SWEN30006 Assignment2: Report

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This report looks at a design analysis of a refactor and extension of the game "PacMan in the MultiVerse" into a new game "PacMan in the TorusVerse" as the second assignment of the subject SWEN30006, 2023. To reflect on the learning outcomes of the subject, both Gang of Four (GoF) and General Responsibility Assignment Software Patterns (GRASP) have been put into consideration during the refactoring process.

First, we identify the structure of the initial codebase, then we discuss the new design decisions made for the refactor and the reasons they were made. The following diagrams have been provided to better visualize the changes made:

- A domain class diagram for capturing the covering the domain concepts relating to the autoplayer and game levels/maps for PacMan in the TorusVerse
- A static design model (i.e., a design class diagram) for documenting your design relating to the autoplayer and game levels/maps for PacMan in the TorusVerse.
- Additional static and/or dynamic design models to support P1 and P2 above as you judge useful and appropriate

Initial codebase structure

The initial codebase contains the source directories for two separate programs:

1. The source code of the simple version of "PacMan in the MultiVerse"
2. The source code of a GUI to be used as a map maker

The integration of the graphical user interface (GUI) into the PacMan game, along with the implementation of the new functionality in the TorusVerse version, requires

careful consideration. Merely porting the GUI into the original game's potentially inadequately designed codebase has the potential to result in a suboptimal overall design. Thus, to make the best results, first we will analyze the simple version of the game and check what changes can be made.

Simple version of the game

The problem

Initially, all the game logic, handling of individual variables, and a few classes are in the `Game` class. Keeping it all in one place strongly goes against the following GRASP principles:

1. Low Coupling - since every individual object interaction happens in the `Game` class, any changes made to other classes would cause a massive impact to the entire program, thus making it harder to maintain
2. High Cohesion - The `Game` class does more than one well-defined job, thus leaving its purpose to be very unfocused around separate responsibilities. This makes it difficult to change and maintain the code; since responsibilities are closely knit together, extending the game into the TorusVerse version could be a potential disaster, potentially making it inevitable to write the code from scratch.
3. Creator - The object initialization for all individual monsters and PacMan happens in the `Game` class. This makes it difficult to implement new monsters and maintain old ones while ensuring that the new logic is followed everywhere within the source code.

What changes can be made?

A table of considerations are made for all classes. For each consideration, the resulting design pattern chosen is proposed:

Consideration to make	**Pattern**
Does any Class in the codebase need refactoring and simplification?	`Facade`
Does any Class get an "evolution"; a new version of itself with potentially advanced features?	`Decorator`
Does any Class have an increasingly high number of parameters, notably during initialization?	`Builder`
Should any Class adapt compatibility with any interface?	`Adapter`

Does any Class contain only a single shared instance	`Singleton`
Does the class contain subclasses where its instantiation logic is irrelevant to where it's being used?	`Factory`

Note: While no class really needs any patterns to be functional, the word "need" refers to any decision which leads to more meaningful semantics for the program.

The changes made

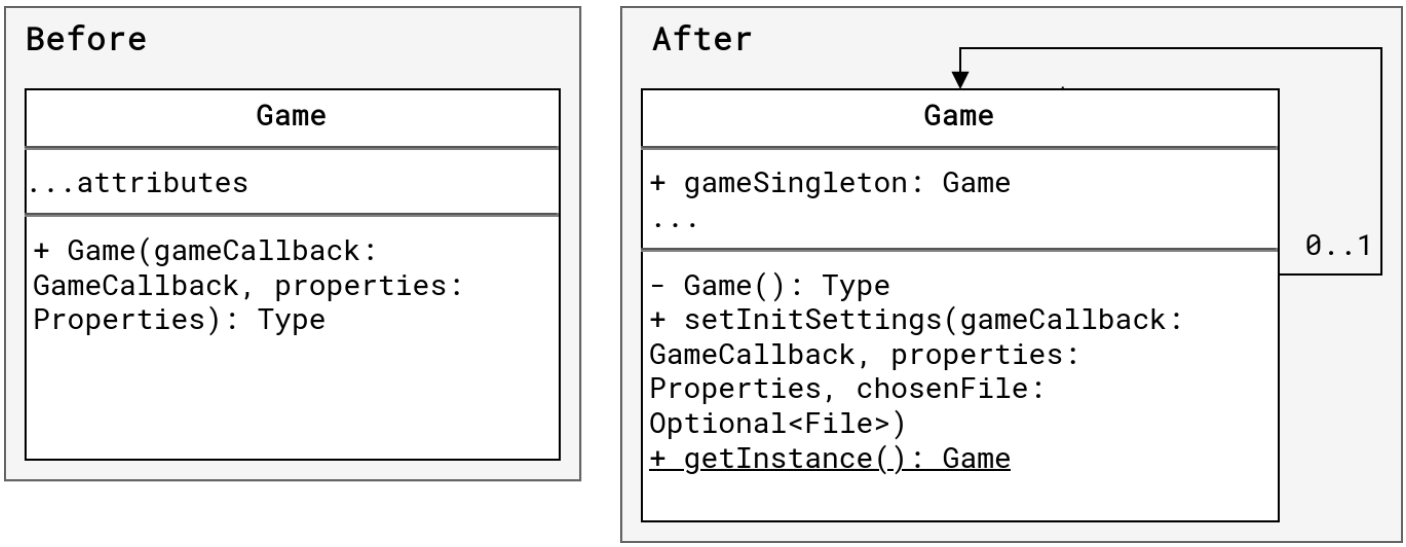
After going through each class, the following design decisions have been made:

Class	Pattern	Reason
`Game`	Facade	Provides a higher-level interface for the interaction of monsters, simplifying the logic in the `Game` class
`Game`	Facade	Provides a higher-level interface for the interaction of Pills, simplifying the logic in the `Game` class
`Game`	Singleton	Used to enforce that only one game is ever created during runtime
`Monster`	Factory	Hide the implementation logic of each monster to let external code focus on the usage of the `Monster` rather than its initialization
`Monster`	Adapter	Allow polymorphic behavior between itself and `PacActor`
`PacActor`	Adapter	Allow polymorphic behavior between itself and `Monster`

The singleton pattern on the `Game` class

Applying this pattern to the Game class has the added advantage of reducing dependencies between object parameters and minimizing tight coupling in the code base. This ensures that other objects that depend on `Game` can now access a global single instance which eliminates the need to pass around the single `Game` instance explicitly. Now, any object that needs access to `Game` can just reference it using `Game.getInstance()`.

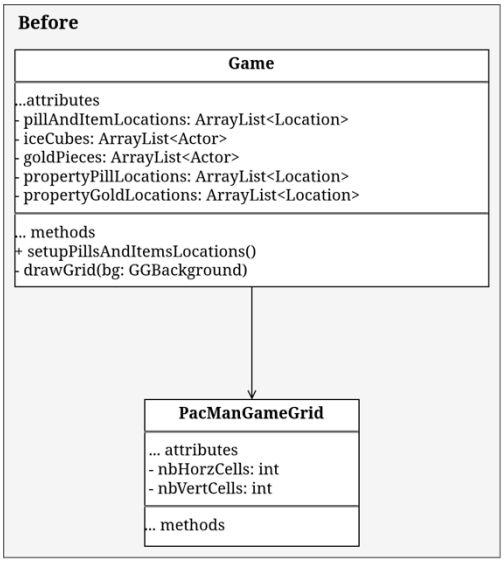
Since the same `Game` object can be referred to from anywhere, other objects relying on it will no longer need to store a reference to it. Due to this, adding new descendant classes (like new Monsters set by a new specification) will not require any kind of change in other classes. This makes the design more extensible and flexible which allows for easier extension of the TorusVerse.

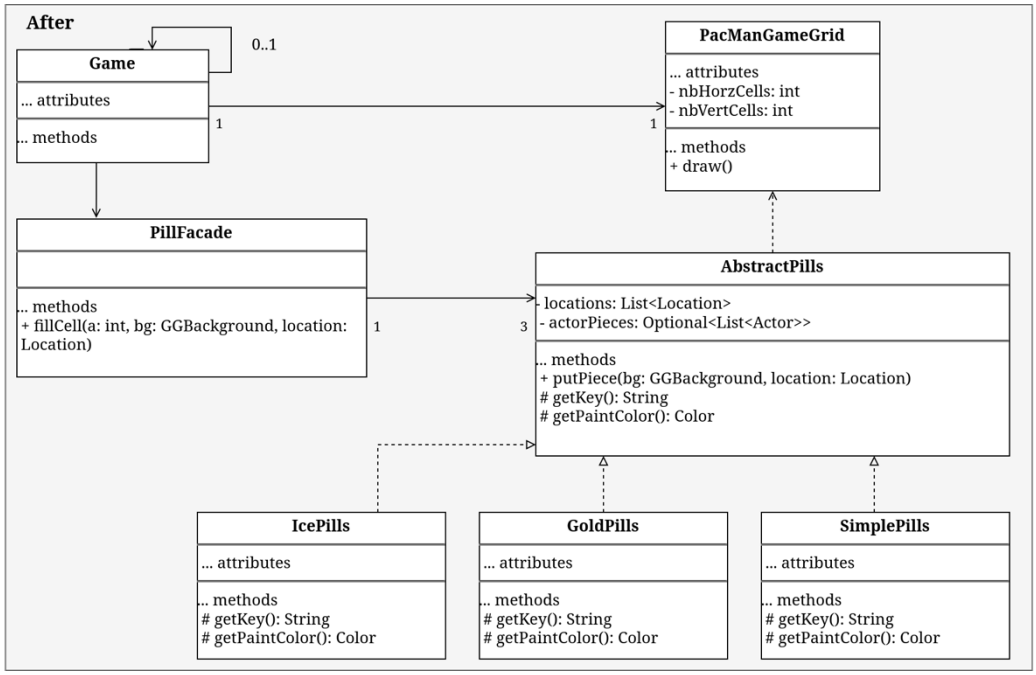


The `PacManGameGrid` class and the Facade pattern on the `Game` class for Pills

During the implementation process of the Facade pattern on the Game class to encapsulate pill-related items, it became apparent that separating grid parsing functionality from it would be beneficial. This decision aligns with the High-cohesion principle of GRASP, as it brings the Game class closer to fulfilling this principle. By extracting the grid parsing functionality, the Game class becomes more focused on its core responsibilities, enhancing its cohesion and overall design. The progressive application of these design principles fosters improved modularity and maintainability within the system.

It was decided to extract grid parsing to the `PacManGameGrid` class as it makes more sense to parse grid-related items in said class. This is important especially for this specification, as the new functionality is strongly dependant on how the grid is parsed. Since the logic for grid-parsing now only happens in `PacManGameGrid`, this would be the only class that would eventually need to be changed when porting the 2D Map Editor. This saves us (the developers) from potentially introducing bugs in other parts of the codebase while also contributing to it by adding the newly requested features.

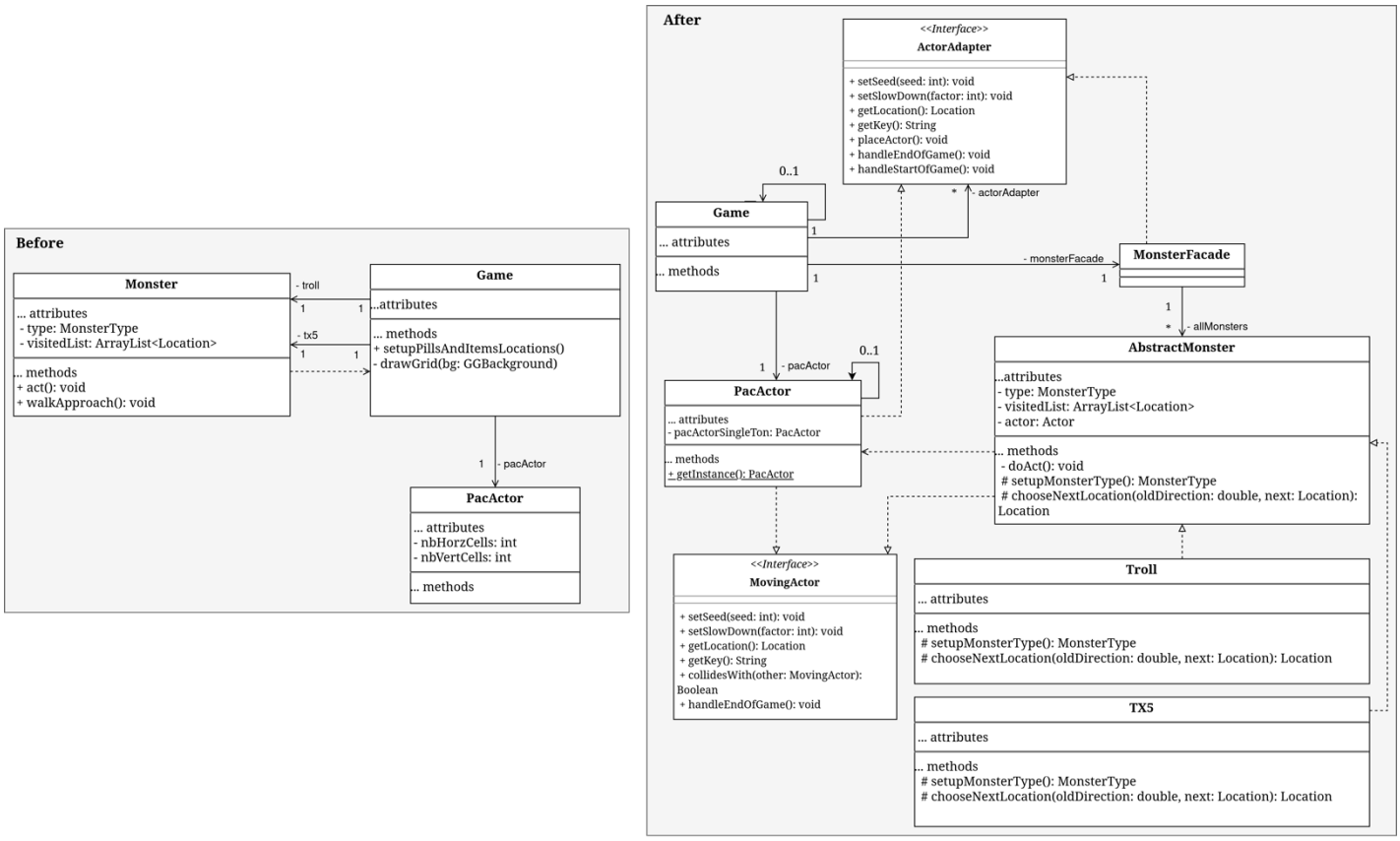




The singleton pattern on the `PacActor` class and the Facade pattern on the `Game` class for Monsters

The singleton pattern implemented in the `PacActor` class assisted in the proccess of implementing the Facade pattern for the `Monster` class. The code resulted in less calls to `getInstance` from the Game class, as `PacActor`'s single instance was now available without coupling the Game state in.

This contributes to better cohesion, thus making the code more-closely follow with a GRASP principle. If Arcade 24 (TM) ever wants to make new Monsters, they would only need to worry about the `MonsterFacade` class and its set of attributes rather than the whole game. With that same idea, since the implementation details of the Torus effect is in the current specification, implementing it would no longer require the developers to worry about the implementation of Monsters or other unrelated aspects of the Game.



In summary, the result of refactoring with patterns is the following:

1. New monsters can be made without having to worry about any unrelated aspects of the Game logic
2. New Pills can be made without having to worry about any unrelated aspects of the Game logic
3. Now only the `PacManGameGrid` class is responsible for all aspects related to the creation of the Game Grid

The most notable advantage for this assignment is the third point (although the other two are equally important for extensibility). Using this lowly-coupled class, we can now migrate the 2D Map Editor into the `/pacman` source code.

Integrating the 2D Map Editor

The 2D Map Editor comes mostly pre-implemented. It only now needs to be integrated into the `/pacman` source code**.** Due to the initial refactoring, the custom PacManGameGrid instance became the focus of the editor for map creation, rendering it as the only class necessitating substantial modifications.
In general, the overall set of changes include:

- Ensuring the existence of a `/pacman/Game` directory
- transferring the sprites from `2D-Map-Editor-master/data` to a new directory `/pacman/torusData`
- Changing how the `String[] args` parameter in the `main` method of `/pacman/src/Driver` parsed the commandline arguments to follow the new specification.
- Changing how the Game would handle the file/directory provided in the commandline arguments. This included safe-checks to go back to the original (refactored) version of the game.
- Changing how `PacManGameGrid` would convert the XML files to match with the game implementation.

When an XML file is loaded into the program using the 2D Map Editor's `Controller.loadFile` method and the `GridModel` class, the map is originally stored as a 2D array containing characters, whereas the original version stored the map as a 2D array of integers.
To resolve the disparity of using different datatypes for parsing the same map, the `PacManGameGrid` class accomplished two extra goals (both related to Map parsing, thus maintaining high cohesion):

1. Since the rest of the program was implemented to understand the 2D integer-array, the 2D-character-array was converted into a 2D integer-array.
2. It parsed the properties of the grid to now prefer the properties of the XML Grid over the `.properties` file. This was one of our tasks from the specification.

The first point could be easily done in the `PacManGameGrid` class, as it only was concerning the initialization of the grid.

The second point would have been difficult to implement if not for the newly refactored version of the code. With the new version, instead of changing every individual object and variable to reflect the new XML file, only the `MovingActor.initializeLocation()` method would need changing, thus affecting every single relevant class without needing to change them individually. With the availability of a Game singleton, no other part of the codebase required restructuring and could be seamlessly called to access the new data in the `PacManGameGrid` class.

This is a great example of the perks that come with mixing the Singleton and Adapter patterns with the polymorphism and high cohesion GRASP principles, proving the improvement in maintainability and scalability of the new codebase whilst also reducing the chances of human error.

Conclusion

The use of GoF design patterns and GRASP principles significantly improved the extensibility of the "PacMan in the MultiVerse" game during its refactoring and extension into the new "PacMan in the TorusVerse" game. The initial codebase's limitations and issues were identified, and appropriate design decisions were made to solve these concerns and improve the overall design.

In the initial codebase, it has low coupling and high cohesion problems. All the game logic and individual variables were handled within the Game class, which made it challenging to maintain and extend the codebase, when introducing new TorusVerse-specific features and entities. To tackle these issues, various design patterns and principles were used.

For the Game class, the Singleton method was used so that only one instance of the game is produced during runtime. This decreased object dependencies and coupling, resulting in a more modular, flexible, and adaptable codebase. Other classes could now access to use the single instance of the Game without using explicit references, making the extension process easier.

For both Pills and Monsters, the Facade design was used to the Game class, providing higher-level interfaces for interaction, and abstracting away complexity. This improved the Game class's coherence by dividing separate responsibilities into independent classes. It also made it easier to add new Pills and Monsters because the code for their initialisation and behaviour was encapsulated within the corresponding Facade classes.

For the Monster class, the Factory pattern was used to hide the implementation details of each monster and allow external code to focus on utilising the Monster instances rather than worrying about their initialisation. This makes it easy to create new monsters and maintain current ones while ensuring adherence to the specified logic throughout the codebase.

The Adapter pattern was used to allow polymorphic behaviour between the Monster and PacActor classes, allowing them to interact and be compatible. This seamless integration of various types of monsters and actors increased the game's flexibility and adaptability.

The refactor and extension process involving integrating the 2D Map Editor into the codebase, which required changes in directory structure, file handling, and parsing methods. The new refactored design, with the PacManGameGrid class responsible for grid parsing and customization, facilitated the integration process. The high cohesion and modular design of the PacManGameGrid class allowed for seamless conversion of map data from the XML format used by the 2D Map Editor to the existing integer-

based grid representation. This reduced the effort required to adapt the codebase to the new map format and extended functionality.

To summarise, the use of GoF design patterns and adherence to GRASP principles greatly enhanced the codebase during the refactoring and extension of PacMan in the MultiVerse into the TorusVerse. The design became more modular, adaptable, and maintainable, making extension and modification easier. The use of design patterns and principles was critical in increasing the game's general flexibility, making it easier to add new features, entities, and functionality while maintaining a high code quality.