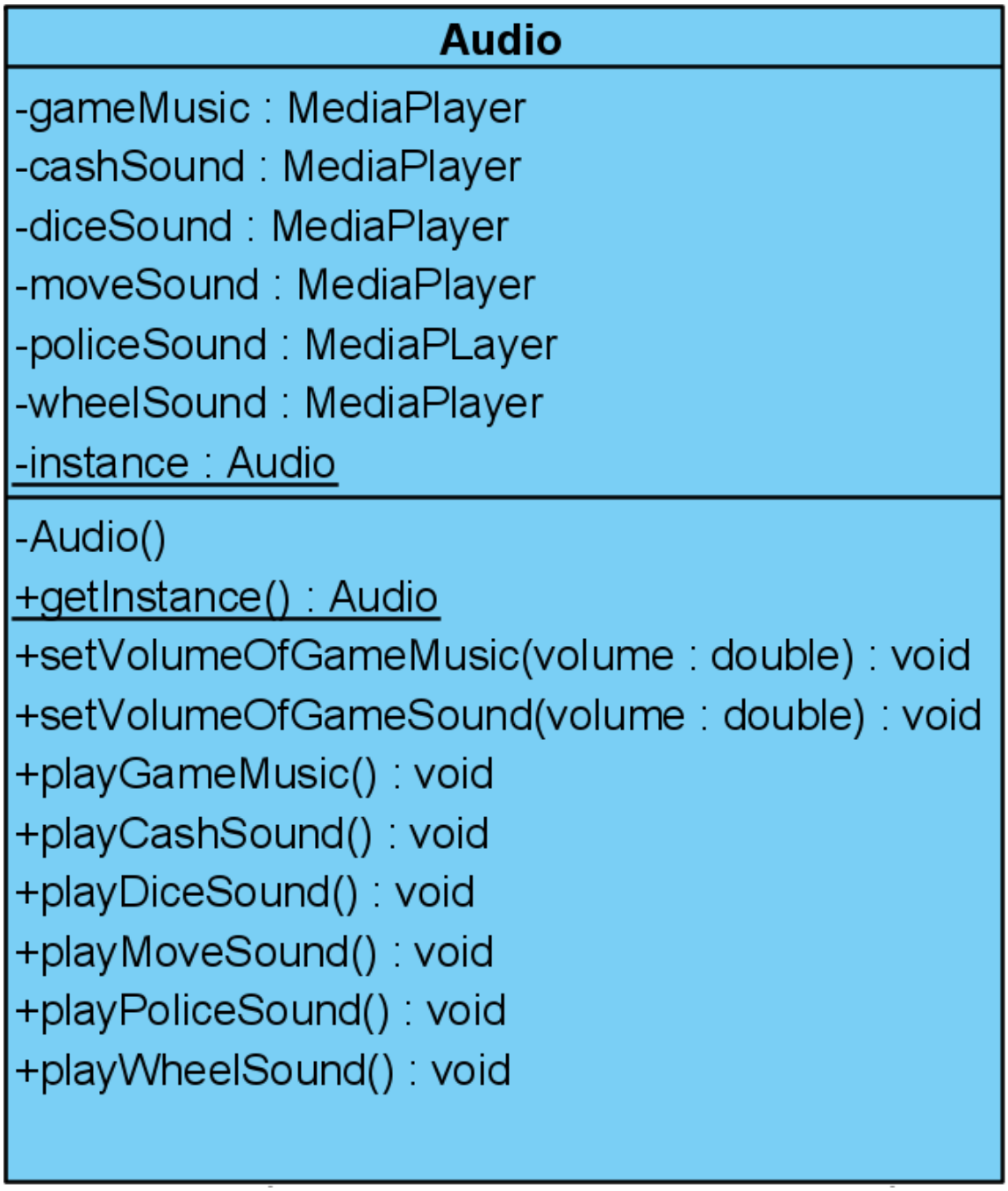
- **Private Audio audio:** The Audio singleton used for handling the game music and sounds.
- **Private FileManager fileManager:**The FileManager singleton used for logging exceptions that manages loading games, saving games and logging exceptions that happen when the game is running to an external file.

Methods:

- **public void setBoard(Board board):** Passes the board object to the dynamicBoardController's setDynamicBoard method for the map to be drawn to the screen.
- **public int[] rollDice(String name):** Shows the user the dice roll prompt and returns the rolled dice values in an array.
- **public int chooseToken(String name):** Shows the user the token choice prompt and returns the integer value that corresponds to the chosen token.
- **public void drawToken(String tokenName,int index):** Draws the token given with the tokenName property at the given index by calling the dynamicBoardController's drawToken method with these values.
- **public void showMessage(String message):** Shows the player a prompt with the given message and a button to close the prompt.
- **public boolean buyProperty(PropertySpace property):** Shows the player a prompt asking if they want to buy the given property or if they are willing to let it be auctioned among all players.
- **public void finishTurn() :** Shows the player a prompt that asks if they want to finish their turn.
- **public boolean postponeCard():** Shows the player a prompt asking if they want to open the card they have drawn now or postpone it to open later.
- **private void exitButtonAction(ActionEvent event):** Shows the player a prompt asking if they want to save their game when they presses the "Exit" button in the game screen, saves if the response is positive, then exits from the game that is being played to the main menu.
- **private void settingsButtonAction(ActionEvent event):** Shows the player the settings menu when the player presses the "Settings" button in the game screen.
- **private void restartButtonAction(ActionEvent event):** Shows the player a prompt asking if they want to save their game when they press the "Restart" button in the game screen, saves if the response is positive, then restarts the game with the same players.
- **private void saveButtonAction(ActionEvent event):** Saves the game when the player presses the "Save" button in the game screen.
- **private void tradeButtonAction(ActionEvent event):** Opens the trading menu and handles the trade, when the player presses the "Trade" button in the game screen.
- **private void buildButtonAction(ActionEvent event):** Opens the building menu and handles the building action, when the player presses the "Build" button in the game screen.
- **private void mortgageButtonAction(ActionEvent event):** Opens the mortgage menu and handles the mortgage action, when the player presses the "Mortgage" button in the game screen.

- **private void redeemButtonAction(ActionEvent event):** Opens the redeem menu and handles the redeem action, when the player presses the “Redeem” button in the game screen.
- **private void playerAssetsButtonAction(ActionEvent actionEvent):** Opens the player assets menu and shows the player their net worth, money, title deed cards, get out of jail free cards and their buildings.

Audio Class



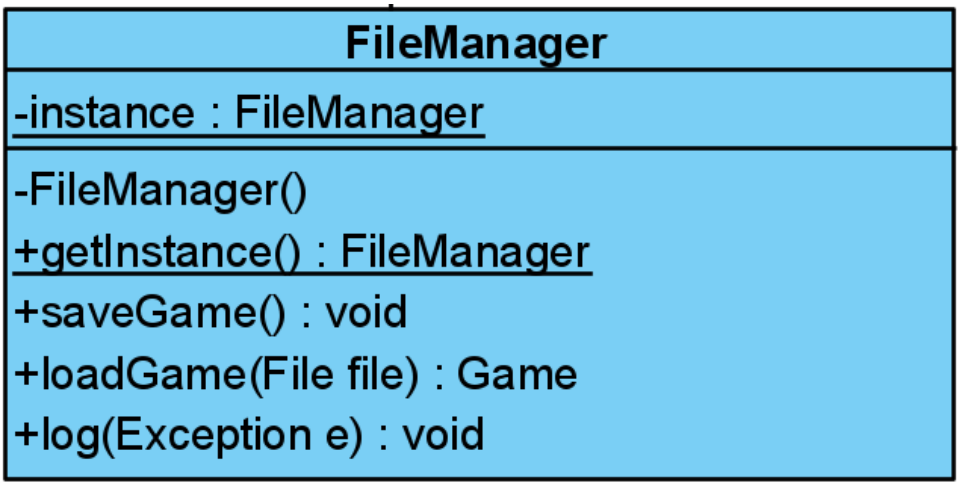
Attributes:

- **private MediaPlayer gameMusic, cashSound, diceSound, moveSound, policeSound, wheelSound:** MediaPlayers used to play the sounds.
- **private static Audio instance:** The singleton instance for Audio

Methods:

- **public static Audio getInstance():** Returns the singleton instance
- **public void setVolumeOfGameMusic(double volume):** Sets the volume for the game music
- **public void setVolumeOfGameSound(double volume):** Sets the volume for the game sound effects
- **public void playGameMusic():** Plays the game music
- **public void playCashSound():** Plays the cash sound effect
- **public void playDiceSound():** Plays the dice sound effect
- **public void playMoveSound():** Plays the move sound effect
- **public void playPoliceSound():** Plays the police sound effect
- **public void playWheelSound():** Plays the wheel sound effect

FileManager Class



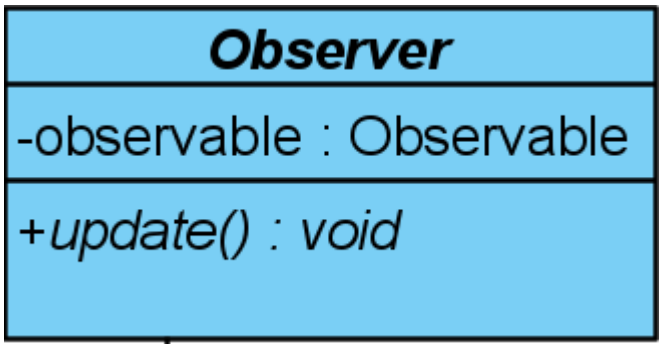
Attributes:

- **private static FileManager instance:** The singleton instance for FileManager

Methods:

- **public static FileManager getInstance():** Returns the singleton instance
- **public void saveGame():** Saves the game data to an external game save file.
- **public Game loadGame(File file):** Loads a game from an external game save file.
- **public void log(Exception e):** Logs the given exception to an external log file

Observer Class



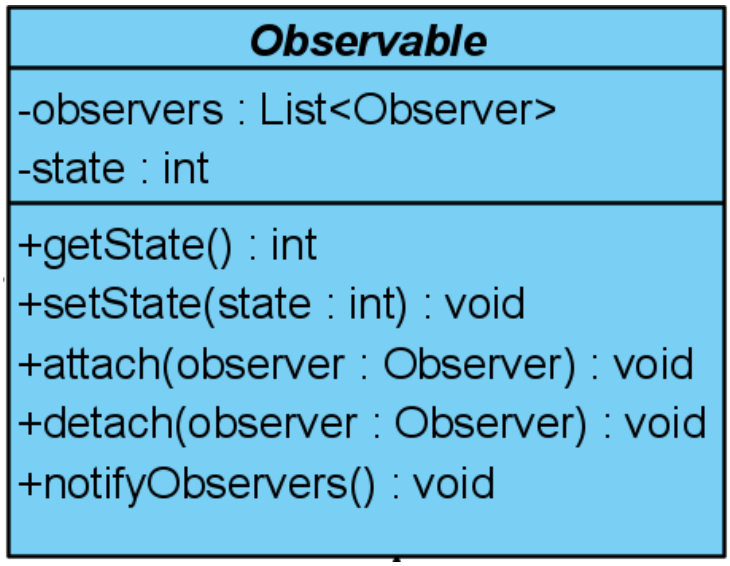
Attributes:

- **private Observable observable:** This attribute holds the Observable object the observer class wants to observe. The Observer should be attached to the observable for the design to work.

Methods:

- **public abstract void update():** This abstract method is called by the Observable when its state changes. Any class that extends Observer should override this method to provide functionality.

Observable Class



Attributes:

- **private List<Observer> observers:** This attribute is a List of Observer Classes which are the attached Observers that observe the state changes in this Observable.
- **private int state:** This attribute holds the state of the Observable object and should be enumerated by the classes that extend Observable

Methods:

- **public int getState():** This method simply returns the Observable object's state
- **public void setState(int state):** This method updates the Observable's state and notifies its Observers.
- **public void attach(Observer observer):** Adds the Observer to the Observable's *observers* list.
- **public void detach(Observer observer):** Removes the Observer from the Observable's *observers* list.
- **public void notifyObservers():** Iterates through the list of *observers* and calls all of their update() methods.

4. Low-level Design

4.1. Object Design Tradeoffs

***Usability vs. Functionality*:** Designs that aim functionally provide more operations to the user and designs that aim usability provide a simpler interface that is easy to learn. We prioritised usability over functionality because we believe a player should focus more on the game without trying to understand what each function does. In addition, if the interface is complicated and unusable both the new and old functionalities would not be utilized to their full extent anyways reducing the overall quality of the game.

***Reliability vs. Delivery Time*:** A code that is more reliable and handles each case separately will cause the length of the code to increase and cause a difference in the delivery time. However, experiencing crashes, game data losses would provide a bad experience for any user. Therefore, we believe it is important to make a reliable system, even though delivery time would increase.

Extensibility vs. Delivery Time: An extensible code separates the system into parts so that the amount of work that should be done increases and this causes a difference in the delivery time. We aim to make the game extensible by following Object Oriented Programming (OOP) principles so that we can make fixes and improvements on the game even after the initial delivery.

4.2. Abstract Classes

CardEvent Abstract Class:

This class will be used to produce card events. There will be several card events that will inherit from this class.

Space Abstract Class:

There are several types of spaces such as CardSpace, TaxSpace, WheelOfFortuneSpace, GoSpace, and so on. These classes will inherit from the Space class.

Property Abstract Class:

There are three types of properties, LandProperty, TransportProperty and UtilityProperty. They inherit from the Property class, so rent calculations and other property related operations can be done in a polymorphic sense.

Observable Abstract Class:

The Auction class inherits from the Observable class and is linked with the Game class which is an Observable to create an Observer Design Pattern system by notifying its observers when its state changes.

Observer Abstract Class:

The Game class inherits from the Observer class and is linked with the Auction class which is an Observer to create an Observer Design Pattern system by making updates when it is alerted by its Observable.

MenuController Abstract Class:

MenuController abstract class implements the back button functionality that allows going back to the previous menu page for UI menu classes. Currently five classes inherit from MenuController abstract class, SettingsMenuController, MainMenuController, NewGameMenuController, LoadGameMenuController and CreditsController.

PlayStrategy Interface:

Different types of strategy classes and decorator classes implement this interface. Hence, the DigitalPlayer class will use different strategy methods by using the methods in this interface. This increases polymorphism in the project. This interface is used by the strategy and decorator design patterns in the project.

4.3. Design Patterns

Singleton Design Pattern

The Singleton Design Pattern is used to ensure that a class has only one instance. We used the Singleton Pattern on two classes: Audio and FileManager.

The Audio class is for playing various audios during the program and it is controlled from the SettingsMenuController, GameScreenController, and MainMenuController classes. The audio control needed to be made simultaneously. Therefore, for some error or reason, we did not want different classes to reach different instances of the Audio class which would create a mix of game audio and disturb the players. Hence, the Audio class is created according to the Singleton Pattern. It has a private constructor, a “getInstance” method to reach the single instance that is accessible to all classes, and it has a static Audio attribute which is the unique instance.

The FileManager has save, load and log operations. The GameScreenController and Board classes use FileManager to perform save, load and log operations. We wanted this class to be Singleton as well because we wanted to decrease the workload of the operating system and the file system. In addition, we wanted to minimise error possibilities when writing on a file especially with log files since during an exception many requests will be made to write on the same file. Therefore, the FileManager class is also created as a Single class with a private constructor, a “getInstance” method, and a static FileManager attribute which is the unique instance of the class.

Strategy Design Pattern

The Strategy Design Pattern is used to encapsulate algorithms for code reuse and it enables choosing algorithms at runtime. We needed this flexibility when creating a computer player in our game. Since there can be more than one computer player, we wanted to provide multiple personalities for this artificial player. These personalities can be achieved by implementing a Strategy Pattern because it will allow multiple decision algorithms to be used and be interchangeable.

The class of our artificial player is named DigitalPlayer (it also extends the Player class) and has an attribute named "strategy". This strategy attribute holds a PlayStrategy instance which is an interface for different decision strategy classes which all implement PlayStrategy. These classes are named EasyStrategy, MediumStrategy, and HardStrategy. Each strategy follows different requirements and expectations when making a decision. Hence, they are the different strategies of the PlayStrategy of the DigitalPlayer.

Decorator Design Pattern

The Decorator Design Pattern is used to extend algorithms to improve code reuse and dynamically add functionality and behaviour to an object. We wanted to increase behaviours of our artificial players and decided to use the Decorator Pattern on the DigitalPlayer class. However, we also implemented a Strategy Pattern on DigitalPlayer. Hence, we used the Decorator Pattern with the Strategy Pattern. This way, we had interchangeable different decision algorithms with the Strategy Pattern and more various decisions and personalities with the Decorator Pattern.

The DigitalPlayer class only has the strategy attribute. The PlayStrategy interface has decorator classes implementing it and these classes also have a PlayStrategy as an attribute. These classes are named GenerousDecorator, RiskyDecorator, and StingyDecorator. With the addition of these decorators, the game can have generous, stingy, and risky artificial player personalities in all difficulty levels.

Observer Design Pattern

The Observer Design Pattern is used to create a hierarchy where a one-to-many relationship in between objects that await a specific change in another object exists. The objects that need to be notified of a change are called Observers and the object that notifies them is called Observable..This pattern allows for loose coupling in which the Observers are not notified of every single action that takes place in the Observable, but rather the specific state changes that would concern them. We wanted to utilize such a relationship in our implementation of Auction.

The implementation of an Auction in regards to the game's Bank really fit this design pattern as the Bank wants to be notified when an Auction starts and its winner and the bid when the Auction ends. Furthermore, Observer Design Pattern provides loose coupling. The Bank and the Auction are linked with one another as they transfer information between them which makes them coupled and the Bank is not aware of events like bids or folds nor is the Auction aware of events like rents, sales, mortgages which makes them loosely coupled. The only interaction between the two classes will occur when the Auction starts and ends through changing the Auction's state and notifying its observers.

4.4. Packages

- **java.util**

We used java.util classes such as ArrayList, Optional, and Scanner.

- **java.io.File**

We used File class for reading and writing from text files.

- **javafx**

We used javafx package classes for event-driven programming, user interface components, such as scene controls, the set of classes for loading and displaying images, and so on.

- **lombok**

  To make getters, setters for the attributes and default no arguments/all arguments constructors where needed, in classes automatically.javafx.scene.image.Image

5. References

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