**Sorcery – Design and Documentation**

CS 246 – Assignment 5

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**Introduction**

*Sorcery* is a computer game written in C++ based on the popular card game *Magic: The Gathering*. The game was written from start to finish using the C++ standard library, and managed with the git source control tool. Sorcery was designed with robustness and resilience to change in mind—the code was written to have low coupling and high cohesion simultaneously. This was done by using the MVC architectural style, with several other common and widely-used design patterns used for specific components of the game. The game can be played both through a command-line interface, as well as an optional graphical user interface. In creating this game, we ran into several challenges. [BRIEFLY INTRODUCE CHALLENGES]

**Overview**

Sorcery begins by taking the players’ names and the location of their respective deck in the main function. Main then constructs the BoardController, or the “game loop” responsible for the underlying logic. BoardController first constructs the required players’ data stored inside the BoardModel, as well as establishing a display to the user (either a text or graphics display, or both). This is a basic MVC foundation upon which the rest of the game is built: the BoardController represents the “controller”, handling input, and manipulating data (the “model”) which is transmitted into the “view,” TextDisplay and GraphicsDisplay.

Upon initializing the data, the BoardModel stores the data of the two players on its stack. The players’ data consists of the Player class, which contains fields for the players’ health, magic, and pointers to their respective cards. The physical cards are always allocated on the heap, and Player uses smart pointers to access these cards. The smart pointers are moved around in various lists (represented by std::vector) to represent movement of cards from the deck, to the hand, the field, and the graveyard.

The cards are first constructed by passing the name of the file containing the deck’s data to its respective player. This data is a list of filenames, where each corresponding file contains a card’s data. The player then iterates through this file, and constructs each card with the data inside the file. The pointer to each newly constructed card rests in the list representing the player’s deck, as all cards must start from the deck. After the entire deck is constructed, it is shuffled randomly.

The cards themselves are organized in a top-down hierarchy starting with an abstract class, *Card*, which allows every card access to other cards’ and players’ data.Card breaks off into two direct subclasses: Player, and NonPlayer. Every card played in the game therefore inherits from NonPlayer as either Minion, Spell, Enchantment, Ritual, or Ability (which has subclasses Triggered and Activated). Minion is a concrete class, while the other card types are abstract, with each physical card directly inheritting its type (e.g. AddSpell directly inherits Spell). Furthermore, Minion employs the decorator pattern, where the decorators are the triggered and active abilities that Minion is enhanced by.

[JAFER PLS ALSO TALK A BIT (LIKE 1 PARAGRAPH) ABOUT THE DISPLAY TYVM]

**UML**

**Design**

From a glance, the design follows the MVC pattern. The BoardController acts as the main controller that handles transmission of data (the “model”) into the display for the user (the “view”) using a modified Subject-Observer pattern, where the BoardController acts as a subject (but it does not inherit an abstract subject, because there is no other concrete subject that would make sense to have), and TextDisplay and GraphicsDisplay inherit an abstract observer. The BoardController owns a list of observers, and it notifies each observer in the render function based on data from the BoardModel. Since the model, view, and controller only interact with each other minimally and responsibility is separated independently, this provides a design with low coupling and high cohesion.

[TALK ABOUT VIEW IF NECESSARY]

The model, which is wrapped in BoardModel, consists primarily of the players and their card data. The players are stored on the stack of the BoardModel, and the physical cards are always allocated on the heap. This is because cards move constantly throughout the game: from a hand, to the field, to the graveyard, and potentially even to the other player. In addition, cards often need direct access to other cards to modify other cards’ data, as per the game’s features. Allocating the cards on the stack would potentially make movement and access of the cards more difficult, especially when a card must move to the other player. As a result, the cards are kept on the heap, with smart pointers accessing their data located on Player’s stack. Shared pointers to cards are always used in lieu of unique pointers, because it is more efficient in moving cards: where a unique pointer would require a deep-copy move assignment when a card moves from the deck to the hand, a shared pointer simply requires that we create a new pointer to the same card, and remove the previous pointer.

The Card class allows every subclass access to the BoardModel through a static pointer to BoardModel. This provides every card the access it needs to any card and player in the game, which allows for unlimited card customizability (specifically spells, rituals, and enchantments) and a great deal of flexibility in adding more features in the future. Furthermore, Card has a pure virtual *updateState* function (called through the public *update* method) that concrete subclasses must implement. Thus, the rules of APNAP order can be easily implemented through this function, which takes in a list of the events that occured (by reference), so that every card can act accordingly.

Player directly inherits Card. In doing so, Player implements *updateState*, which simply calls that same function for all of the required cards (i.e. the ritual and the minions on the field), passing forward the list of events that occured. Again, this allows implementation of APNAP order to be done in a very simple and organized fashion. Furthermore, the different types of cards inherit from Card through the other direct subclass of Card, NonPlayer. NonPlayer provides public getters and setters for for data such as the magic cost of a card, or the card’s current owner. It also provides the *cast* functionality, which is the main way cards are utilized in the game. As such, every physical card implements this function which can be customized according to the respective card.

NonPlayer then breaks up into each type of card: Minion, Spell, Ritual, Enchantment, and also Ability, to represent triggered and active abilities (although Ability and its derived classes are never used as physical cards placed on a board, rather as an attachment to a minion). The Minion and Ability class follows a modified Decorator pattern [IS THIS TRUE?], where Minion acts as a concrete component and Ability is a decorator. However, Minion *owns* Ability, since a minion’s ability moves with the minion wherever the minion moves throughout the game (including to the graveyard). Moreover, only Minion is a concrete class, since all Minions do the same thing: they attack, and the *cast* function simply uses an activated ability. Thus, the only features differentiating minions are their names, attack, defense, and the abilities they own. Spell, Ritual, and Enchantment are abstract, and the physical cards corresponding to each type inherit directly from these classes.

**Resilience to Change**

Throughout the entire development of the game, one question always prevailed: “how easily can we accommodate change?” In other words, we created the code such that adding new features in any part of the game would, overall, require the least amount of code and architectural changes possible. Such features can be broken up into the major different aspects of the game that would potentially change: the display, the number of players and the interactions between them, the game rules, and the cards themselves (modification or addition of new cards).

To start, a change in display is easily accommodated because the only class that interacts with it is BoardController (the main function simply instantiates it)—however, BoardController does not actually know what type the display is, and it doesn’t need to. All it needs to do is pass in the correct data from the model side of the application to its list of displays (i.e. observers), and the display will handle the rest. Thus, adding new displays (e.g. 3D graphics, split screen, virtual reality, etc.) will be relatively easy to integrate into the game. This is also an example of low coupling, since the view is only dependent on the controller for getting the right data, and it shows high cohesion in that the view and BoardController work towards the same goal: displaying data to the user.

In addition, the BoardModel, which wraps the player and card data in one class, allows for the flexibility of adding additional players with additional cards, since it holds a vector of players. The rest of the rules remain the same, only that the main game loop must now iterate through the additional players. The view is also left unchanged, since the displays don’t care which player’s turn it is, or which player owns which card—it simply takes in data, and displays it. As well, improving the interaction between players (for instance, by using separate controllers as opposed to the same keyboard) can simply be changed in the main function which takes in raw user input to process, and then send it to the BoardController. Again, this shows that through a highly cohesive design where the individual classes are minimally dependent on each other (low coupling), and the code is resilient to changes even as major as changing the way users interact in addition to the number of users that can play one game.

The game logic is split up between main, BoardController, and the implementations of the cast function. While this may seem coupled, from a closer look, it is evident that main simply iterates through the players to call the pre-turn effects, then the turn itself, and finally the post-turn effects—it therefore handles *only* the logic of the order in which things happen. What actually happens is dealt with in BoardController, which determines what needs to be done. Thus changing the order of the game or changing what actually happens in each turn means that we only need to change one part of the code. Moreover, if we wish to change the functionality of a specific card, the only change that needs to be done is that card’s specific implementation of the cast function; everything else remains the same, especially since each card has full access to other players’ and cards’ data through the static pointer to BoardModel.

This leads us to the modification and/or addition of cards. Modifying them is a simple matter of changing field values in the concrete implementation or modifying the cast function implementation, which changes the usage/effect of that card. Adding new cards in a deck is a simple matter of creating the concrete classes for each of Spell, Ritual, Enchantment, and Ability, inheritting from its respective type, and then implementing updateState and cast. For the minion, all that is required is a unique name and its own attack and defense fields. The rest of the code need not change—the logic and execution of the players’ turns remains the same, and the display does not change either, since all it needs is the card’s data so that it can display it.

**Questions**

**Extra Features**

**Final Questions**

**Conclusion**