Dukemon - Developer Guide 

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1. Setting up

Refer to the guide here.

2. Design

2.1. Architecture

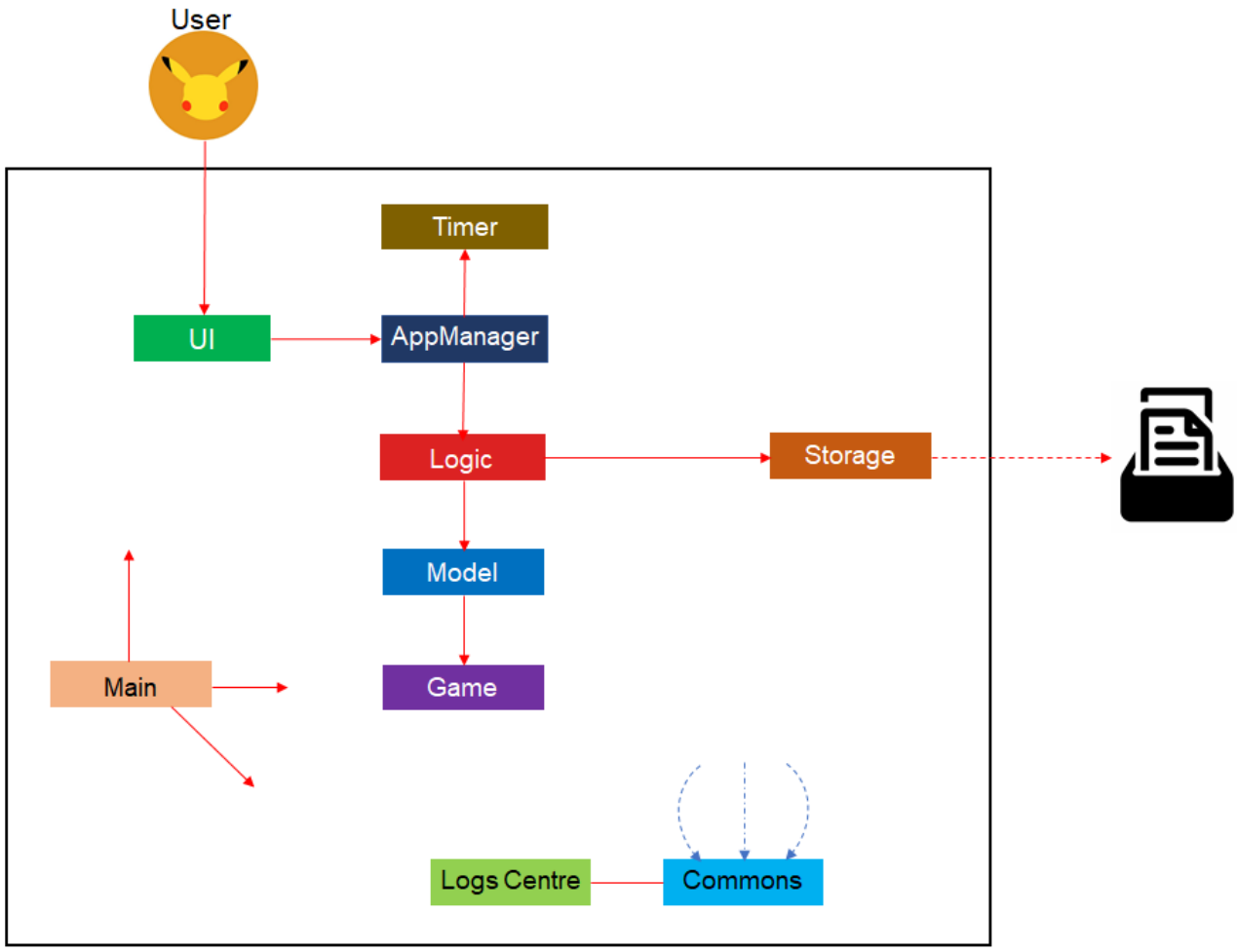


Figure 1. Dukemon Architecture Diagram

The ***Architecture Diagram*** given above explains the high-level design of Dukemon. Given below is a quick overview of each component.

> **TIP** The `.puml` files used to create diagrams in this document can be found in the diagrams folder. Refer to the Using PlantUML guide to learn how to create and edit diagrams.

`Main` has two classes called `Main` and `MainApp`. It is responsible for,

- At app launch: Initializes the components in the correct sequence, and connects them up with each other.
- At shut down: Shuts down the components and invokes cleanup method where necessary.

`Commons` represents a collection of classes used by multiple other components. The following class plays an important role at the architecture level:

- `LogsCenter` : Used by many classes to write log messages to the App's log file.

The rest of **Dukemon** contains *seven* componenets.

- `UI`:
  The Graphical UI of Dukemon that interacts with the user.
- `AppManager`:
  The buffer between the User and Dukemon's internal components.
- `Timer`:
  The internal Timer that triggers events based on time elapsed.
- `Logic`:
  The main command executor and performer of operations.
- `Model`:
  Holds the non-game data in-memory.
- `Game`:
  Holds the data of live game sessions in-memory.
- `Storage`:
  Reads data from, and writes data to, the local hard disk.

For the components UI, Logic, Model, Timer, Storage and Game:

- Defines its *API* in an `interface` with the same name as the Component.
- Exposes its functionality using a `{Component Name}Manager` class.
  - ie. `StorageManager` implements `Storage`, `GameTimerManager` implements `GameTimer`.

The sections below give more details of each component.

2.2. UI component

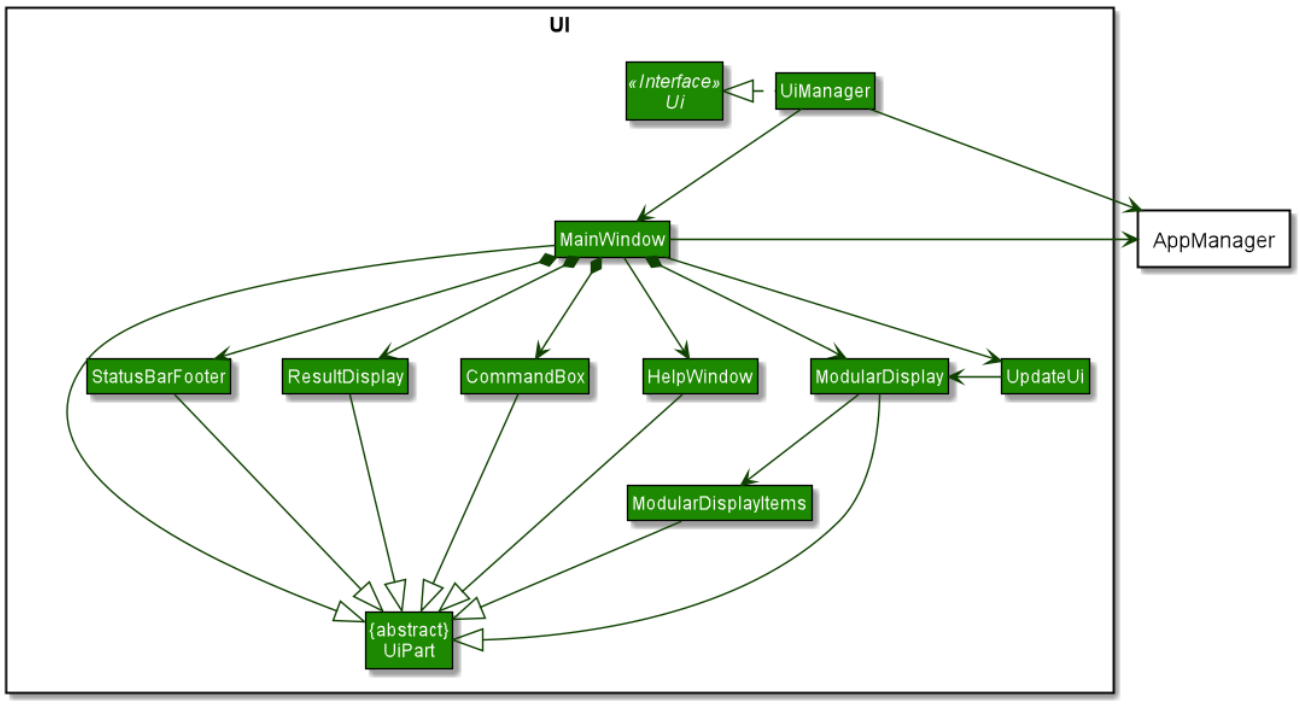


Figure 2. Structure of the UI Component

API : `Ui.java`

The UI consists of a `MainWindow` that is made up of parts e.g.`CommandBox`, `ResultDisplay`, `ModularDisplay`, `StatusBarFooter` etc. All these, including the `MainWindow`, inherit from the abstract `UiPart` class.

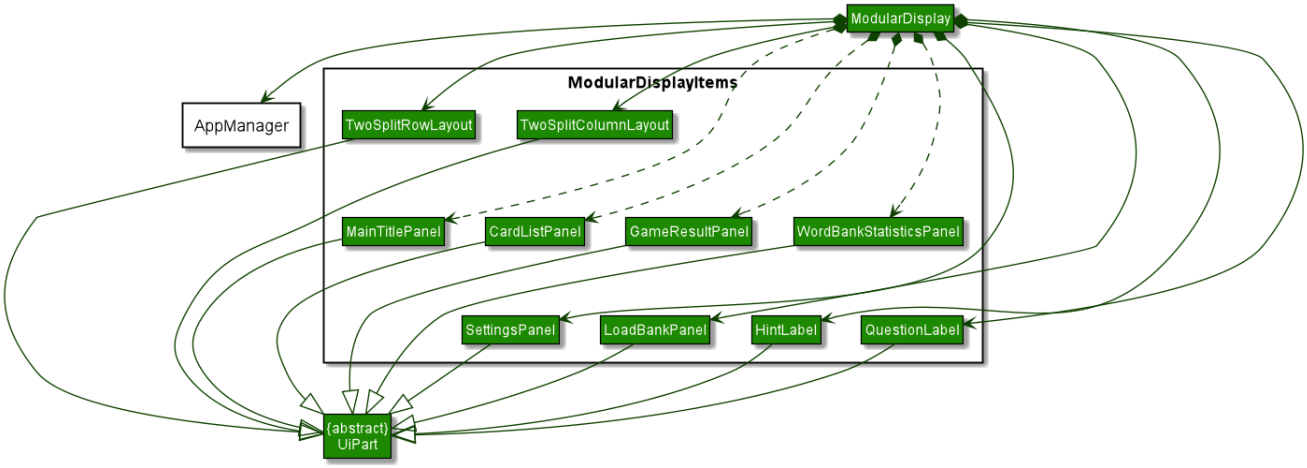


Figure 3. Structure of the ModularDisplay items.

As our application also comprises a dynamically changing UI in replacement of the `PersonListPanel`, `ModularDisplay` contains multiple other `Panel` classes in itself in order to render the proper screens during runtime. This rendering is controlled by `UpdateUi` in `MainWindow`.

The `UI` component uses JavaFx UI framework. The layout of these UI parts are defined in matching `.fxml` files that are in the `src/main/resources/view` folder. For example, the layout of the `MainWindow` is specified in `MainWindow.fxml`

The `UI` component,

- Executes user commands using the `AppManager` component.
- Listens for changes to `Model` data and `Timer` through the `AppManager` so that the UI can be updated correspondingly.

2.3. AppManager component

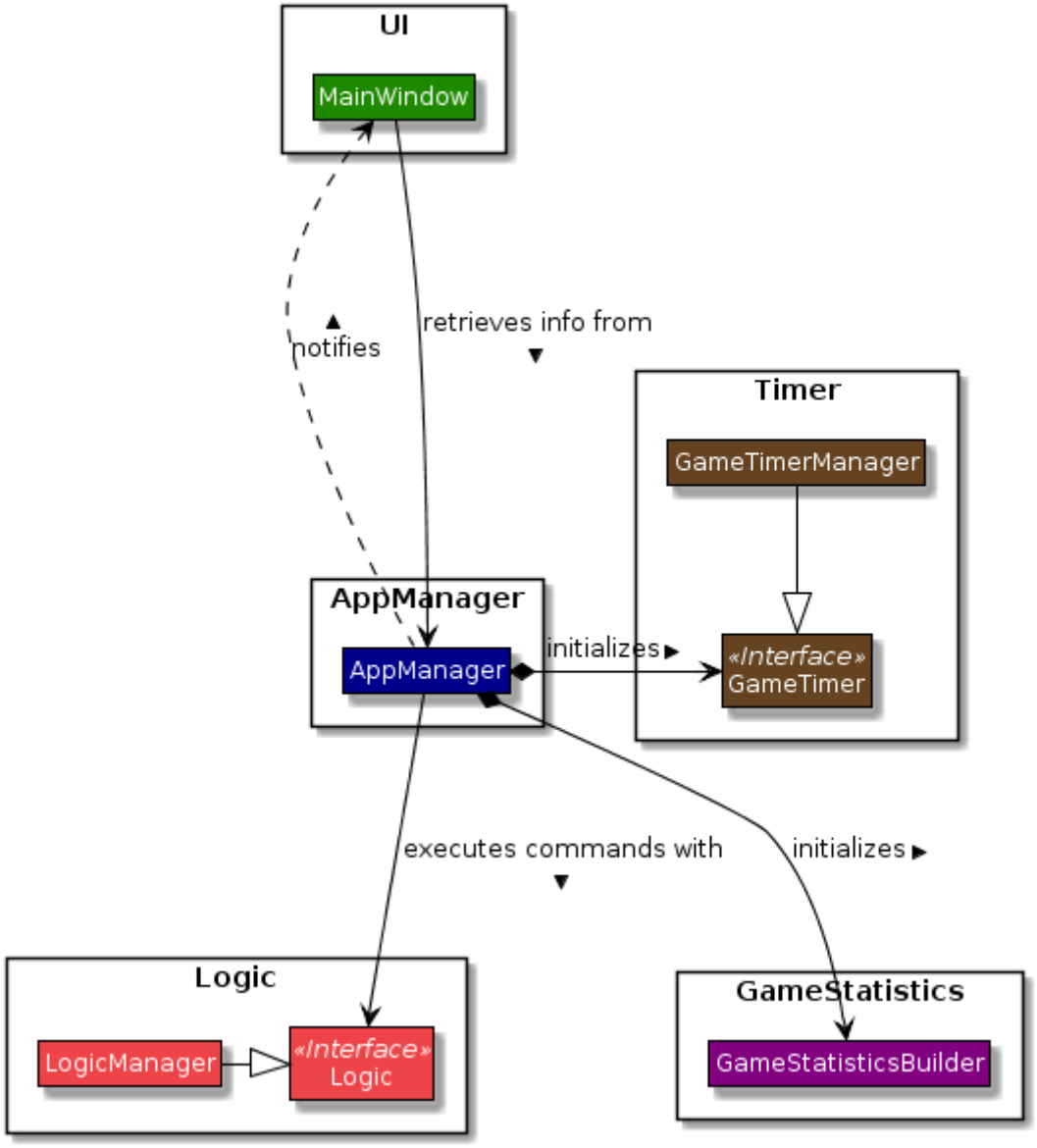


Figure 4. Structure of the AppManager Component

The `AppManager` component serves as a *Facade* layer and communication hub between the internal components of *Dukemon* and the *UI* components. Using this extra layer provides better abstraction between the `UI` and the internal components, especially between the `Timer` and the `UI`.

`AppManager` communicates with both the `Logic` and `Timer` components to send feedback to the `UI` to display back to the user.

- Gets feedback for commands by through `Logic`
- Starts and Stops the `Timer` when required.
- Makes call-backs to the `UI` to update various `UI` components.

- Initiates collection of `Statistics` by pulling data (eg. Time Elapsed) from `Timer` and `Logic`.

2.4. Timer component

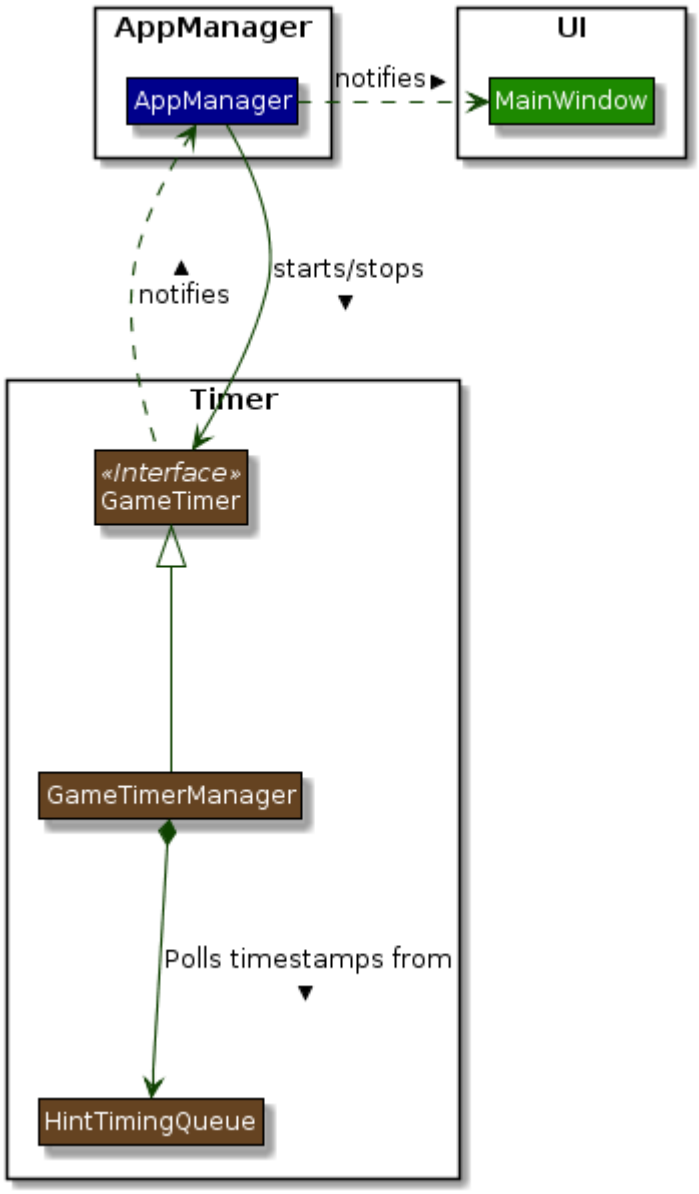


Figure 5. Structure of the Timer Component

API : `GameTimer.java`

The `Timer` consists of a `GameTimer` that will keep track of time elapsed via an internal countdown timer and notify the `AppManager`, who will notify the `UI` components.

- Dealing with the internal countdown timer that runs during a game session.
- Periodically triggering *callbacks* that will notify the `AppManager` component.
- Gets timestamps to trigger `Hints` via a `HintTimingQueue`

Due to the fact that the `Timer` has to work closely with the `UI` and `AppManager` (without being coupled directly), it is separated from the `Logic`, `Model` and `Game` components.

2.5. Logic component

This section breakdown the logic package into its internal components

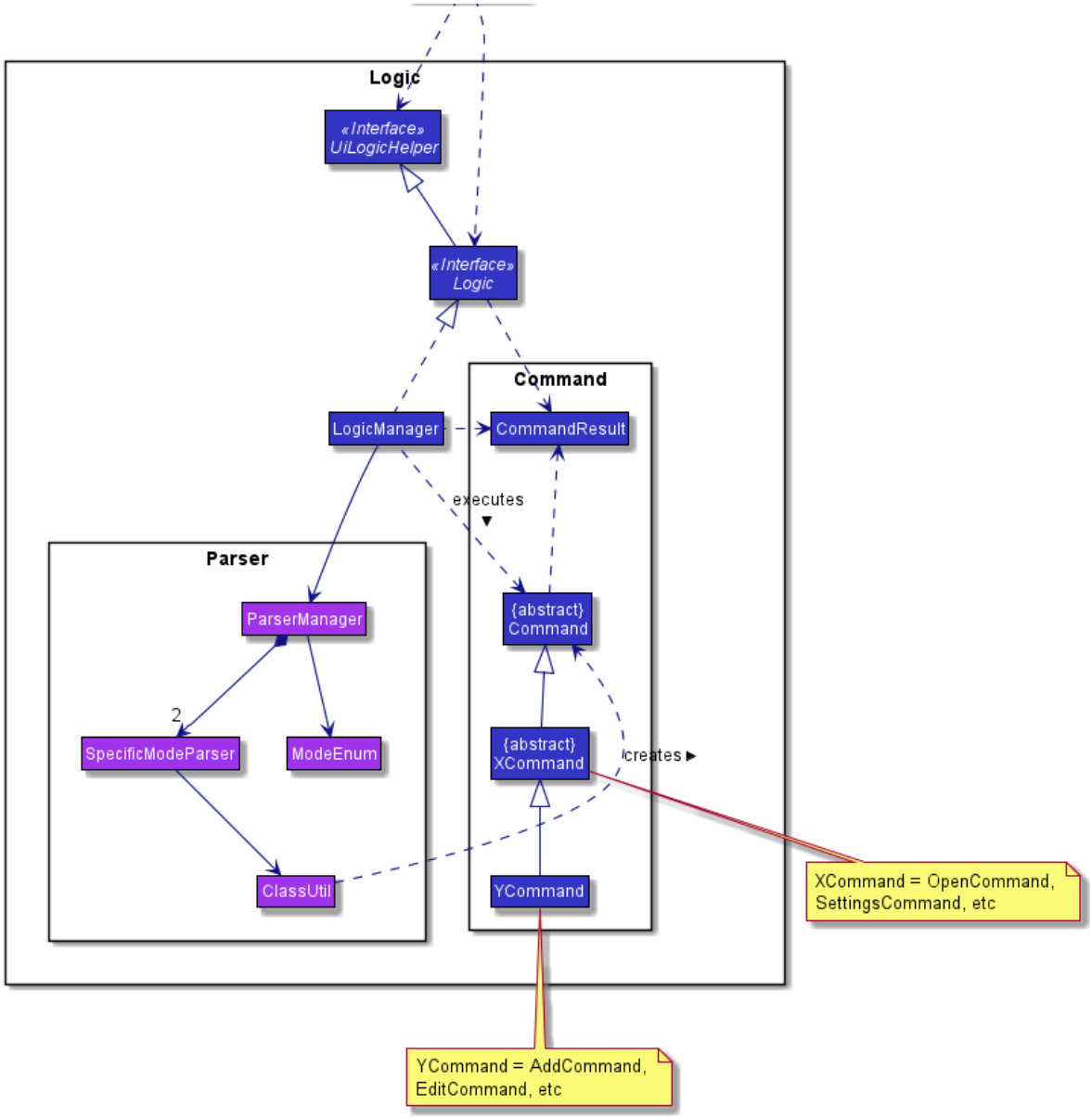


Figure 6. Structure of the Logic Component

Logic is primarily built by two segments: Command and Parser.

Command

```
Command is an abstract class.
```

```
Four other abstract classes (WordBankCommand, CardCommand, GameCommand and
SettingsCommand) extend Command.
```

```
Concrete Command classes with an execute method implementation extend one of the above
four abstract classes.
```

Parser

```
ParserManager holds reference to two SpecificModeParsers
```

```
The SpecificModeParsers change based on current application mode.
```

```
They hold references to all concrete Parser and Command Classes with the help of
ClassUtil
```

Logic fulfils its contracts with other packages through two interfaces: Logic and UiLogicHelper

2.5.3. Interaction through Logic Interface

Examples of transactions promised by Logic API include command execution, command result and update statistics.

- Command Execution through `Logic Interface`
  1. A String from Ui package gets to `ParserManager` and gets converted into a `Command` object which is executed by the `LogicManager`.
  2. The command execution can affect the `Model` (e.g. adding a word meaning pair into wordbank).
  3. The result of the command execution is encapsulated as a `CommandResult` object which is passed back to the `Ui` and `AppManager`.
  4. In addition, the `CommandResult` object can also instruct the `Ui` to perform certain actions, such as displaying help to the user.

2.5.4. Interaction through UiLogicHelper Interface

UiLogicHelper APIs is a subset of Logic APIs and only contains transactions for AutoComplete. It exposes the functionalities through the following getter methods:

- `List<AutoFillAction>#getMenuItems(String text)` — Gets a List of AutoFillActions to fill up AutoComplete display based on current user input given in text
- `ModeEnum#getMode()` — Retrieves the application mode to display visually to the user (represented by enumeration object ModeEnum)
- `List<ModeEnum>#getModes()` — Retrieves the possible modes the user can transition to from current mode

The following sequence diagram shows how the AutoComplete operation runs when user keys in

"st" into command box.

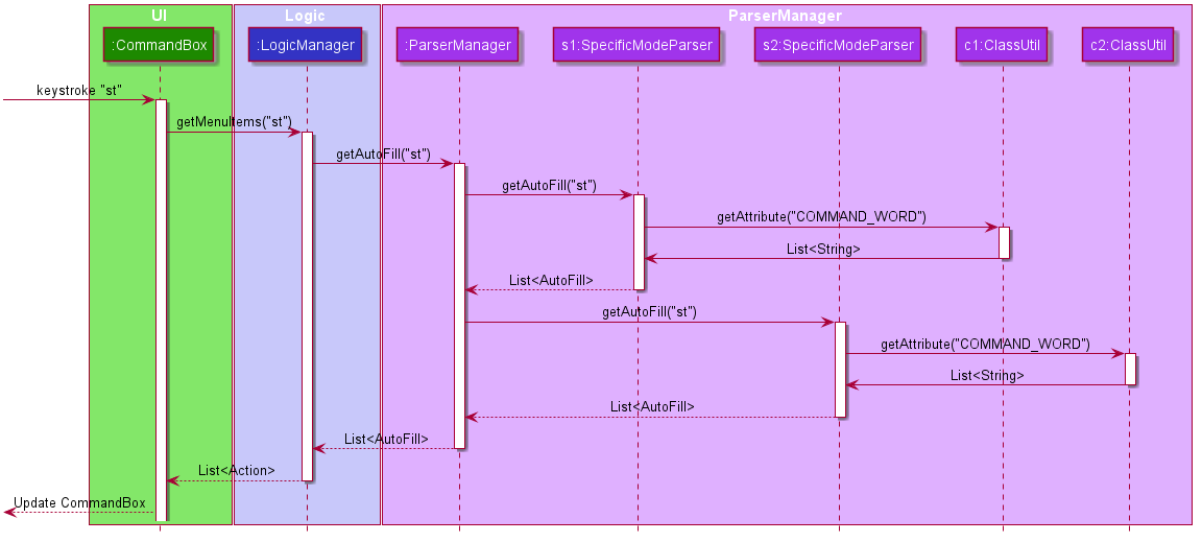


Figure 7. Sequence Diagram of AutoComplete

API : `Logic.java` `UiLogicHelper.java`

2.6. Model component

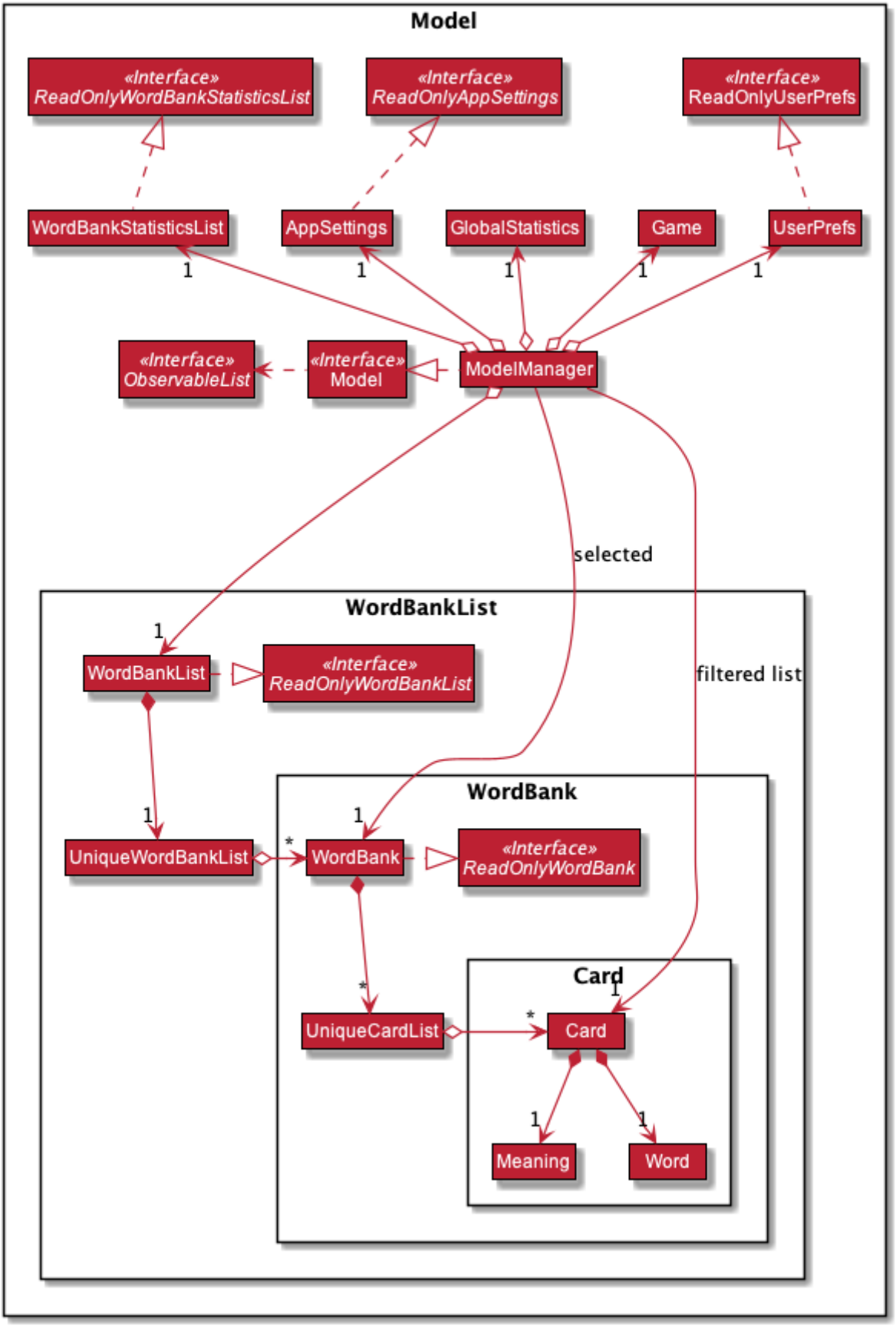


Figure 8. Structure of the Model Component

API : `Model.java`

The `Model`,

- contains information that the game requires at run time. They include: `WordBankList`, `WordBankStatisticsList`, `GlobalStatistics`, `Game`, `AppSettings`, `UserPrefs`.
- does not depend on any of the higher level components. i.e. `Ui`, `Timer`, `AppManager`, `Logic`, `Storage`.
- has a direct reference to a user selected `WordBank`.
- exposes an unmodifiable `ObservableList<Card>` that can be 'observed' e.g. the UI can be bound to this list so that the UI automatically updates when the data in the list change.

2.7. Game component

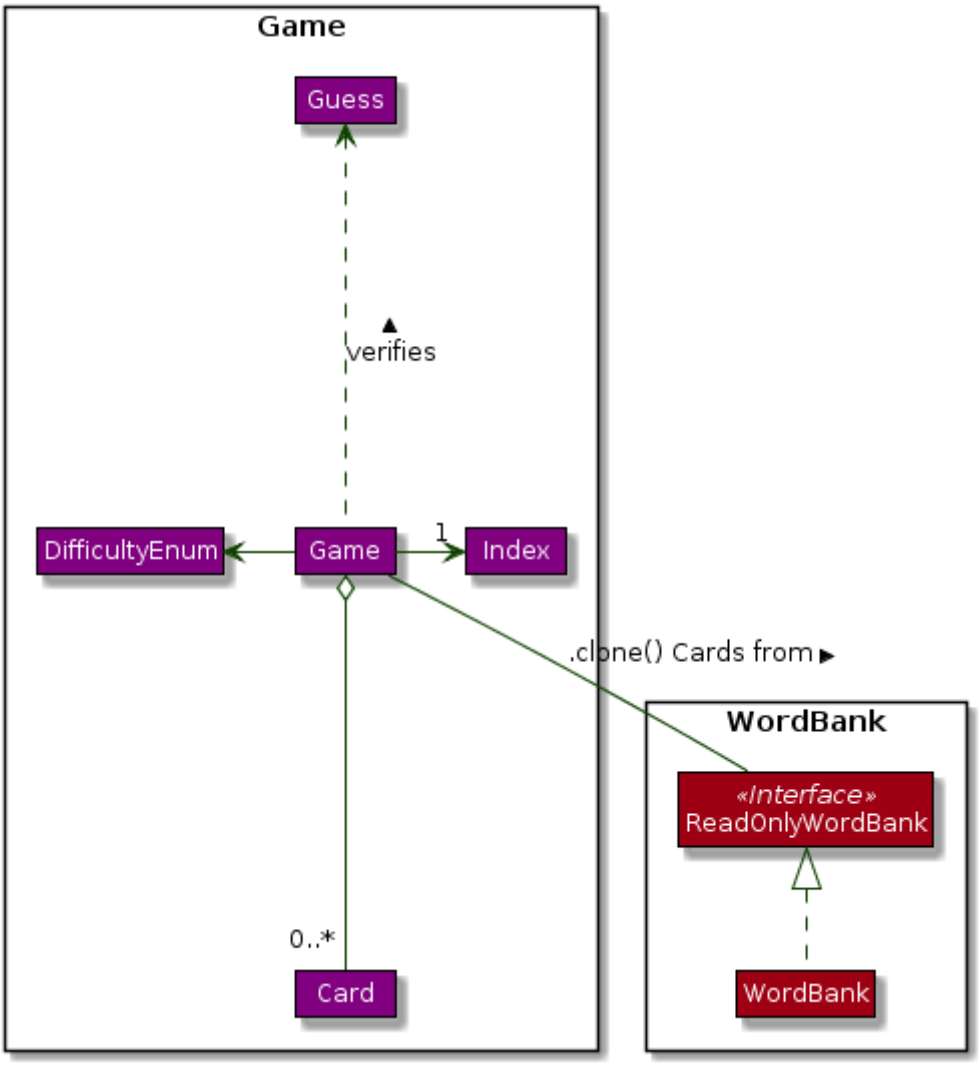


Figure 9. Structure of the Game Component

The `Game` component,

- stores a *shuffled* `List<Card>` that is cloned/copied from a `ReadOnlyWordBank`.
- maintains an `Index` to keep track of the state of the game.
- has an associated `DifficultyEnum` that dictates the time allowed for each question.
- verifies `Guess` that are sent by `Logic` (User's guesses)

2.8. Storage component

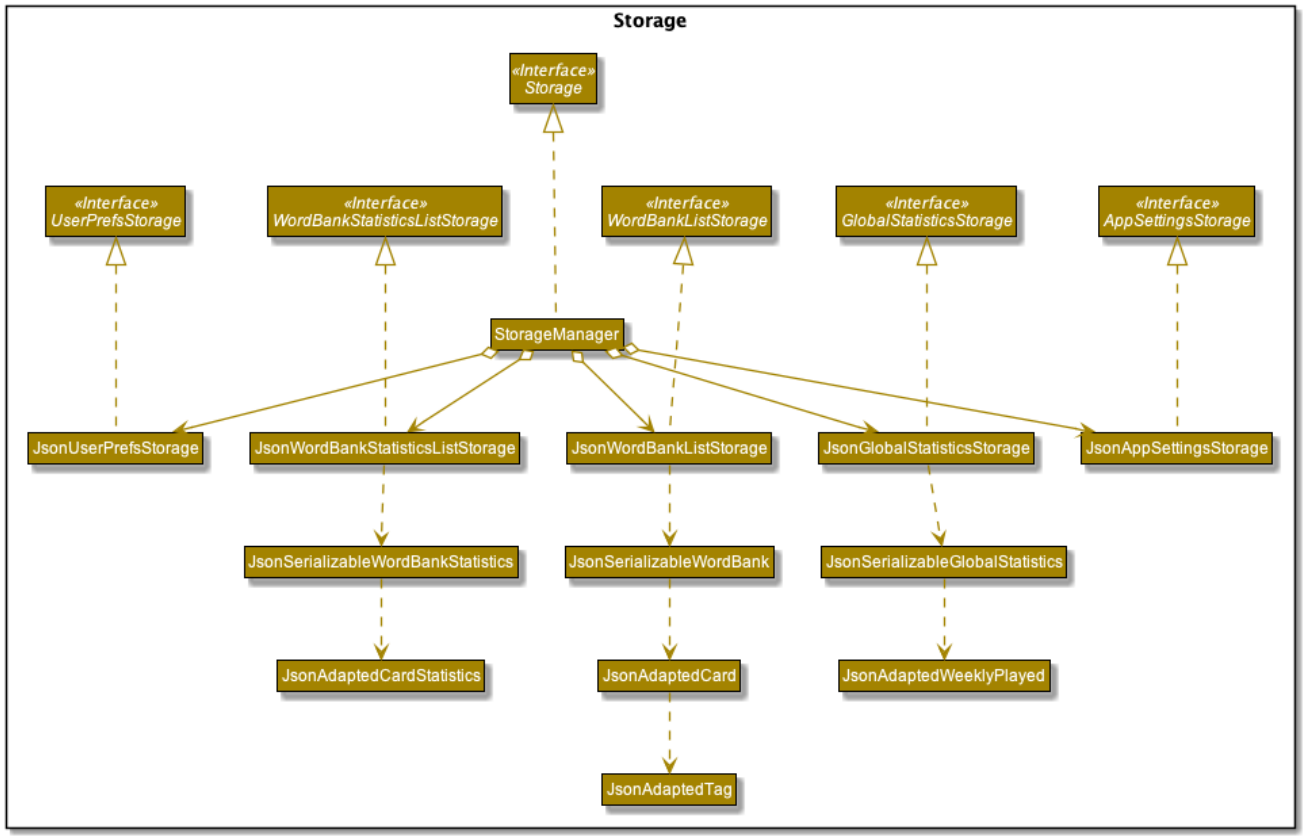


Figure 10. Structure of the Storage Component

API : `Storage.java`

The `Storage` component,

- contains multiple types of distinct storage system.
- does not depend on any of the higher level components. i.e. `Ui`, `Timer`, `AppManager`, `Logic`, `Model`.
- handles function calls directly to the computer's system.
- can save data objects in json format and read it back.

2.9. Statistics component

The Statistics component includes 2 main subcomponents:

- A `GlobalStatistics`, containing the user's total number of games played and the number of games played in the current week.
- A `WordBankStatisticsList`, which is a collection of `WordBankStatistics`, one for each `WordBank`.

The class diagram of the Statistics component is shown below:

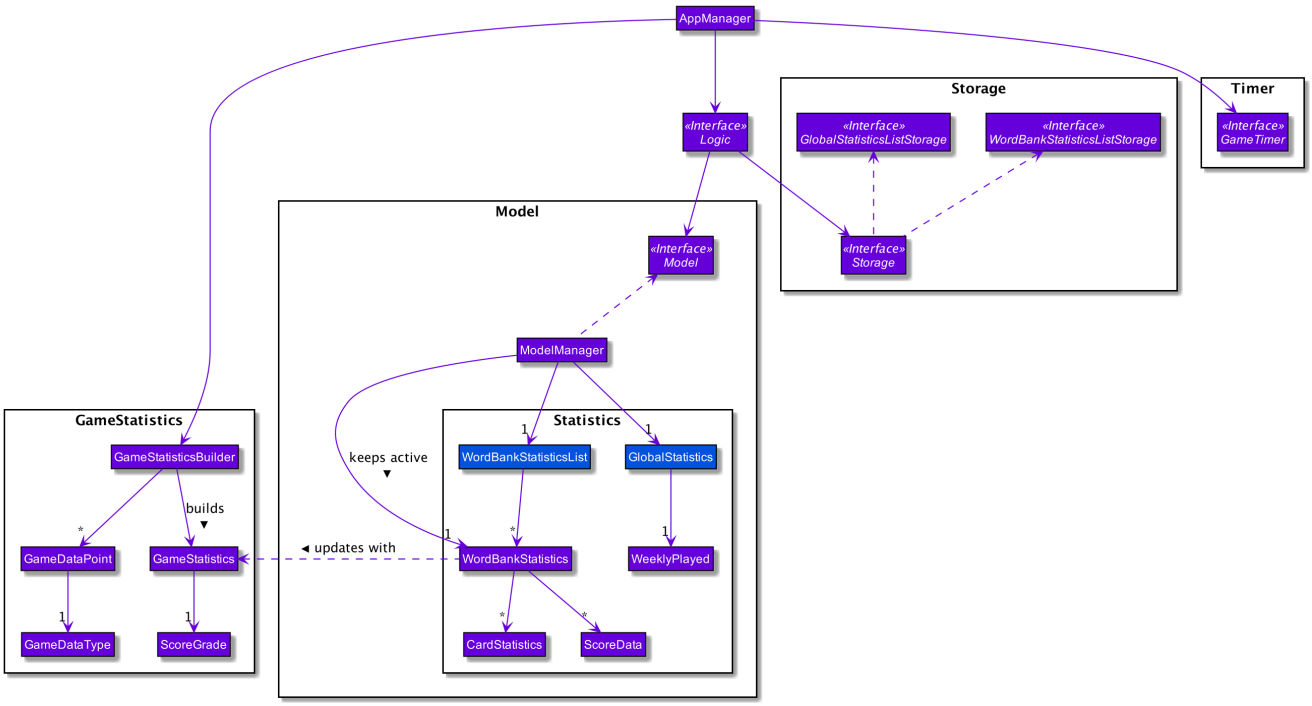


Figure 11. Statistics class diagram.

2.10. Common classes

Classes used by multiple components are in the `seedu.Dukemon.commons` package.

3. Implementation

This section describes some noteworthy details on how certain features are implemented.

3.1. AutoComplete/Parser Feature

This section explains how the design choice of Dynamic Parsers fulfils AutoComplete and Command Execution.

ParserManager dynamically changes parser depending on current mode the game is at. This is modeled using the Strategy Pattern. https://en.wikipedia.org/wiki/Strategy_pattern.

Instead of choosing a single parser to use at compile time, they are chosen at runtime depending on runtime state. This supports a variety of benefits which are explained under design considerations.

The above implementation empowers the application with the following features :

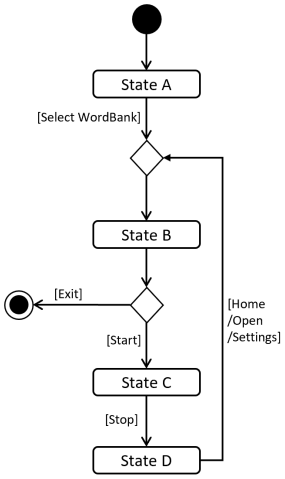
1. Every user keystroke only auto completes the right commands
2. Only the right commands get parsed and executed. What are the right commands? They are the commands that belong to the current mode and switch commands when preconditions are met.

3.1.1. Implementation details of ParserManager

1. `ParserManager` instance has reference to two `SpecificModeParser` objects

2. When user enters a keystroke, the `SpecificModeParser` which holds switch commands or `SpecificModeParser` which holds current mode commands are accessed based on internal state.
3. Internal State consists of booleans: gameIsOver, bankLoaded and enumeration ModeEnum: HOME, OPEN, GAME, SETTINGS
4. Boolean algebra is used to derive the four overall states.

```
The below activity diagram demonstrates four possible states and a typical user flow.
```



State	Switch	Mode	Purpose
A	✗	✓ only Home Commands	To ensure that WordBank is selected before switching to another mode
B	✓	✓ let Z be current mode	any Z Commands where Z is Home, Open or Settings
C	✗	✓ only Game Commands	Game is running. Unable to switch modes
D	✓	✗	Game has ended. Only can switch to other modes.

Figure 12. Activity diagram of a typical application flow

- Definitions of Switch and Mode in table above
  - SwitchCommands = (commands that change mode)
  - ModeCommands = (commands that belong to a specific mode ie Home, Open, Game and Settings)

3.1.2. Implementation details of SpecificModeParser

- SpecificModeParsers use ClassUtil to handle instantiation of Parser and Command objects.
- ClassUtil holds a list of references to Command and Parsers classes. In Java class references are passed using .class attribute. Example: AddCommand.class
- Internally, ClassUtil employs java reflections to find attributes of classes without instantiating them. Code for it is succinct and shown in the snippet linked here.
- Also, when a command needs to be executed, it instantiates the Parser object (if any) and Command object at runtime.
- Here is a snippet is from ParserManager. Just one line of code is necessary to include a new command with its parser. Example:

```
temp.add(NewCommand.class, NewCommandParser.class);
```

3.1.3. Design Considerations

	Alternative 1	Alternative 2
Aspect 1: How parser and command objects are instantiated in SpecificModeParser	**Use java reflections to hold a list of classes and iterate through them to pick the matching classes** *Pros:* Open Close Principle strictly followed. Adding a command and a parser takes only one line of code. *Cons:* It is developer's responsibility to ensure classes subclass the abstract Command class as compile time errors would not be thrown.	**Use switches to match the command word with the right parsers** *Pros:* Compile time error would be thrown if new command or parser does not subclass correctly. *Cons:* Adding a new command with parser would require the developer to insert it into multiple locations as the autocomplete feature needs an iterable command list.
Why did we choose Alternative 1: Given that ClassUtil gracefully handles wrongly passed class references, the lack of compile time check does not impair the functionality of the application. Furthermore, alternative 1 prevents code duplication for autocomplete and executing.		
Aspect 2: Single Parser vs Parser Manager	**Using a ParserManager to dynamically switch between Parsers based on current state** *Pros:* Commands not belonging to specific mode would not be parsed *Cons:* More code to write for initial developer.	**Use a single parser** *Pros* We do not need to restructure the logic package. *Cons* Bad user experience as it autocompletes and parses commands that do not belong to a particular mode.
Why did we choose Alternative 1: As commands are stateful, it would be easy to overlook the edge cases when so many combinations and permutations are likely. Segregating them by modes allows a better user experience and minimises the possibilities of bugs. Also, future extensibility is improved for new modes and parsers as the Open Close Principle is abided.		

3.2. Settings Feature

3.2.1. Implementation

`AppSettings` is a class that was created to be integrated into the `Model` of the app. It currently contains these functionalities:

- `difficulty [EASY/MEDIUM/HARD]` to change the difficulty of the game.
- `hints [ON/OFF]` to turn hints on or off.
- `theme [DARK/LIGHT]` to change the theme of the app. Currently only supporting dark and light themes.

This feature provides the user an interface to make their own changes to the state of the machine. The settings set by the user will also be saved to a `.json` file under `data/appsettings.json`.

The activity diagram below summarizes what happens in the execution of a settings command:

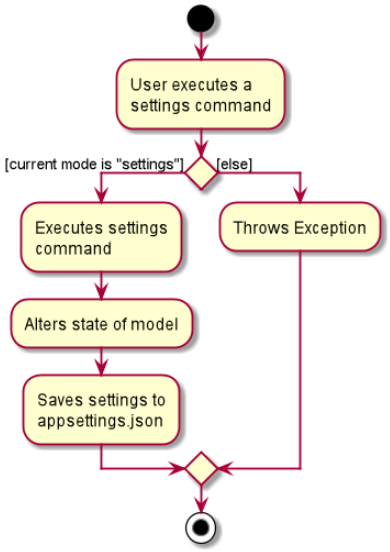


Figure 13. Activity diagram of the execution of a settings command.

NOTE Take note that "mode" as defined in our project is the state in which the application is able to take commands specific to that mode.

Given below is a step by step walk-through of what happens when a user executes a difficulty command while in settings mode:

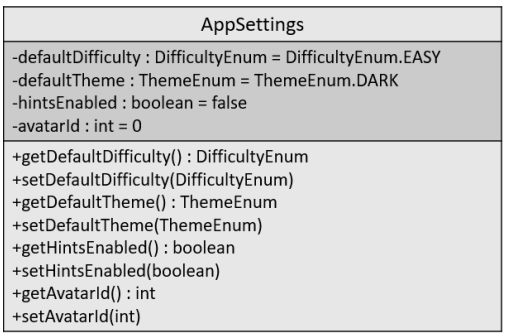


Figure 14. Before state of application.

Step 1:
Let us assume that the current difficulty of the application is "EASY". The object diagram above shows the current state of `AppSettings`.

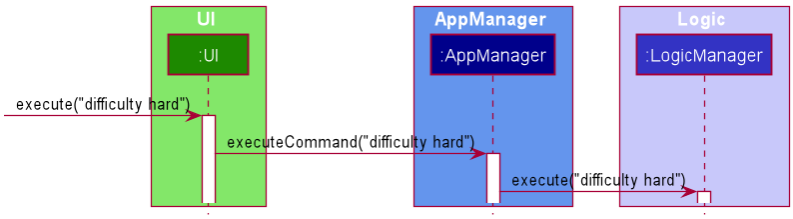


Figure 15. Sequence diagram of Step 2.

Step 2:
When the user enters `difficulty hard`, the command gets passed into Ui first, which executes `AppManager#execute()`, which passes straight to `LogicManager#execute()` without any logic conditions to determine its execution path.

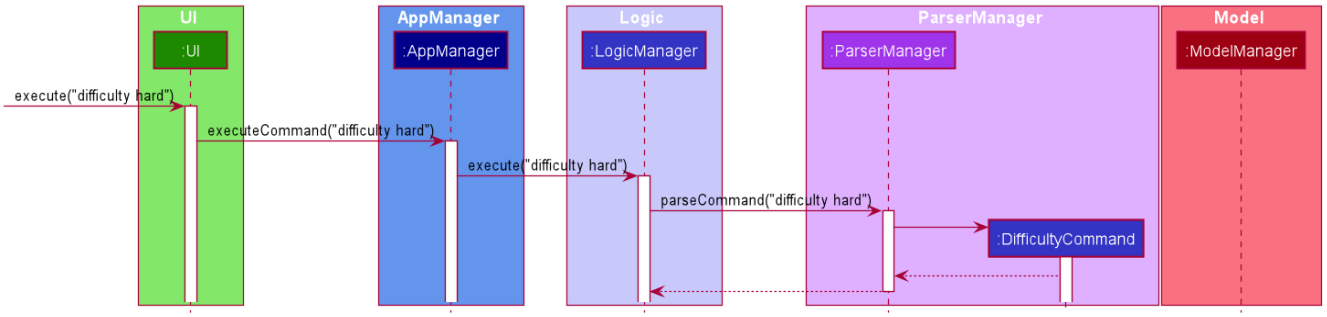


Figure 16. Sequence diagram of Step 3.

Step 3:
At `LogicManager#execute()` however, the command gets passed into a parser manager which filters out the `DifficultyCommand` as a non-switch command and it creates a `DifficultyCommand` to be executed.

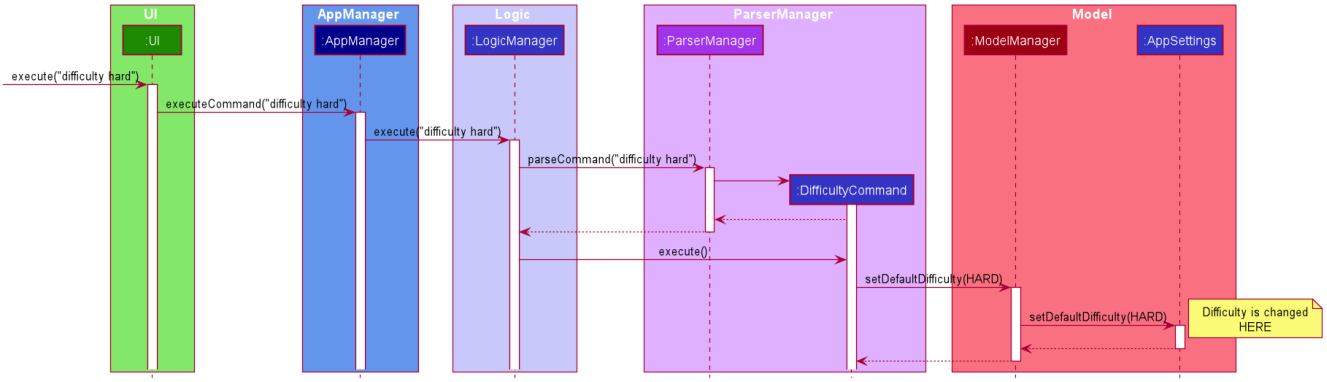


Figure 17. Sequence diagram of Step 4.

Step 4:
Upon execution of the `DifficultyCommand`, the state of the model is changed such that the `DifficultyEnum` in `AppSettings` is now set to `HARD`.

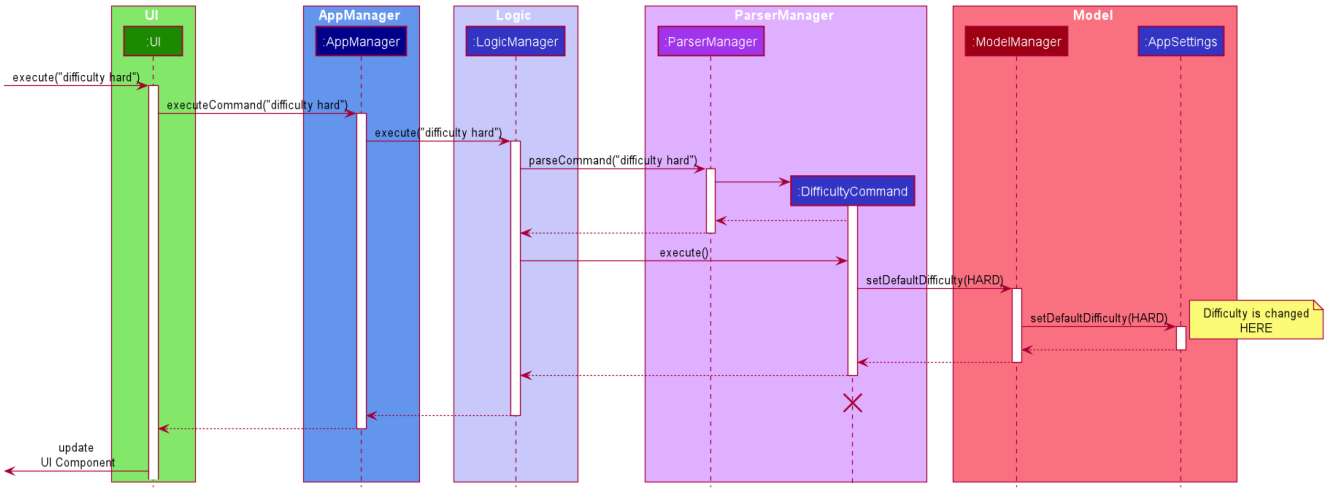


Figure 18. Sequence diagram of Step 5.

Step 5:
Since the main function of the `difficulty` command is accomplished and all that is left is to update the ui, the `CommandResult` that is produced by the execution of the command goes back to `Ui` without much problem.

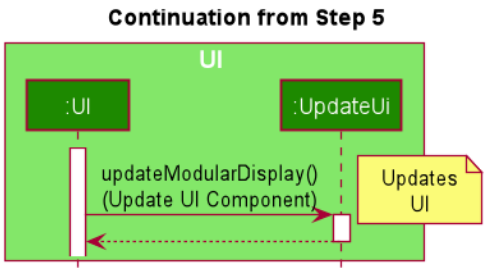


Figure 19. Sequence diagram of Step 6.

Step 6:
Assuming that there were no errors thrown during the execution of the `difficulty` command, the execution calls `updateModularDisplay` in `UpdateUi`. In here, the `ModeEnum.SETTINGS` is registered and it updates the settings display to properly reflect the change in difficulty.

The state of appSettings is then as follows:

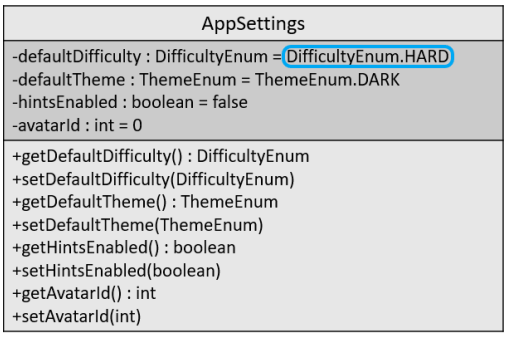


Figure 20. After state of application

3.2.2. Design Considerations

There were a few considerations for implementing an interface that essentially allows users to touch a lot of parts of the application through settings and some of these methods break software design principles. These are the considerations we came across:

	Alternative 1	**Alternative 2**
Aspect 1: Where to effect change when a setting is changed by the user	**Effecting the change inside the `execute()` command of the settings commands**: *Pros:* Since the Command is taking care of all the execution, there is no need to worry about extra implementation of the settings' effects in their classes. *Cons:* However, there are certain situations that will break software design principles, such as the **Single Responsibility Principle** by doing the job of already existing classes.	**Effecting the change in the part of the architecture that the setting is affecting. E.g, Changing the theme inside Ui or changing the difficulty inside model** *Pros:* This method practises good software engineering principles and it abides by the architecture diagram shown above as to where the changes of the settings are being effected. *Cons:* This method however requires that the reader gets familiar with the whole architecture diagram as they need to know where to implement the actual change in settings as opposed to creating a new class that performs the same functionality of an existing class.
Why did we choose Alternative 2: We believe that software design principles exist for a reason. Furthermore, while alternative 1 may seem a lot simpler, Alternative 2 allows for extension just by adding new methods and refrains the user from having to extensively rework the structure of the application in order to add a new setting.		

Aspect 2: How to store information regarding the different settings	**Storing it inside the enumerations that make up the choices for the settings** *Pros:* Having the information stored inside the enum allows for immutablilty, such that no other class can change the properties of the enums. Only the developer can change the values of the enums and it will subsequently affect all the methods and functionality that relies on said enum. *Cons:* In the case that the user wants to customise certain continuous settings such as time limit, they are unable to as those settings are already defined by the developer to be discrete options.	**Storing it inside the classes that implement the settings** *Pros* The information is easily accessible from within the class itself and there is no need for extra import classes to handle the enums in alternative 1. *Cons* Unlike Alternative 1, the developer can create an extension to the class implementing the setting to allow the user to customise their settings even further, allowing for continuous values to be used rather than discrete values.
Why did we choose Alternative 1: The considerations for this aspect was mainly down to how much customisability we wanted to grant our users. While having more customisability is better in some cases, in this one, we do not think the added functionality of allowing the user to extensively customise their experience with our application to be particularly impactful not necessary. Moreover, alternative 2 makes for a less organised code base and we wanted to avoid that as much as possible.		

3.3. Timer-based Features

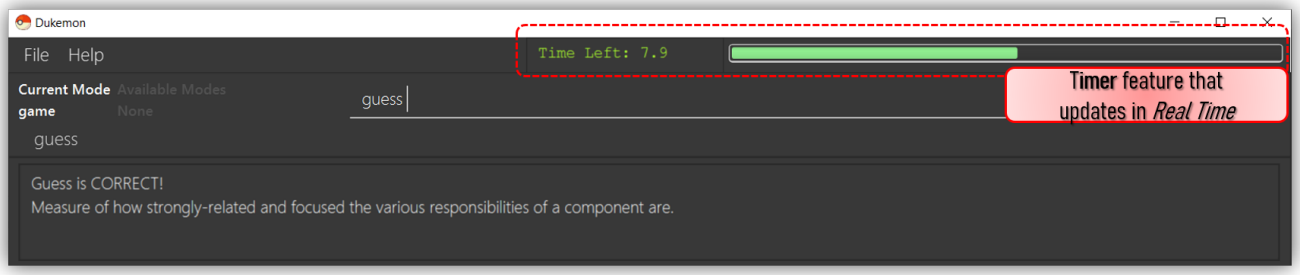


Figure 21. Screenshot of the `Timer` component in action.

3.3.1. Implementation Overview - Timer

The `Timer` component utilizes the `java.util.Timer` API to simulate a stopwatch that runs for each `Card` in a `Game`. It relies on using *Functional Interfaces* as *callbacks* for the TImer to periodically

notify other components in the system without directly holding a reference to those components.

Internally, the `Timer` works by using the method `java.util.Timer.schedule()` that schedules `java.util.TimerTasks` at a fixed rate (*every 50ms*).

An *Observer Pattern* is loosely followed between the `Timer` and the other components. As opposed to defining an *Observable* interface, the `AppManager` simply passes in *method pointers* into the `Timer` to *callback* when an event is triggered by the `Timer`.

NOTE	To avoid synchronization issues, all *callbacks* to change `UI` components are forced to run on the **JavaFX Application Thread** using `Platform.runLater()`.

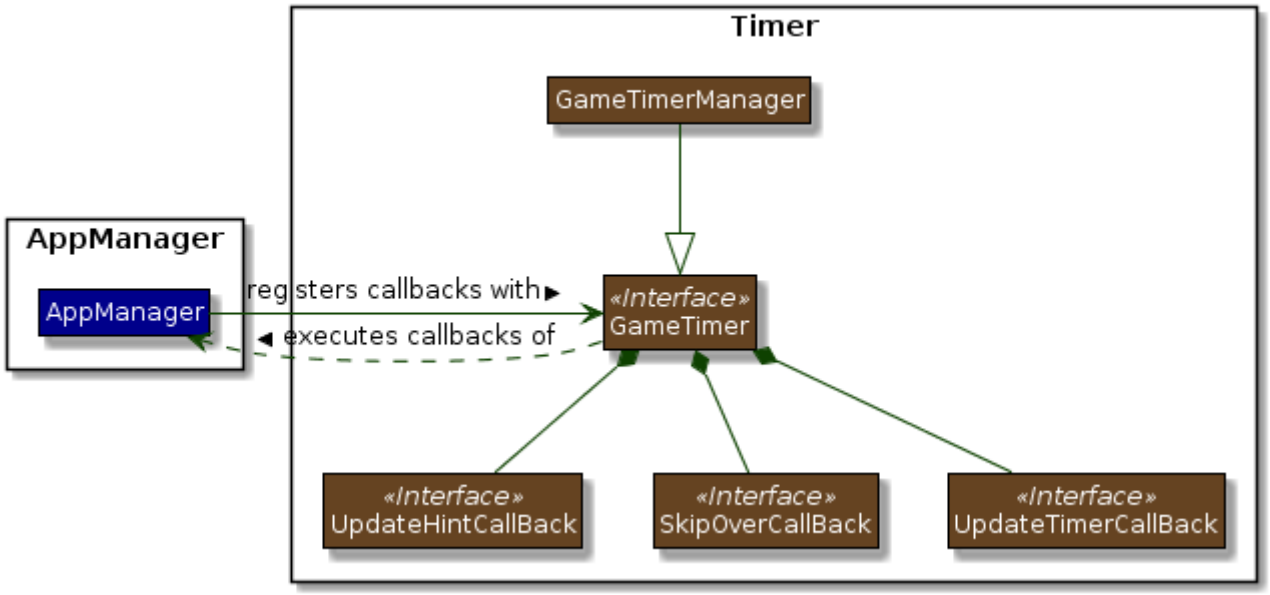


Figure 22. Class diagram reflecting how the callback-functions are organized in the Timer component.

The three main events that are currently triggered by the `Timer` component which require a *callback* are:

1. Time has elapsed, *callback* to `AppManager` to **update and display the new timestamp** on the `UI`.
2. Time has run out (*reached zero*), *callback* to `AppManager` to **skip over** to next `Card`.
3. Time has reached a point where `Hints` are to be given to the User, *callback* to `AppManager` to **retrieve a `Hint` and display** accordingly on the `UI`.

The *callbacks* for each of these events are implemented as nested *Functional Interfaces* within the `GameTimer` interface, which is implemented by the `GameTimerManager`.

3.3.2. Implementation Overview - Hints

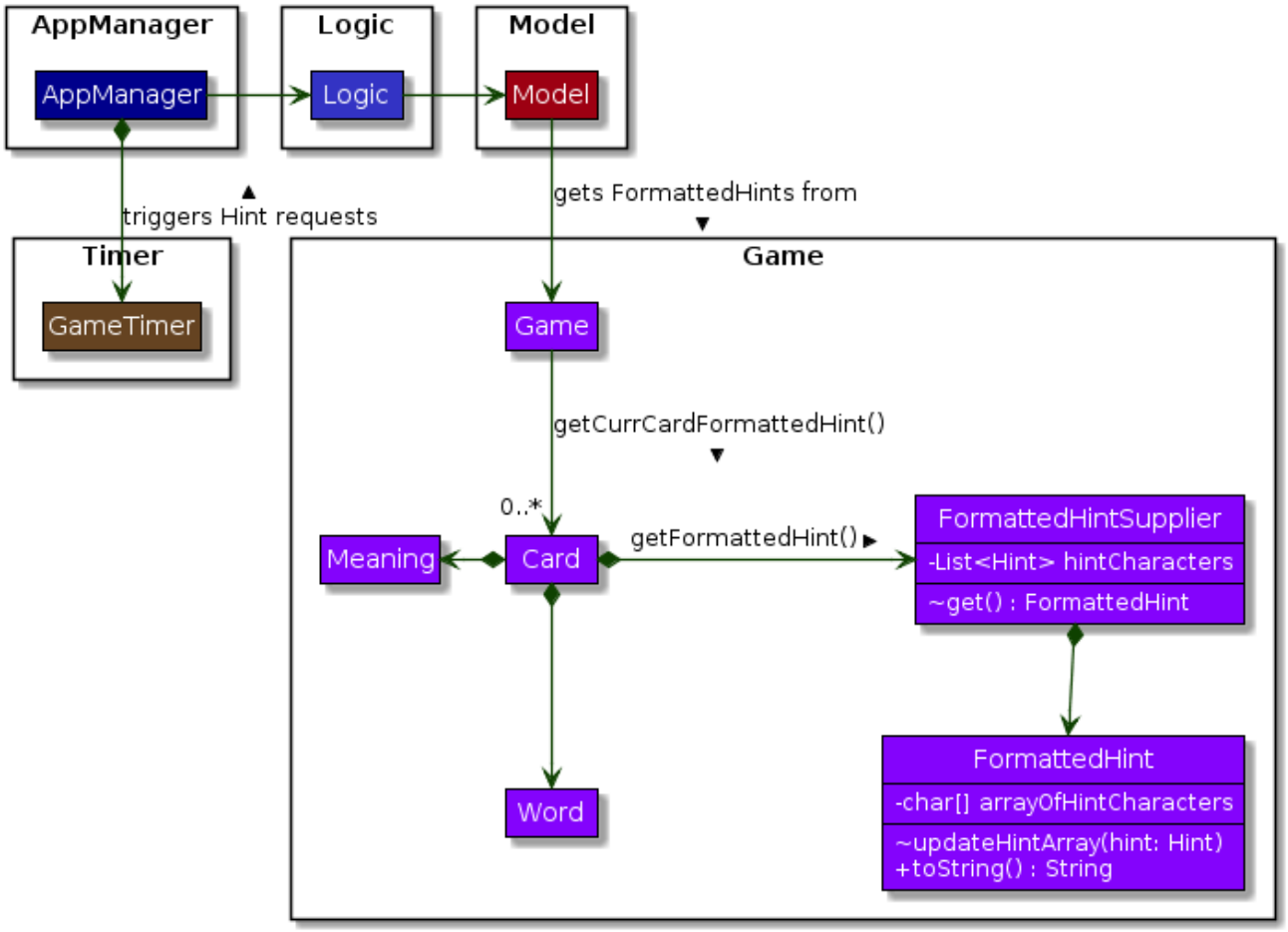


Figure 23. Class Diagram showing structure of `Hints` and its relationships to other components. (Some details omitted)

In order to display the `Hints` component to the user in a *Hangman-esque* style, **string formatting** has to be performed.

- Each `Card` contains a `FormattedHintSupplier` that supplies `FormattedHints` ready to be shown to the user.
- Each `FormattedHintSupplier` contains a `FormattedHint` that is periodically updated.
- Each `FormattedHintSupplier` contains a `java.util.List` of `Hint` to update the `FormattedHint` with.
- Each `FormattedHint` maintains a `char[]` array that it's `toString()` method uses to format the output `Hint` string with.
- Each `Hint` encapsulates a `Character` and an `Index` which the `Character` is to be shown in the `FormattedHint`.

The `Timer` component **triggers a request to update `Hints`** to the `AppManager`, who then updates and retrieves the updated `FormattedHint` from the current `Game` via the `Logic` component.

3.3.3. Flow of Events - `Hints` Disabled

This section describes the general sequence of events in the life cycle of a single `GameTimer` object with **no hints**.

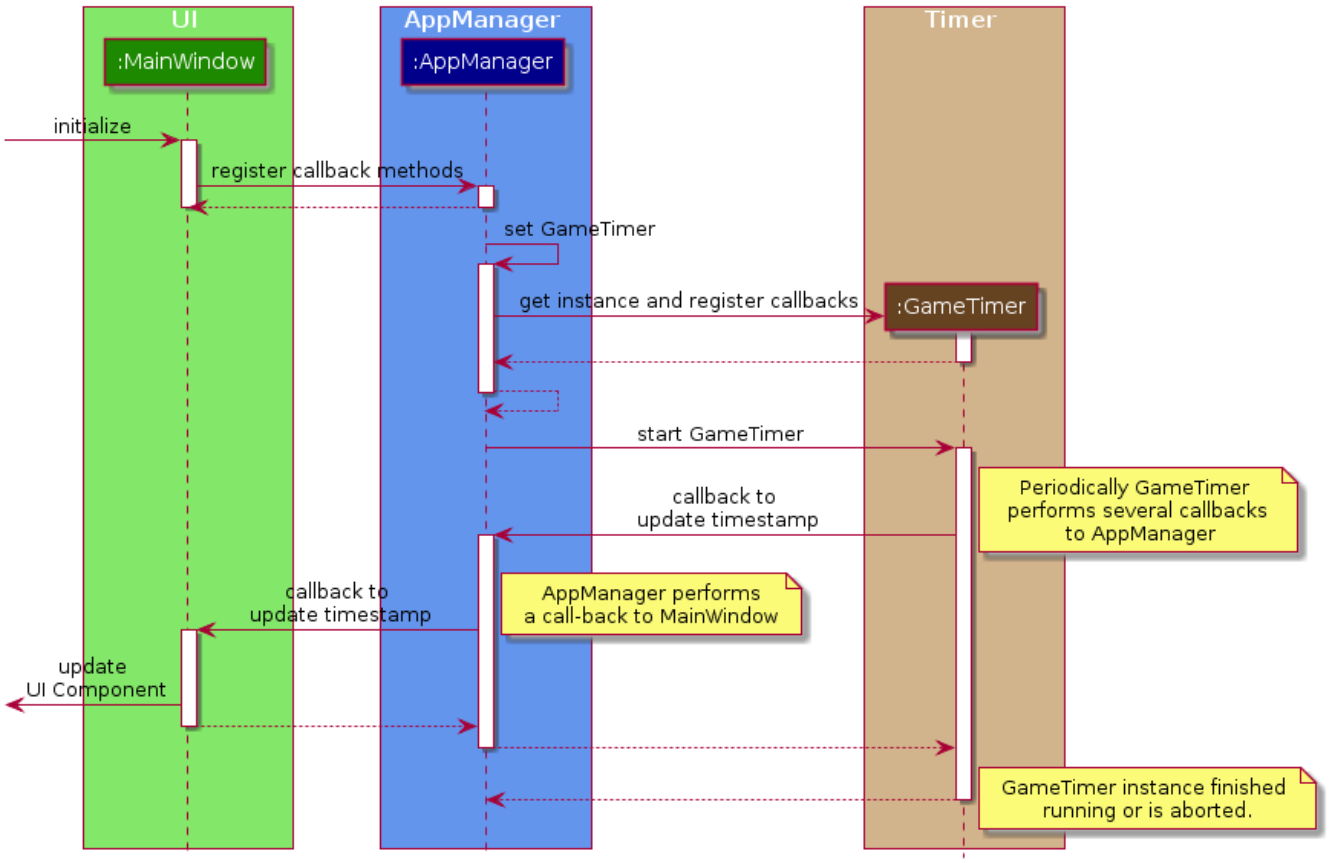


Figure 24. Sequence diagram (with some details omitted) describing the flow of registering and executing callbacks between the different components

NOTE	`GameTimer` interface uses a factory method to create `GameTimerManager` instances. This behavior is omitted in the above diagram for simplicity.

A new `GameTimer` instance is created by the `AppManager` for every `Card` of a `Game`. The `AppManager` provides information regarding the duration in which the `GameTimer` should run for, and whether `Hints` are enabled.

1. `UI` component first registers *callbacks* with the `AppManager`.
2. When a *Game* is started, `AppManager` initializes a `GameTimer` instance for the first *Card*.
3. `AppManager` registers *callbacks* with the `GameTimer` component.
4. `AppManager` starts the `GameTimer`.
5. Periodically, the `GameTimer` notifies the `AppManager` to update the `UI` accordingly.
6. `AppManager` is notified by `GameTimer`, and then notifies `UI` to actually trigger the `UI` change.
7. `GameTimer` finishes counting down (or is **aborted**).
8. `AppManager` repeats Steps 2 to 7 for each *Card* while the *Game* has **not** ended.

Using this approach of *callbacks* provides **better abstraction** between the `UI` and `Timer`.

3.3.4. Flow of Events - `Hints` Enabled

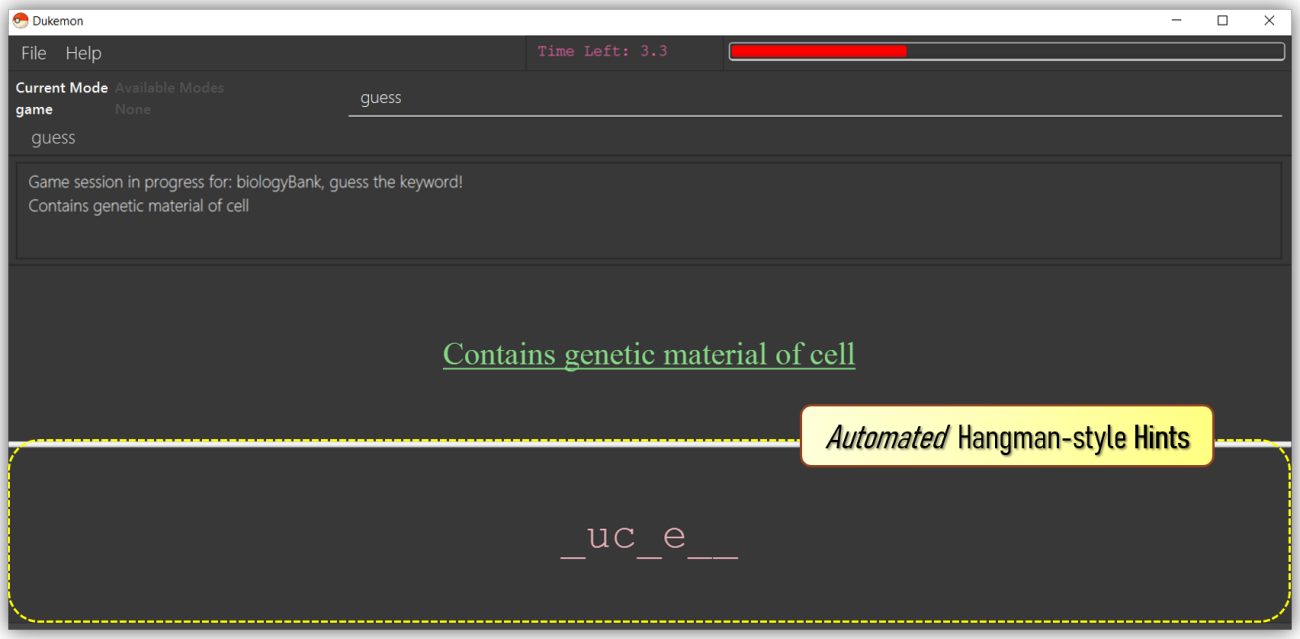


Figure 25. Screenshot of the automatic `Hints` feature in action.

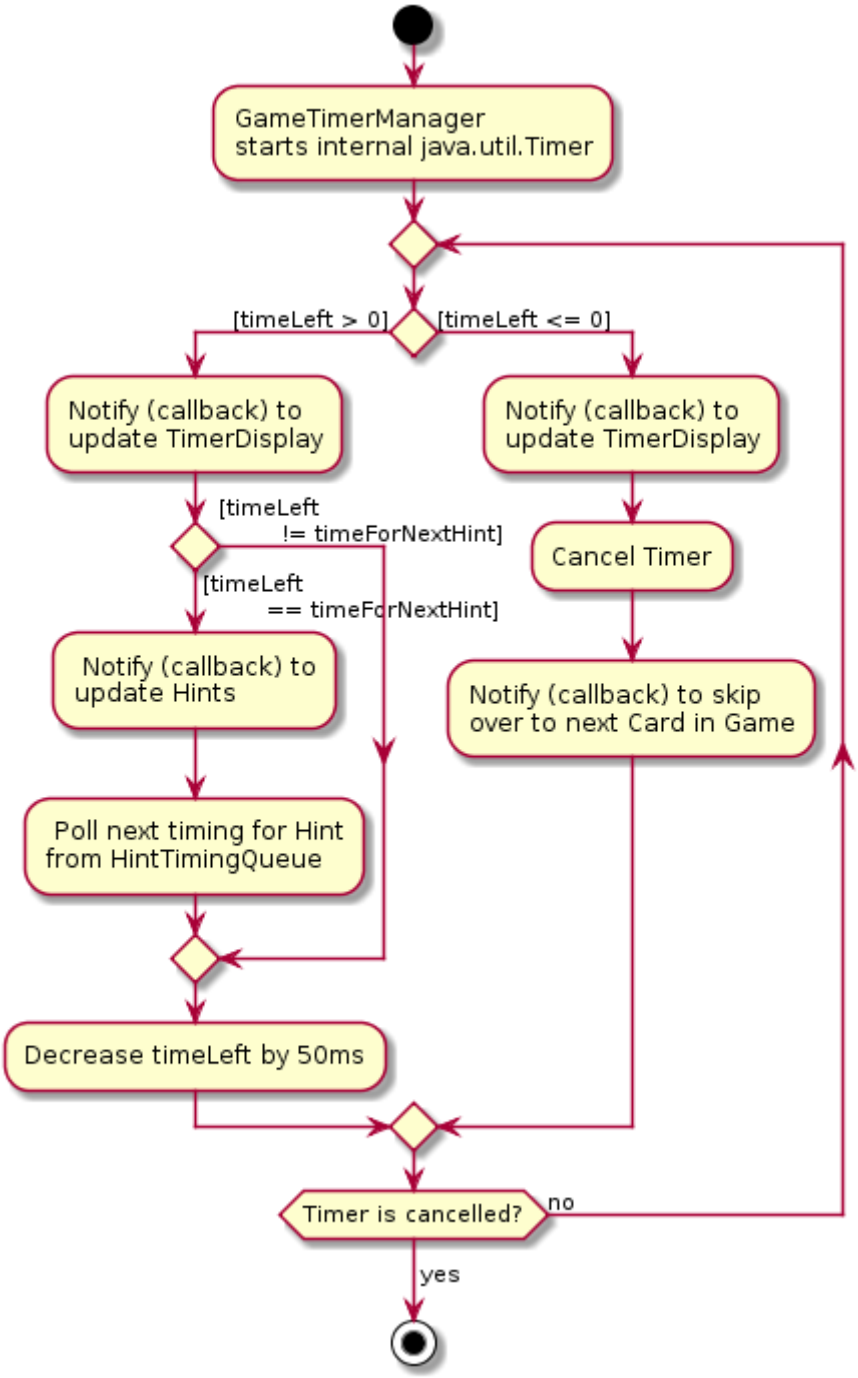


Figure 26. Activity diagram of the `run()` method of an instance of `GameTimerManager` when `Hints` are enabled.

- In the diagram as **shown above**, the internal `Timer` is started when `GameTimerManager` calls the `.schedule()` method of its internal `java.util.Timer`, which schedules `TimerTasks` immediately, every 50 milliseconds until the `java.util.Timer` is cancelled. The field `timeLeft` is initialized to be the amount of time allowed per *Card* (in milliseconds), and is updated every 50ms.
- The behavior of `Timer` when `Hints` are enabled is **largely still the same.**
- When `Hints` are enabled, `AppManager` initializes a `HintTimingQueue` in the `GameTimer` for each *Card*. `HintTimingQueue` is a class that contains a `java.util.Queue` of *timestamps* (in milliseconds). `GameTimer` polls from the `HintTimingQueue` and checks against these polled *timestamps* to update the `Hints` provided periodically.

3.3.5. Design Considerations

There were a few reasons for designing the `Timer` and `Hints` this way.

	Alternative 1	**Alternative 2**
Aspect 1: Where and How to effect changes to the `Ui` and other components when the `Timer` triggers an event.	**Holding a reference to `Ui` and other components directly inside `GameTimer` itself**: *Pros:* Straightforward and direct, can perform many different tasks on the dependent components. *Cons:* Poor abstraction and high potential for cyclic dependencies, resulting in high coupling.	**Using *Functional Interfaces* as Call-backs to notify components indirectly.** *Pros:* Maintains abstraction and minimal coupling between `Timer` and other components *Cons:* Relies on developer to register correct call-back methods with the `Timer`. Different actions need to be implemented as different call-backs separately. Possible overhead in performing few levels of call-backs.
Why we chose Alternative 2: To ensure better extendability of our code for future expansion, we felt it was important to maintain as much abstraction between components. This is also to make life easier when there comes a need to debug and resolve problems in the code.		
	Alternative 1	**Alternative 2**

Aspect 2: Where and how to perform string formatting for `Hints` to be displayed.	**Move retrieval of individual Hint characters and all formatting outside of the Game component completely**: *Pros:* Maintains immutability of each `Card` inside `Game` component. *Cons:* Breaking abstraction as higher level components should not have to deal with string formatting.	**Perform formatting at the lowest level possible, using a `FormattedHint` class.** *Pros:* Higher level components need not know about string formatting at all, maintains good abstraction. *Cons:* Individual `Game` components like each `Card` become stateful, need to make deep copies to prevent state from carrying across `Game` sessions.
Why we chose Alternative 2: Implementing cloning of `Cards` affects other areas of code the least, and reduces unnecessary coupling. Since changes to higher level elements can potentially affect all other components, it was safer to modify more atomic areas of code.		

3.4. WordBank-related Feature

This section discusses the implementation of *WordBank* Management in various levels of detail. This can be split into four complimentary distinct sections.

They are:

- Word bank's data structure and its storage system
- User Commands
- Drag and drop
- Revision word bank

3.4.1. Word bank's data structure and its storage system

Allows developers to use and extend this architecture to streamline their feature implementation. Allows user to save and load their word banks.

Observe closely the attributes and methods of the following class diagrams.

They describe and explain word bank's data structure and its storage system in detail.

We start from the lowest level - `Card`.

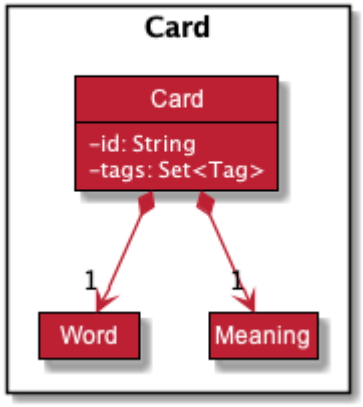


Figure 27. Class diagram of `Card`.

A `Card` contains a unique `id`, a `word`, a unique `meaning`, a set of `tags`.

`id` : for statistical tracking
`word`: answer to the question (meaning)
`meaning`: the question that will appear in the game
`tags`: optional tags to classify *Cards*

> **NOTE** `Cards` with the same meaning are duplicates, and is disallowed.

Next, the second level - `WordBank`

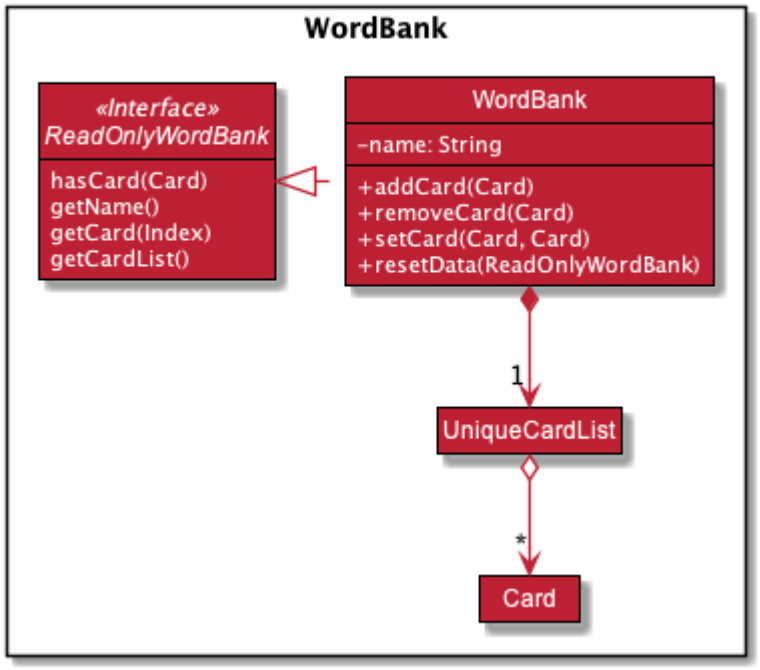


Figure 28. Class diagram of `WordBank`.

A `WordBank` contains a `UniqueCardList` and a unique `name`.

`UniqueCardList` : prevent duplicate `Cards`
`name`: unique name of the word bank

NOTE	`WordBank` exposes an unmodifiable `ObservableList<Card>` that can be 'observed'. The UI can be bound to this list so that the UI automatically updates when the `Cards` in the list change. Word banks with the same name are duplicates, and is disallowed.

Now the third level - `WordBankList`

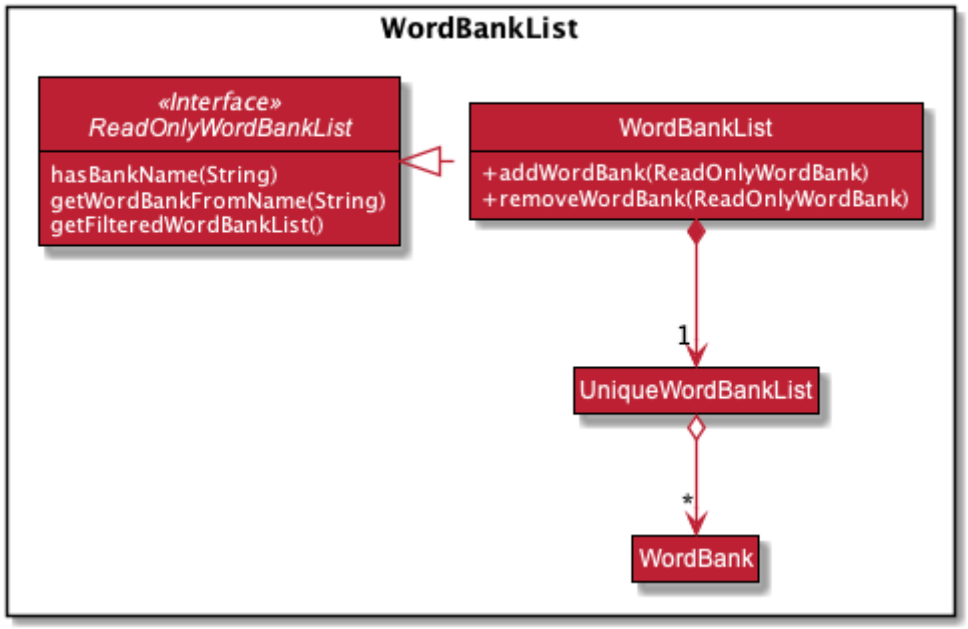


Figure 29. Class diagram of `WordBankList`.

A `WordBankList` contains a `UniqueWordBankList`.

`UniqueWordBankList` : prevent duplicate word banks

NOTE	`WordBank` exposes an unmodifiable `ObservableList<WordBank>` that can be 'observed'. The UI can be bound to this list so that the UI automatically updates when the `Cards` in the list change.

In Dukemon, there is should only be one `WordBankList`, which is created upon `Storage` initialisation. `Model` holds a reference to that specific `WordBankList`.

Architecture overview - `WordBankList`

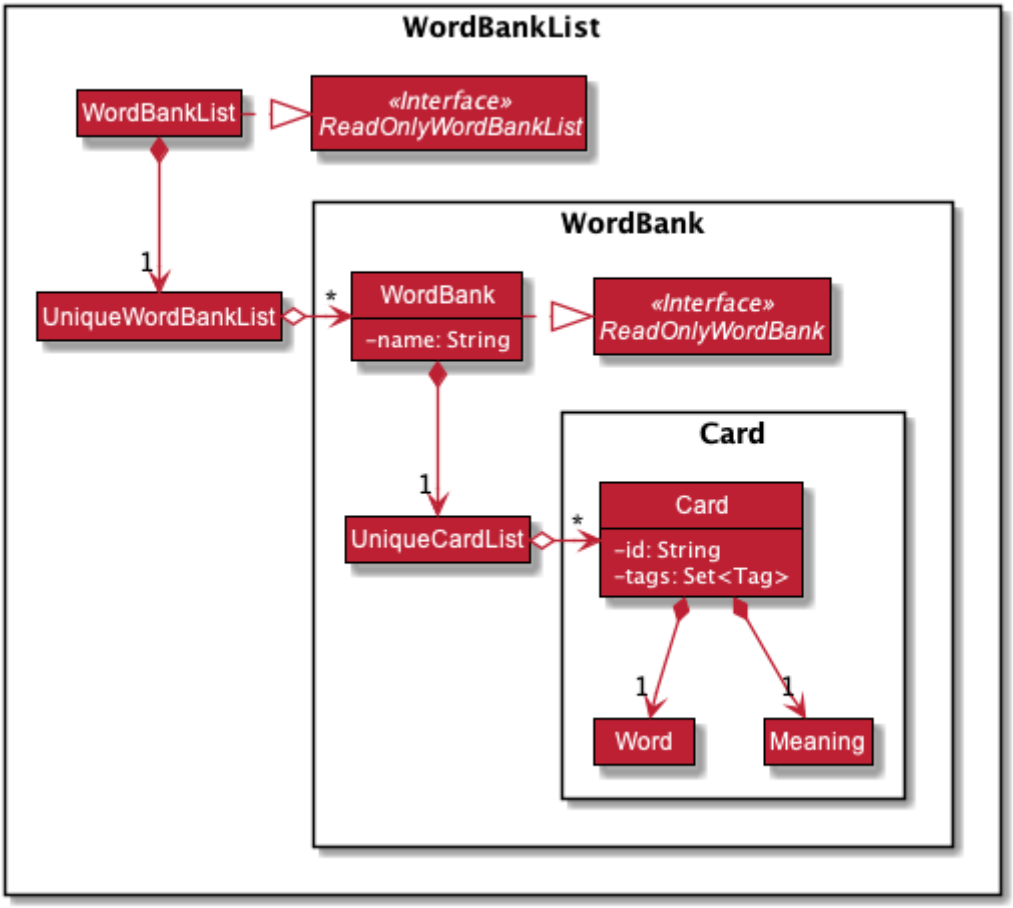


Figure 30. Overview of `WordBankList`.

Word bank's storage system integration.

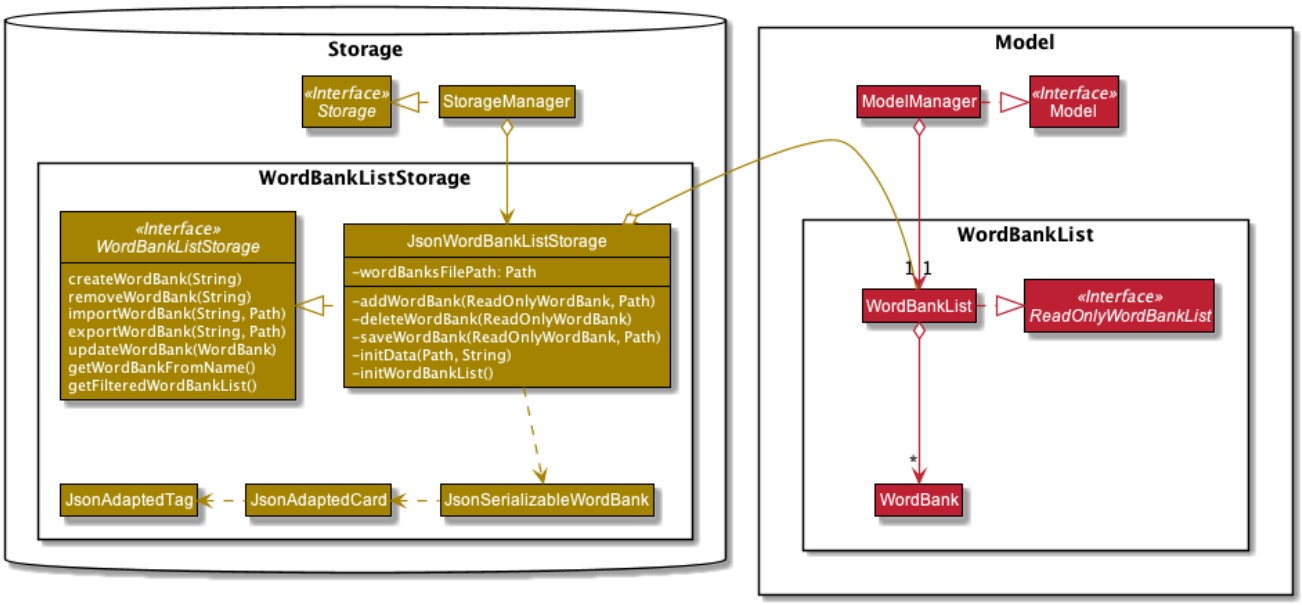


Figure 31. Integration of `WordBankList` *within* `Storage` *and* `Model`.

WordBankListStorage consists of robust and self-explanatory methods in which users can use and extend upon easily.
Alongside with word bank's data structure, they lay the foundation for my other complementary

sections of Word Bank Management.

On top of that, they serve as a essential foundation for Dukemon. As such, these data structures and methods were required by my teammates, to build their own feature implementations. (Statistics, Game, Settings)

3.4.2. User Commands

Allows user to customise `Cards` and group them according to topics (word banks).
User commands edits and manipulates `Cards` and `WordBanks` heavily.

NOTE	As mentioned previously, user commands will extend and utilise word bank's data structure and storage heavily. You can refer to it to enhance your understanding of this implementation.

Let me first introduce you how these commands are implemented and structured in `Logic`.

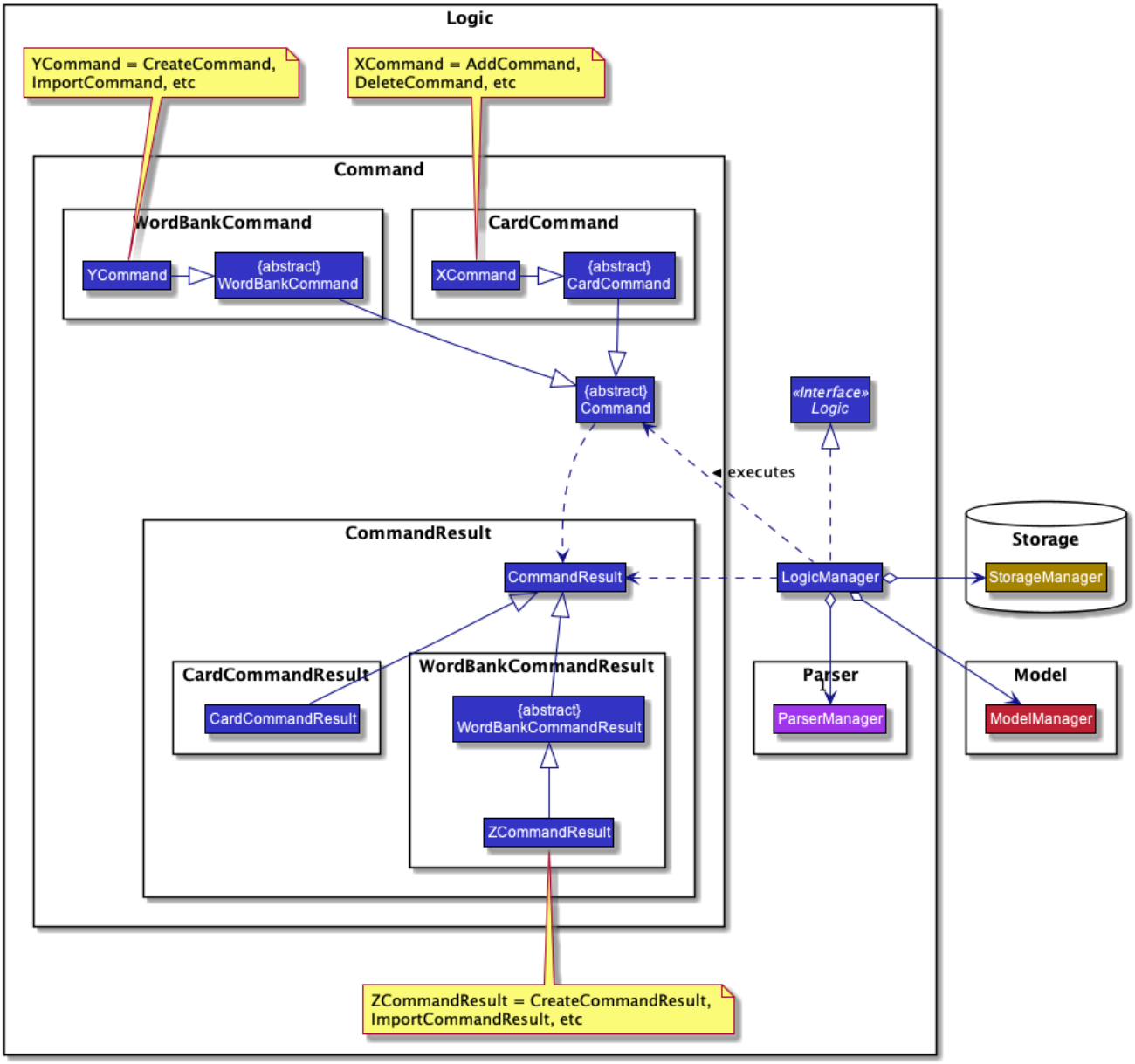


Figure 32. Overview class diagram of `Logic` with emphasis on CardCommands and WordBankCommands.

Commands reside in `Logic`. They work on `Model` and `Storage` through `Logic`.
To segregate `Cards` according to their function, we distinguished the following:

`CardCommands` work on `Cards`.

`WordBankCommands` work on `WordBanks`.

Walkthrough - `ImportCommand`.

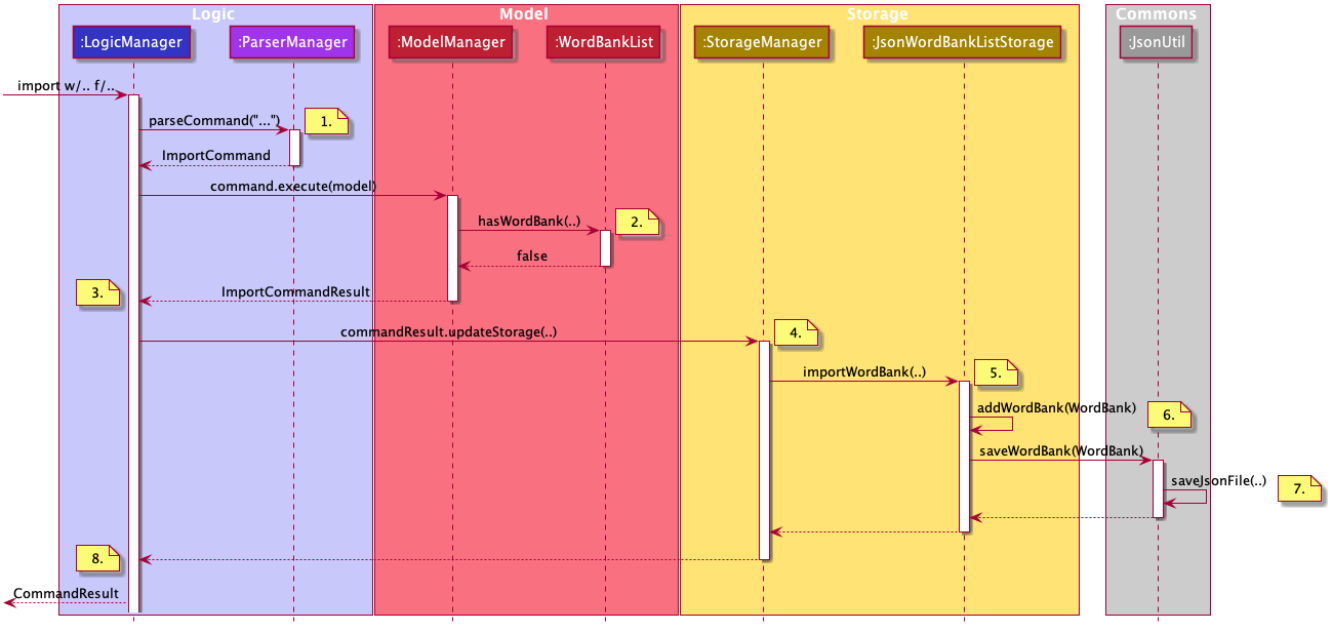


Figure 33. Sequence diagram detailing a successful `WordBankCommand` through different components.

NOTE	Most of these methods utilised can be found in my word bank data structure and storage class diagrams. The emphasis here is to show how these commands utilise word bank's data structure and storage.

We will see the case where an Import command is valid.
For example, for the input: "import w/bank1, f/~/downloads"

1. Depending on the input, a specific `Command` type is returned by `ParserManager`. i.e. `ImportCommand`.
2. Each type of `Command` executes with slight variance. `ImportCommand` executes and checks in `Model` to check if `WordBankList` already contains `WordBank`.
3. Relevant information is stored in a specific `CommandResult` and is returned back to `LogicManager`. i.e. `ImportCommandResult`.
4. Each type of `CommandResult` updates the storage with slight variance. `ImportCommand` calls the importWordBank method.
5. `JsonWordBankListStorage` contains the abstracted details of how a commandResult should be handled. For importWordBank method, addWordBank and saveWordBank private methods are called.
6. Within addWordBank method, `WordBank` is added into the underlying UniqueWordBankList.
   Two synchronisation happens here.
   Firstly, as `Model` contains the same `WordBankList`, the two list contains synchronised data.
   Secondly, `WordBankList` exposes an unmodifiable `ObservableList<WordBank>` that can be 'observed'. `UI` was bounded to this list upon initialisation. Hence, it allows the user sees the updated word bank automatically.
7. Within saveWordBank method, an even lower level saveJsonFile function is called to write to the disk. This is performed through the common class: `JsonUtil`.
8. It returns back to `LogicManager`, and a success message is passed back to `AppManager`, then to the `UI` to notify the user.

- Other `CardCommands` and `WordBankCommand` work similarly to `ImportCommand`, with slight variance.

3.4.3. Drag and drop

Allows user to export their word bank out of their computer simply by dragging it out of Dukemon. Likewise, it allows user to import a word bank file from their computer by dragging it into Dukemon.

Improves user experience by making it easy to share word banks with friends.

NOTE	As mentioned previously, drag and drop will extend and utilise word bank's storage heavily. You can refer to it to enhance your understanding of this implementation.

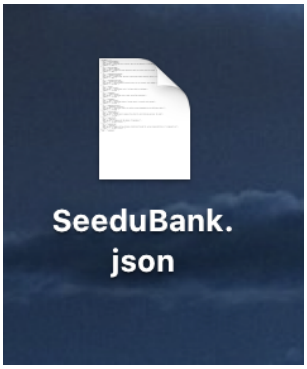


Figure 34. Word bank file.

Figure 35. Dragging into Dukemon.

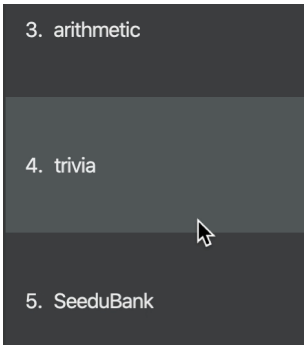


Figure 36. Dukemon registers the bank.

From `HOME` mode, you can view your `WordBanks`. Simply drag and drop a `WordBank` json file from your computer into Dukemon. Likewise, drag and drop a `WordBank` out of the application, into say, your desktop, or chat applications.

Walkthrough - Drag in.

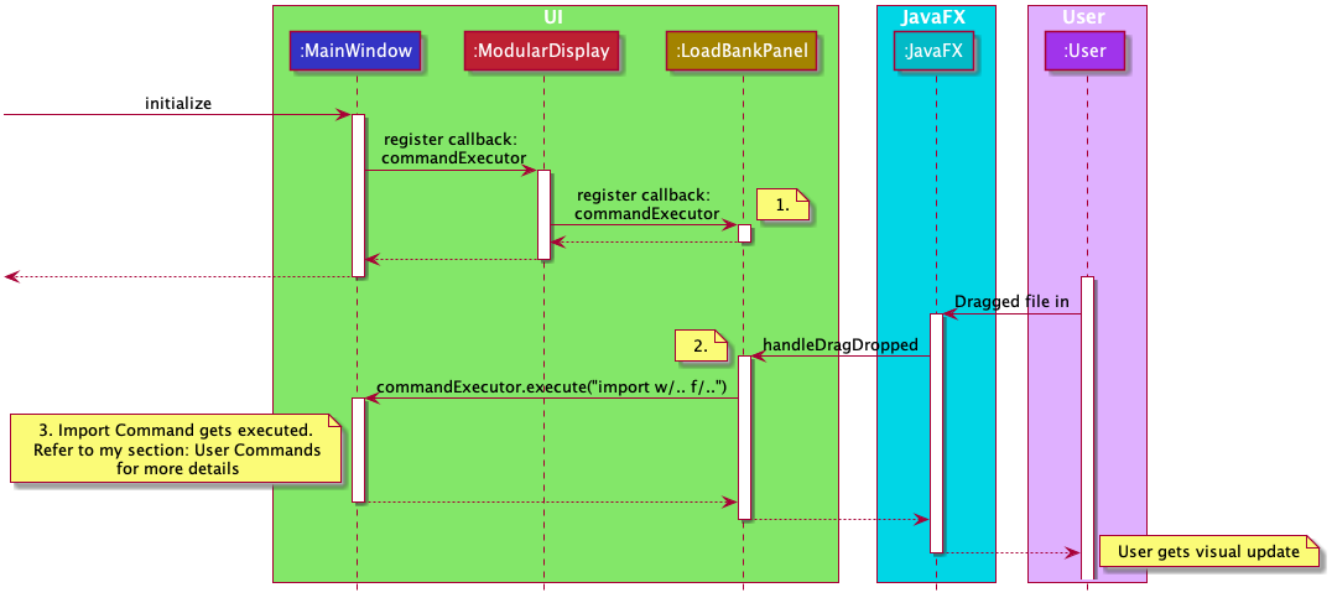


Figure 37. Sequence diagram showing how drag and drop utilises the ImportCommand and thus the word bank's storage.

`LoadBankPanel` is the corresponding class and the FXML file that displays the word banks for the user.
It is deeply nested within `UI` and only has access to an `ObservableList<WordBank>`.
This means it has no way to perform commands, update model or update storage.

1. To work around this, a functional callback is registered within LoadBankPanel.
2. LoadBankPanel registers JavaFX's UI drag detection and drag dropped methods, with the callback.
3. After which, the callback essentially performs an `ImportCommand`, to load the word bank.

It is also noteworthy to mention that, dragging into Dukemon functionality is well guarded against:

- Not json file format.

- Json file but data in wrong format.
- Json file with correct format but contains duplicate `Cards` within.

User receives apt feedback through the command box for different cases. This is possible with careful exceptions handling within the `ImportCommand` itself.

3.4.4. Revision word bank

Allows user to visit a centralised word bank that automatically collects `Cards` for revision.
`Cards` that were answered wrongly are automatically added to this revision bank.
Likewise, `Cards` that were answered correctly during game play are automatically removed from this revision bank.

Improves user learning experience by helping the user to collate `Cards` that require revision.

NOTE	As mentioned previously, revision word bank will extend and utilise word bank's data structure and storage heavily. You can refer to it to enhance your understanding of this implementation.

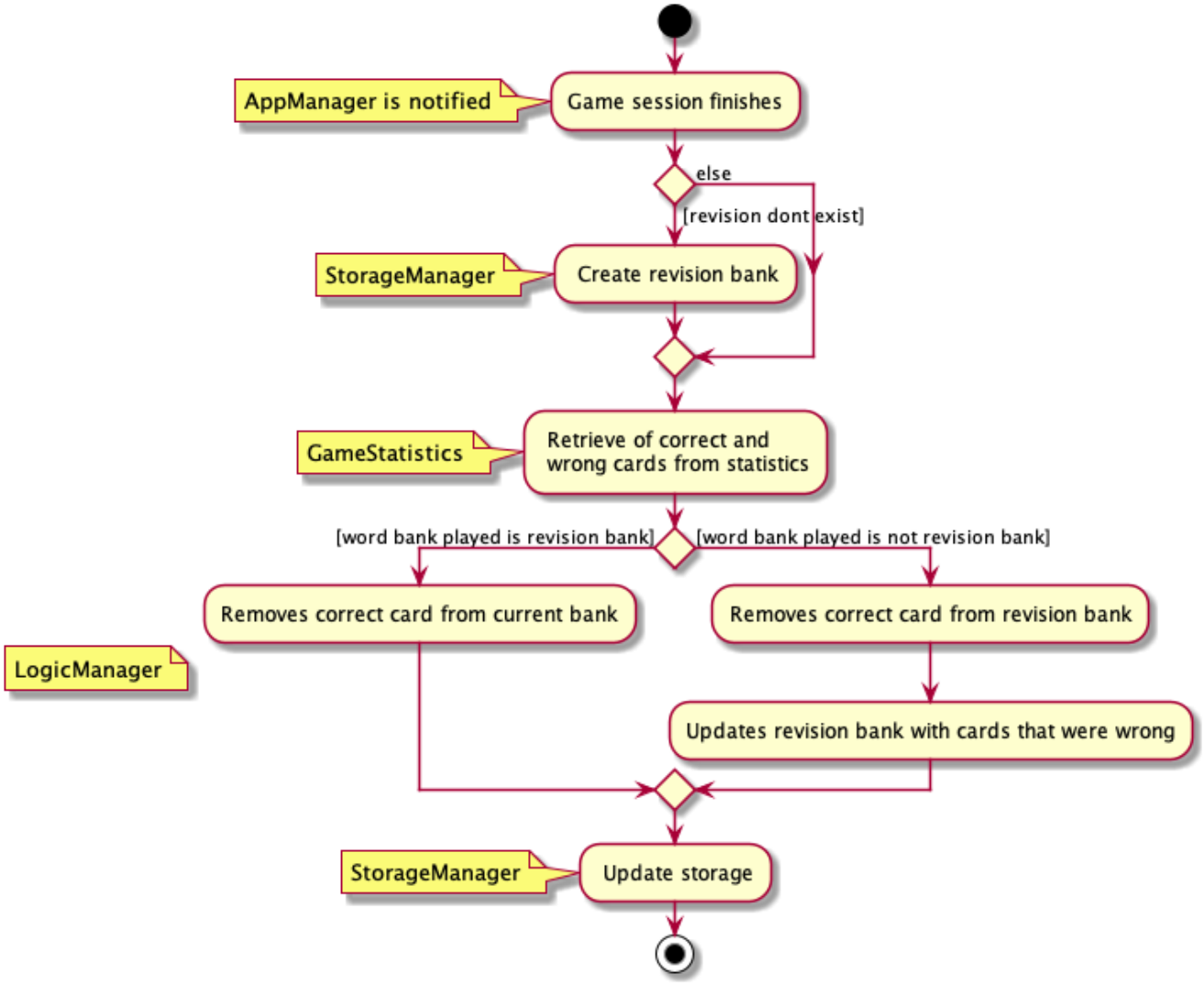


Figure 38. Activity diagram showing different scenarios possible while trying to update revision bank.

Revision bank was one of the essential and dominant features we wanted to implement since early development, however it had to be implemented last because it required multiple components working together.

These components include:

- AppManager
- StorageManager
- LogicManager
- GameStatistics

Given that well-developed methods reside in each of these components, we then require an overview of revision bank implementation. The activity diagram above is able to detail my thought process and implementation.

1. `AppManager` gets first notification that a `Game` session has ended.
2. `StorageManager` creates revision word bank if necessary.
3. `GameStatistics` gives the required information: correct and wrong `Cards`.

4. `LogicManager` manages the processing of these `Cards`, with some slight variance depending on situation, into revision bank.
5. `StorageManager` saves it back into hard disk.

3.4.5. Design Considerations

	Alternative 1	**Alternative 2**
Aspect 1: Data structure for WordBankList.	**Create classes for both WordBankList and WordBank, even though they are very similar in structure.** *Pros:* User's modification to their *WordBanks* and *Cards* requires very different methods. These two data structure requires different access to the storage as well. With two different classes, implementation of the Commands that work on these data becomes more distinct. This ensures methods within `WordBankList` are written for `WordBankCommands` and methods within `WordBank` are written for `CardCommands`, thereby increasing cohesion of individual components and decreasing coupling between the two classes. *Cons:* Implementation requires much more effort.	**Create a generic data structure class, and let both WordBankList and WordBank extend it.** *Pros:* Code that are reusable in WordBank can now be reused for WordBankList. *Cons:* This couples WordBank with WordBankList. Does not follow the Open-Closed principle.
Why did we choose Alternative 1: In the spirit of software engineering principles, it is better to have the basic data structure implemented well. Commands that depend on it becomes much easier to implement. (This can be seen in the drag and drop feature.)		

	Alternative 1	**Alternative 2**

Aspect 2: Storage system for word banks.	**Store one single large json file with word bank names as keys and its word bank data as values**: *Pros:* Always save a snapshot of the data to the same file, regardless of what commands are executed. *Cons:* Unable to share word banks with friends, because one file contains all the word banks.	**Store each word bank as a json file.** *Pros:* Enables sharing of word bank files to friends. *Cons:* Require more consideration to deal with different type of commands which affects the storage dynamically. Harder to read from multiple files.
Why did we choose Alternative 2: This choice was based largely from the user's perspective. As our app is designed to streamline learning, we figured that easy sharing of word banks file with friends is an important aspect in our app, and cannot be compromised.		

	Alternative 1	**Alternative 2**

Aspect 3: Command implementation. (Same goes for Command Result implementation)	**All types of commands extends a single abstract class `Command`:** *Pros:* A rather simple implementation which does not break any software engineering principles. *Cons:* Can be further improved, as in Alternative 2.	**Distinguishing `WordBankCommand` and `CardCommand` specifically - Commands that work on `Cards` extends the abstract `CardCommand` class and commands that work on `WordBank` extends the abstract `WordBankCommand` class.** *Pros:* As we have created distinct data structure for `WordBankList` and `WordBank`, distinguished commands now work solely on their respective data structure. It follows the Single Responsibility Principle and the Separation of Concerns Principle more closely, and decreases the coupling between the two component. *Cons:* Requires tedious implementation to follow the principles.
Why did we choose Alternative 2: Allows for easy extension of Dukemon's functionality. Implementation of the drag and drop feature is now a few function calls away, as all data structure and functions are well written.		

	Alternative 1	**Alternative 2**

Aspect 4: How to implement Drag and Drop. `LoadBankPanel` is a deeply nested class, and is the corresponding class for the `UI` to interact with user's drag and drop action.	**Updates the storage directly from `LoadBankPanel`:** *Pros:* It only requires a reference and then saving directly to `Storage`. This can be implemented with ease. *Cons:* Practically, there are a few exceptions being thrown when calling the storage's method directly. `LoadBankPanel` cannot handle them effectively. This also leads to poor abstraction and high potential for cyclic dependencies, resulting in high coupling.	**Using *Functional Interfaces* as Call-backs to call an `ImportCommand` from `LoadBankPanel`.** *Pros:* Calling an already well-implemented `ImportCommand` allows all exceptions caught to be handled properly. It also maintains abstraction and minimal coupling between `LoadBankPanel` and other components. *Cons:* It makes the code less OOP and more functional.
Why did we choose Alternative 2: Provides a more complete implementation, as it would make sense for exceptions to be caught and allow user to see feedback messages.		

3.5. Statistics Feature

3.5.1. Implementation

The work of the Statistics component can be neatly captured and explained using a common series of user actions when operating the app.

User action	**Statistics work**	**UI Statistics updates**
User opens the app.	User's `GlobalStatistics` and `WordBankStatisticsList` are loaded into `Model` by the `MainApp`.	User is shown their `GlobalStatistics` and their most played word bank from the `WordBankStatisticsList` in the main title page.
User selects a word bank.	The selected `WordBankStatistics` from the `WordBankStatisticsList` is loaded into `Model`.	
User opens the selected word bank.		In open mode, User is shown the `WordBankStatistics` of the opened word bank.

User action	Statistics work	UI Statistics updates
User plays the game.	A `GameStatisticsBuilder` is used to record user actions during the game.	
User finishes the game.	• A `GameStatistics` is created from the `GameStatisticsBuilder`. • The `WordBankStatistics` and `GlobalStatistics` are updated accordingly and saved to disk.	`GameStatistics` and the corresponding `WordBankStatistics` are displayed to user in the game result page.

We will discuss each step with its implementation details primarily on the statistics work.

1. User opens the app

When the user opens the app, their `GlobalStatistics` and `WordBankStatisticsList` are loaded into `Model` by `MainApp`.

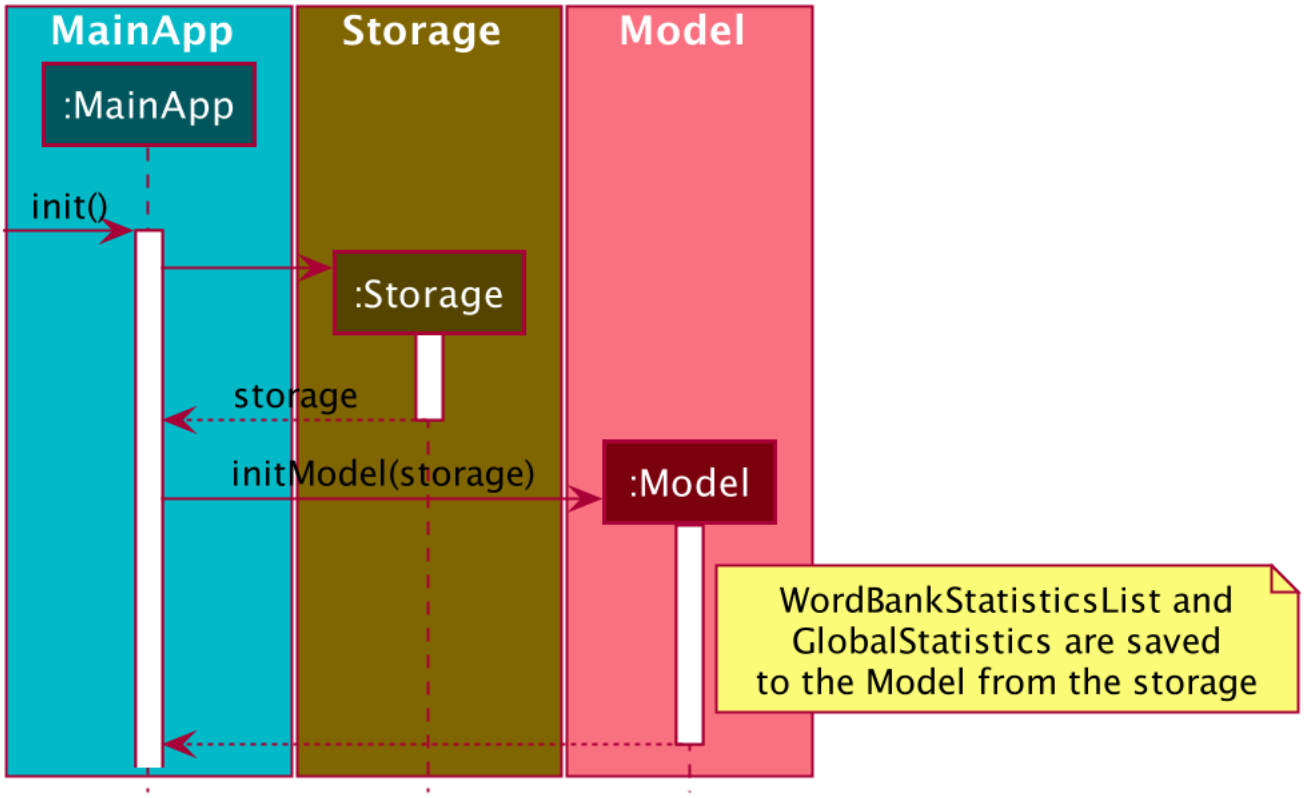


Figure 39. Sequence diagram for loading statistics

2. User selects a word bank

When the user selects a word bank, the selected `WordBankStatistics` from the `WordBankStatisticsList` is loaded into Model.

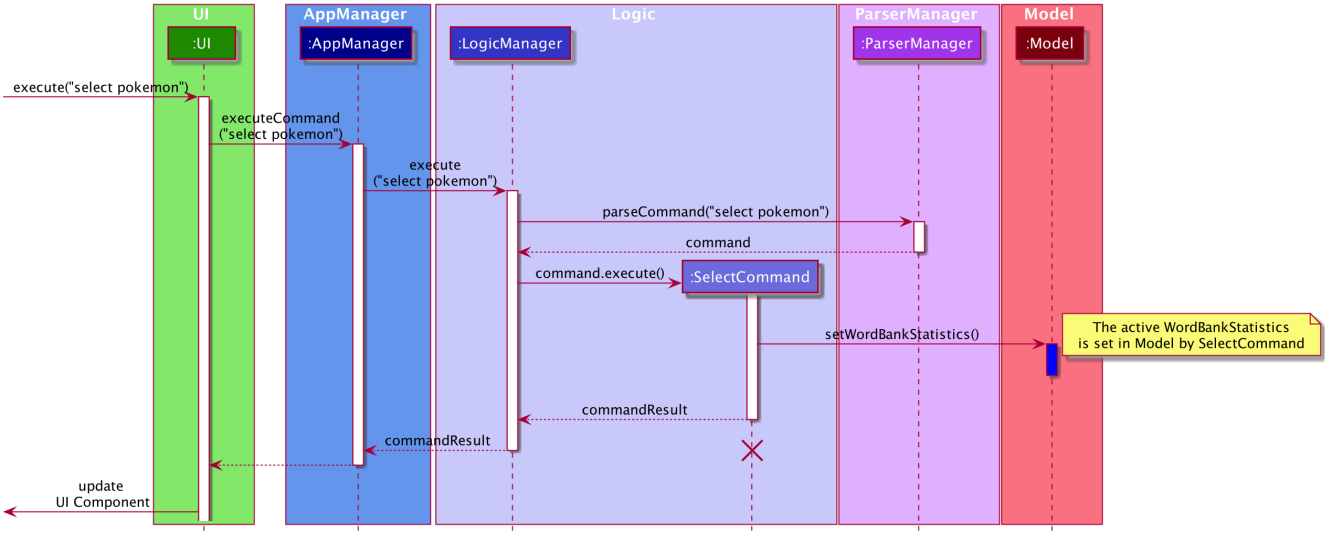


Figure 40. Sequence diagram for selecting a word bank statistics.

It is necessary to set the active `WordBankStatistics` in the `Model` such that when the user opens the `WordBank`, the `WordBankStatistics` can be found in `Model` and shown in the UI.

3. User opens the selected word bank

In open mode, the user is shown the `WordBankStatistics` of the opened word bank, which is set in `Model` at step 2.

4. User plays the game

A `GameStatisticsBuilder` is used to record user actions during the game.

When the user starts the game by calling a `StartCommand`, the `GameStatisticsBuilder` is initialized. Additionally, the `GameStatisticsBuilder` is updated with every `GuessCommand` or `SkipCommand` made during the game. It receives the timestamp from the `GameTimer` which also resides in `AppManager`.

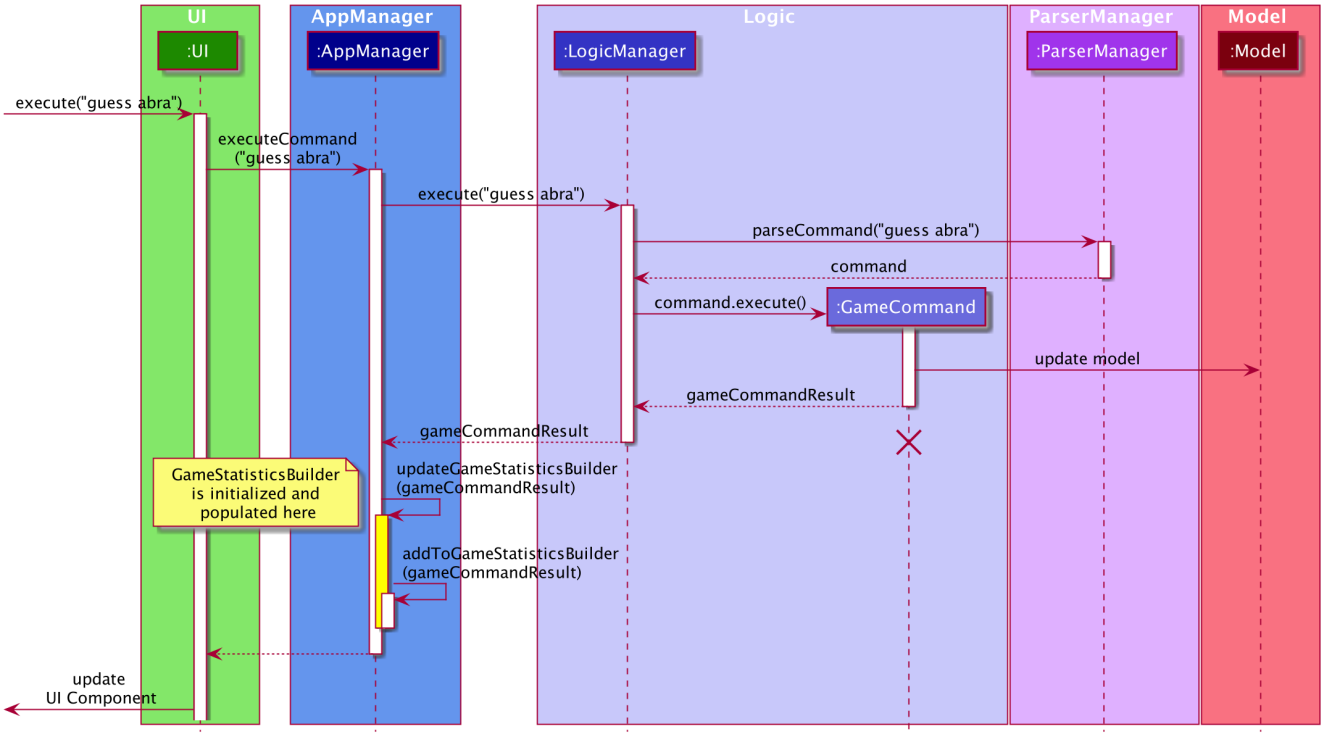


Figure 41. Sequence diagram when user makes a guess.

5. User finishes the game

When the user finishes the game, a `GameStatistics` is created from the `GameStatisticsBuilder`. The `GameStatistics` is shown to the user in the game result page.

The `GameStatistics` is used to update its corresponding `WordBankStatistics`, which is then saved to disk. Additionally, the `GlobalStatistics` is also updated and saved to disk.

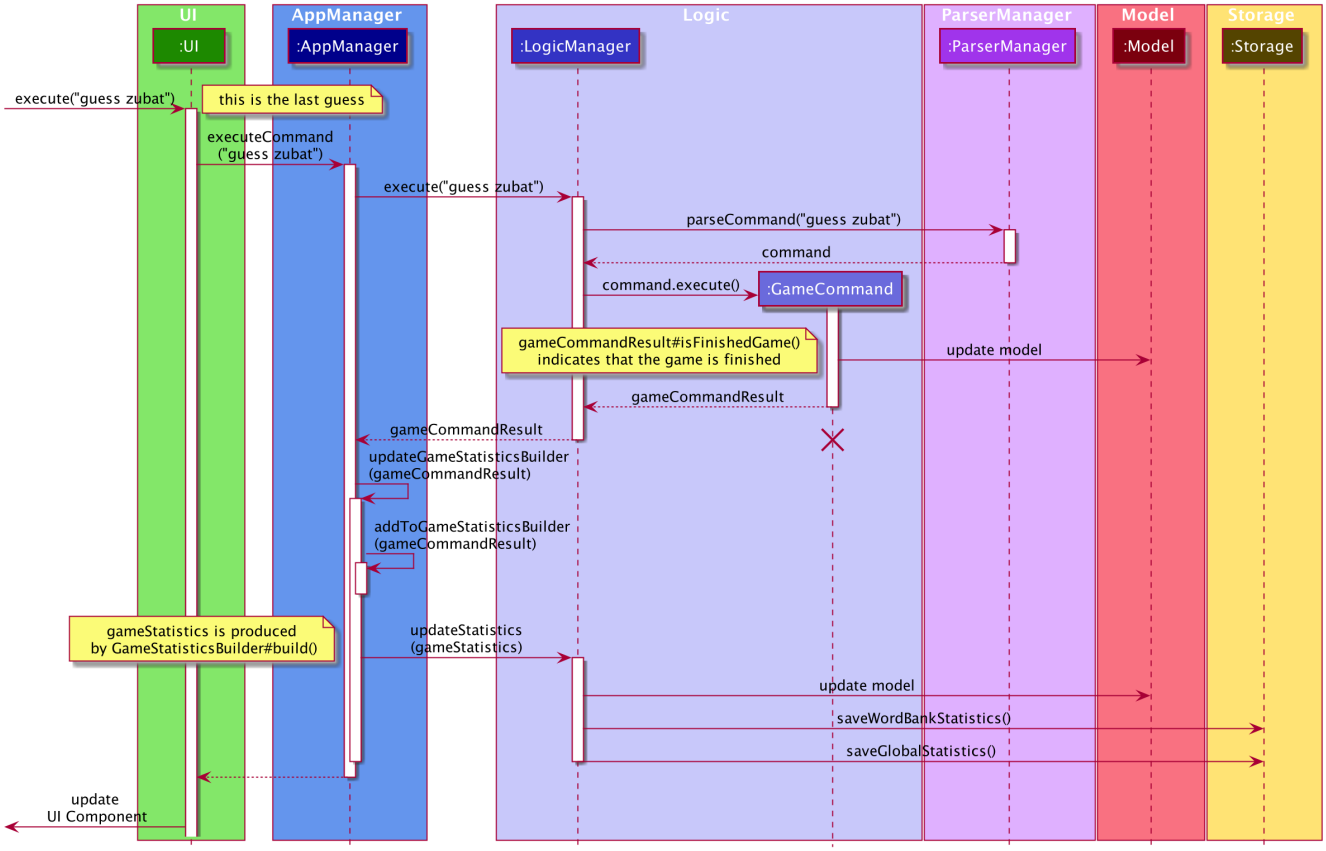


Figure 42. Sequence diagram when the user makes the final guess.

The work done in step 4 and 5 is executed in `AppManager` and the checks to decide what to do are done in the same method `updateGameStatisticsBuilder(CommandResult)`.

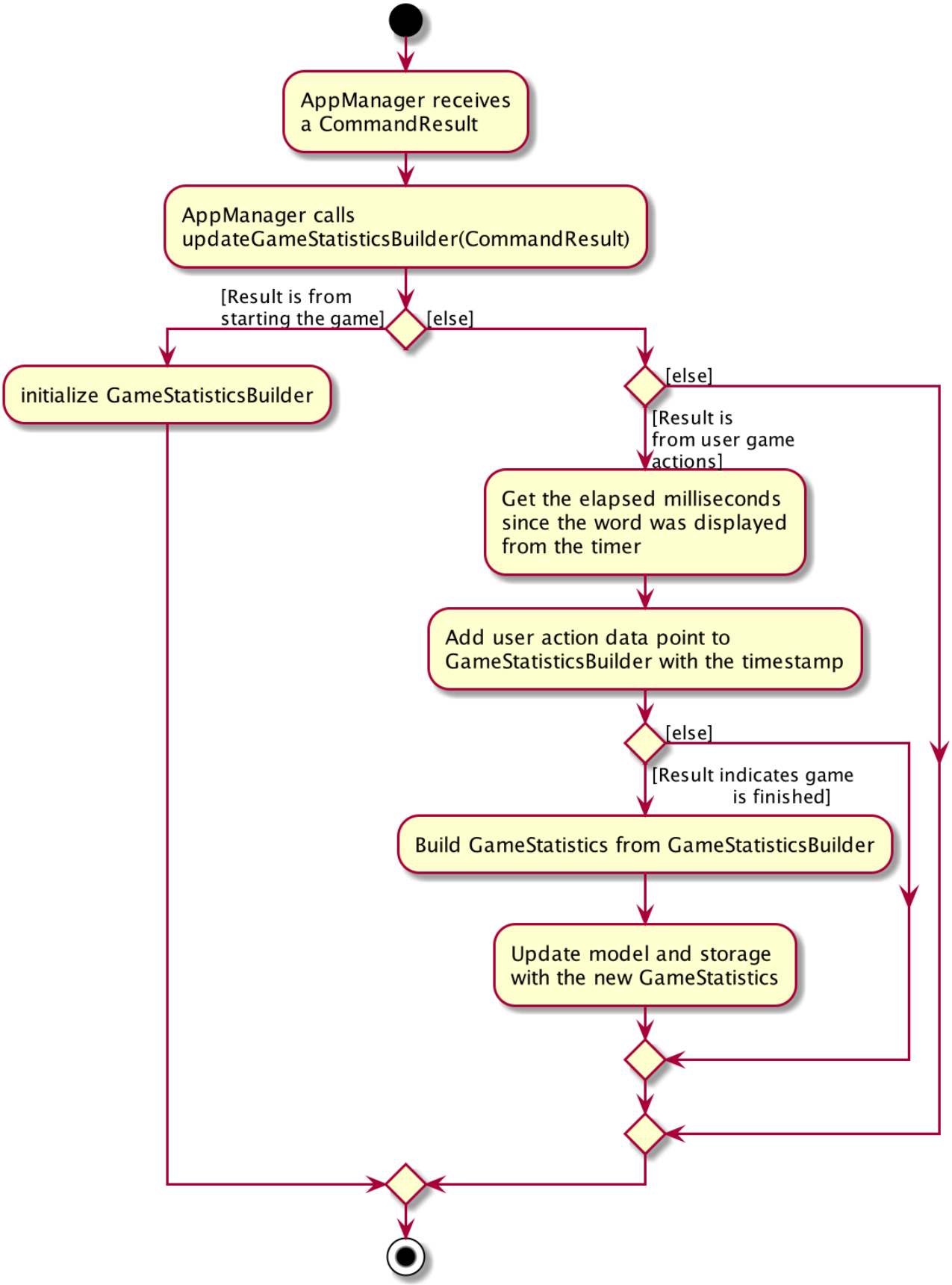


Figure 43. Activity diagram when `AppManager` receives a `CommandResult` (Details unrelated to statistics are omitted).

3.5.2. Design Considerations

There were some design considerations on implementing the statistics.

	Alternative 1	Alternative 2
Aspect 1: How to store `WordBankStatistics` in the storage?	**Store in a separate file from the `WordBank` json file, but with the same name in a different directory.** Example: `WordBank` data is stored at *data/wordbanks/pokemon.json* while the `WordBankStatistics` data is stored at *data/wbstats/pokemon.json* *Pros:* More abstraction to separate the data. *Cons:* The data is linked by name, so if the user changes the file name, the link is broken.	**Store `WordBankStatistics` data in the same file as `WordBank`** *Pros:* Less number of files. *Cons:* Data is combined into one which lowers abstraction.
Why we decided to choose Alternative 1: We decided that abstraction between the data is important as each team member should work in parallel, such that it is easier for one person to modify the storage system for the word bank and another person to modify the storage system for the word bank statistics freely.		

3.6. Logging

We are using `java.util.logging` package for logging. The `LogsCenter` class is used to manage the logging levels and logging destinations.

- The logging level can be controlled using the `logLevel` setting in the configuration file (See Section 3.7, “Configuration”)
- The `Logger` for a class can be obtained using `LogsCenter.getLogger(Class)` which will log messages according to the specified logging level
- Currently log messages are output through: `Console` and to a `.log` file.

Logging Levels

- `SEVERE` : Critical problem detected which may possibly cause the termination of the application
- `WARNING` : Can continue, but with caution
- `INFO` : Information showing the noteworthy actions by the App
- `FINE` : Details that is not usually noteworthy but may be useful in debugging e.g. print the actual list instead of just its size

3.7. Configuration

Certain properties of the application can be controlled (e.g user prefs file location, logging level) through the configuration file (default: `config.json`).

4. Documentation

Refer to the guide here.

5. Testing

Refer to the guide here.

6. Dev Ops

Refer to the guide here.

Appendix A: Product Scope

Target user profile:

- Students in formal educational institutions.
- Students in informal educational contexts.
- Users who are familiar with the keyboard, able to type fast.
- Users who enjoy interactive learning.
- Users who are famiiar and used to CLI-based apps.

Value proposition: Making Learning and Memorization Game-like, Fun and Engaging.

Appendix B: User Stories

Priorities: High (must have) - * * *, Medium (nice to have) - * *, Low (unlikely to have) - *

Priority	As a …	I want to …	So that I can…
* * *	teacher	add, edit, and delete questions in the word banks	make corrections on what my students are supposed to learn

Priority	As a …	I want to …	So that I can…
* * *	teacher	give customised word banks and definitions	can let my students practice specific problems.
* * *	user	list all my word banks	
* * *	user	give titles to word banks	recognise them better
* * *	user	delete word banks	free up some memory when I don’t need it anymore
* * *	user	see the content of the word bank	study beforehand/make changes
* * *	young student	trivia questions to be gamified	enjoy the process
* * *	student	create my own question banks	tailor fit to my learning
* * *	computer science student	have a manual of the commands available	refer to them when I am lost
* *	frequent user	easily access my most recently attempted question sets	can quickly resume my revision
* *	studious student	set and complete goals	have something to work towards
* *	student	see my test statistics	track my progress/improvement

Priority	As a …	I want to …	So that I can…
* *	student	choose different kinds of time constraints	can simulate exam conditions
* *	student	categorise my question sets	easily look for relevant materials
* *	student	mark question sets as important/urgent	know how to prioritise my revision
* *	module coordinator	export lessons	send to their students
* *	student	share and compare my results with my classmates	know where I stand
* *	student	partition the trivia	attempt questions that I'm comfortable with
* *	weak student	have the option to see hints	won't get stuck all the time
* *	computer science student	practise typing bash commands into the CLI	strengthen my bash skills
* *	teacher	export statistics	can compare performance across different students
*	computer science student	customize my "terminal"	changing themes/ background/ font size/ font colour, so that I feel comfortable working on it

Priority	As a …	I want to …	So that I can…
*	teacher	protect tests with passwords	let my students do them in lessons together when password is released
*	teacher	protect the files	doesn't get tampered when distributing to students
*	student	have smaller sized files	have more space on my computer

Appendix C: Use Cases

(For all use cases below, the **System** is the `Dukemon` and the **Actor** is the `User`, unless specified otherwise)

Use case: Delete person

MSS

1. User requests to list persons
2. Dukemon shows a list of persons
3. User requests to delete a specific person in the list
4. Dukemon deletes the person

   Use case ends.

Extensions

2a. The list is empty.

Use case ends.

3a. The given index is invalid.

3a1. Dukemon shows an error message.

Use case resumes at step 2.

{More to be added}

Appendix D: Non Functional Requirements

1. Compatible any mainstream OS as long as it has Java 11 or above installed.
2. User has above average typing speed for regular English text (i.e. not code, not system admin commands); able to accomplish most of the tasks faster using commands than using the mouse.
3. Users can export and import their wordbanks or *Statistics*.
4. Feedback shown to user must be fast (< 0.2s) especially during a *Game*.

{More to be added}

Appendix E: Glossary

Mainstream OS

Windows, Linux, Unix, OS-X, Ubuntu and *etc*.

WordBank

Data structure that contains a list of several *Cards*.

Card

Analogue to a physical Flashcard- contains a *Word* and a *Meaning*.

Word

The component of a *Card* that is to be guessed by the user during a *Game*.

Meaning

The meaning represented by the *Word* of a *Card*; is shown to the user during a *Game*.

Game

A game session that runs on a specific *WordBank* of *Cards*.

Callback

A piece of executable code that is passed as an argument to other another code that is expected to *callback* (execute) the argument at a given time. (Adapted from Wikipedia)

Appendix F: Instructions for Manual Testing

Given below are instructions for the testing of *Dukemon* manually.

NOTE	The below instruction are only intended as starting points for testers to work on; testers are expected to do more *exploratory* testing.

F.1. Initial Start-up and Editing of a *WordBank*

1. Initial clean launch
   a. Download the `Dukemon.jar` file and copy into an **empty folder**
   b. Double-click the `.jar` file
   Expected: GUI appears with some sample *WordBanks*. Default window size may not be optimum.
2. Selecting and viewing a default *WordBank*
   a. Enter `select trivia` to choose the *Trivia WordBank*.
   Expected: GUI shows feedback *"Selected word bank: trivia"* in the *ResultDisplay*.
   b. Enter `open`.
   Expected: GUI switches to *Open* mode, *Cards* belonging to *Trivia* are shown.
3. Adding a new *Card* to a *WordBank*
   a. Enter `add w/Damith m/Lecturer of CS2103T t/Easy`
   Expected: Feedback shown that a new *Card* with the above details are added. List of *Cards* on GUI's right panel reflects the addition of a new *Card*.
   b. Enter `exit` and relaunch *Dukemon*. Enter `select triva` and then `open` upon restarting
   Expected: The new *Card* ("Damith") added previously is correctly stored in the *Triva WordBank*.

F.2. Starting and Force-Stopping a *Game* session without `Hints`.

1. Starting a *Game* after a target *WordBank* has been selected.
   a. Prerequisite: A *WordBank* with **3 or more *Cards*** has been selected using the `select` command.
   b. Enter `settings`
   Expected: GUI switches to *Settings* mode, and various configurable parameters are listed. (ie. *Theme*, *Hints* etc)
   c. Enter `hints off`
   Expected: GUI feedback indicates that *Hints* are turned OFF
   d. Enter `start easy`
   Expected: GUI switches to *Game* mode with two panels stacked on top of each other. A 15s-countdown *Timer* is started at the top right of the GUI. A random `Meaning` of a `Card` belonging to the selected *WordBank* is shown on the upper panel. The bottom panel indicated that there are no `Hints`. When time is running out, the *Timer* region changes color.
   e. Enter `stop` (**before all `Cards` are shown**)
   Expected: *Game* stops, feedback informs that "Game has been forcibly stopped". *Timer* stops running and disappears.
   f. Enter `guess abc` to attempt to make a `Guess` after *Game* ends.
   Expected: No `guess` is processed, feedback indicates that "This command does not work right

now"

g. Enter `skip` to attempt to skip over to another *Card*.
Expected: No skipping over occurs, feedback indicates that "This command does not work right now"

> **NOTE** Other possible Difficulties to start with are `start medium` and `start hard`, allowing 10s and 5s respectively for each *Card*. Other invalid commands will yield similar results after stopping the *Game*.

F.3. Importing and Exporting a *WordBank* using Drag-and-Drop.

1. Starting a *Game* after a target *WordBank* has been selected.
   a. Prerequisite: A *WordBank* with **3 or more *Cards*** has been selected using the `select` command.
   b. Enter `settings` Expected: GUI switches to *Settings* mode, and various configurable parameters are listed. (ie. *Theme*, *Hints* etc)
   c. Enter `hints off`
   Expected: GUI feedback indicates that *Hints* are turned OFF
   d. Other incorrect delete commands to try: `delete`, `delete x` (where x is larger than the list size) *{give more}*
   Expected: Similar to previous.

{ more test cases … }

F.4. Saving data

1. Dealing with **missing/corrupted** data and configuration files
   a. *{explain how to simulate a missing/corrupted file and the expected behavior}*

{ more test cases … }