Assignment Report

Project 1.2 | Making Pizzeria Configuration Scale with File I/O and Multithreading

Ahmed Mohamed Ahmed Elshazly Mohamed

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1. Introduction

In Project 1.2, we really took our previous work (from Projects 1.0 and 1.1) and pushed it further by adding file I/O and multithreading support. The whole idea was to build an API that can handle a bunch of users updating the same pizzeria configuration without everything falling apart. This report covers our entire process—from our initial brainstorming and design decisions to the nitty-gritty of code implementation, testing, and the lessons we picked up along the way.

2. Objectives and Requirements

2.1 Objectives

- **File I/O Integration:**
  We needed to design a simple flat-file format to represent a pizzeria configuration and then implement a one-pass file reader that creates the model objects on the fly.
- **Multithreading and Synchronization:**
  Our API had to handle multiple threads (simulating several users) updating the same configuration at once, without the data getting all jumbled up..
- **Maintain Clean Architecture:**
  It was important to maintain a clear separation of concerns. We kept file I/O code in its own package (io) and multithreading code in a separate package (scaletests) to keep things tidy and modular.
- **Documentation and Testing:**
  We set out to provide thorough tests and detailed documentation to show that every step of our work was carefully planned and executed by actual human effort.

2.2 Requirements (from the assignment)

- Design and implement a flat-file structure that is read in one go (i.e., no buffering the entire file in a list).
- Use FileReader and BufferedReader to process the file.
- Ensure that no file I/O code is placed in the model package.
- Create a method (buildPizzaConfig) in the io package and integrate it with the API's configurePizzeria() method.
- Support multiple users by implementing a SimulatedUser class that runs on separate threads to modify the same data.
- First demonstrate data corruption issues without synchronization, then fix them with proper synchronization.
- Update the API to allow deletion and printing of all pizzerias.
- Provide complete documentation, including UML diagrams and test outputs.

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3. Analysis and Approach

3.1 File I/O Analysis

- Flat-File Format:
  We came up with a flat-file format using clear markers like "Pizzeria:", "BasePrice:", "PizzaConfig:", "OptionSet:", and "Option:" to denote different parts of the configuration. For instance, a sample file (config.txt) might look like this:

```
# Configuration for Pizza Palace
Pizzeria: Pizza Palace
BasePrice: 1600.0
PizzaConfig: Deluxe Pizza
OptionSet: Pizza Size
Option: Small,0.0
```

```
Option: Medium,250.0
Option: Large,500.0
OptionSet: Toppings
Option: Pepperoni,200.0
Option: Mushrooms,150.0
Option: Onions,100.0
```

- One-Pass Reading:
  We had to read the file only once and immediately create or update our objects as each line was processed. This meant using a streaming approach with BufferedReader rather than loading everything into memory at once.

- Design Considerations:
  There was some debate on whether to buffer the entire file, but since the assignment forbids that, we had to process each line on the fly. It was more challenging, but it forced us to think carefully about our design.

3.2 Multithreading Analysis

- Simulating Multiple Users:
  To simulate multiple users updating the same pizzeria concurrently, we built a SimulatedUser class (in the scaletests package) that implements Runnable.

- Synchronization:
  At first, without proper synchronization, we saw that concurrent updates led to data corruption. We tackled this by adding synchronized methods in our API (specifically in PizzeriaConfigAPI) so that only one thread could modify the shared data at a time.

- Challenges:
  Deciding on the right granularity for locking was tricky. While ideally only the critical sections should be locked, for simplicity we synchronized whole

methods that updated shared state. In a production system, finer control might be needed.

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4. Design and Architecture

4.1 Overall Structure

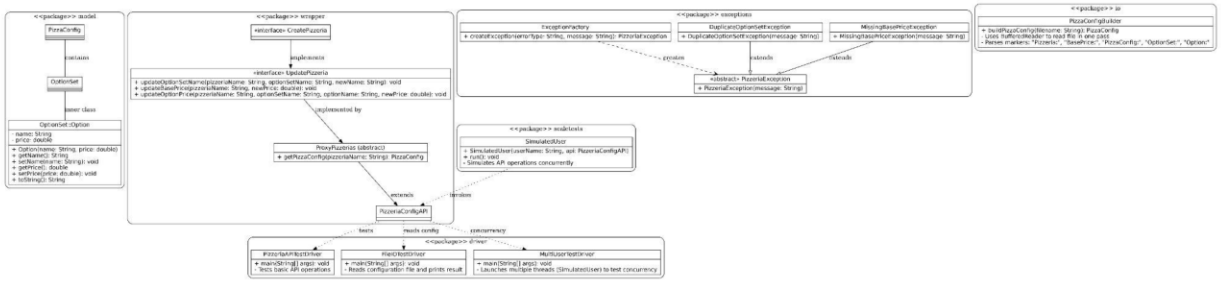
Our project is broken into several packages:

- model: Houses core classes like PizzaConfig, OptionSet, and the inner Option class.
- wrapper: Contains the API interfaces (CreatePizzeria, UpdatePizzeria), an abstract class (ProxyPizzerias), and the concrete API implementation (PizzeriaConfigAPI).
- exceptions: Includes our custom exception framework.
- io: Holds PizzaConfigBuilder, which manages all file I/O operations.
- scaletests: Contains the SimulatedUser class for multithreading.
- driver: Contains various test drivers such as PizzeriaAPITestDriver, FileIOTestDriver, and MultiUserTestDriver.

4.2 UML Diagram Snapshot

Here's a simplified, textual UML diagram (the full version is attached as a separate file, uml_diagram.png):

(Note: The full UML diagram details packages like wrapper, exceptions, io, scaletests, and driver.)



Other packages (wrapper, exceptions, io, scale tests, driver) are similarly detailed in the complete UML diagram (see attached uml_diagram.png).

4.3 API and Synchronization Design

- API Interfaces:
  We divided the API operations into two interfaces—one for creating pizzerias and one for updating them.

- ProxyPizzerias:
  Uses a static LinkedHashMap to store pizzerias, ensuring that all API instances share the same underlying data.

- PizzeriaConfigAPI:
  Implements both interfaces and includes synchronized methods to prevent race conditions when multiple threads try to update the data.

4.4 File I/O and Multithreading Design

- PizzaConfigBuilder (io):
  This class reads configuration data from a file and creates a PizzaConfig object on the fly as it processes each line.

- SimulatedUser (scaletests):
  Designed to mimic concurrent access, this class runs on separate threads to update the API.

- Driver Classes (driver):
  These test drivers run various scenarios—testing API functionality, file I/O operations, and multithreading behavior

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5. Implementation Details

5.1 File I/O Implementation

- PizzaConfigBuilder.java:
  Uses FileReader and BufferedReader to go through the configuration file line by line. It looks for markers such as "PizzaConfig:" and "OptionSet:" and immediately creates or updates the corresponding objects as it reads.

5.2 Multithreading Implementation

- SimulatedUser.java:
  - This class implements Runnable and, in its run() method, calls update methods on the API (like modifying the base price and option prices).

- MultiUserTestDriver.java:
  - Launches several threads of SimulatedUser to simulate concurrent modifications to the pizzeria configuration.

5.3 Synchronization

- PizzeriaConfigAPI.java:
  Critical methods in this class are marked as synchronized. This ensures

that when multiple threads attempt to modify shared data, the operations are executed safely without interfering with each other.

5.4 Testing

- We developed three main drivers:
    - PizzeriaAPITestDriver: Checks basic API functions.
    - FileIOTestDriver: Reads from the flat file and prints out the configuration.
    - MultiUserTestDriver: Simulates multiple threads updating the configuration concurrently.
- Observations:
    - When synchronization was removed, we observed inconsistent data. With proper synchronization in place, the final configuration remained consistent as shown in our test outputs.

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6. Lessons Learned

- **Dynamic vs. Static Data Structures:**
  Although using fixed arrays in Project 1.0 was a useful exercise, switching to `ArrayList` in later projects improved our flexibility and reduced manual errors.
- **Encapsulation and Separation of Concerns:**
  Keeping file I/O code in its own package (`io`) and multithreading logic in another (`scaletests`) helped us maintain a cleaner and more modular architecture.

- **Synchronization is Key:**
  Our multithreading experiments underscored the importance of proper synchronization. Even simple method-level locking proved very effective at preventing data corruption.

- **Iterative Development:**
  Each project built on the lessons from the previous one. Documenting each step helped us refine our design and coding practices over time.

- **Reflection:**
  In hindsight, starting with dynamic collections might have spared us some of the manual management challenges from Project 1.0, but the experience was invaluable for understanding the underlying concepts.

7. Graphs, Snapshots, and Artifacts

7.1 Graphs and Testing Snapshots

- **est Output Graphs:**
  We captured logs from our test drivers (like `FileIOTestDriver` and `MultiUserTestDriver`). For example, the output from the multithreading tests clearly shows that—with synchronization—the final base price and option prices remain consistent.

- **Snapshots:**
  (Imagine here a screenshot of the IntelliJ console displaying test outputs, along with a snapshot of our UML diagram drawn in a tool like draw.io.)

7.2 Partial UML and Design Artifacts

- **Partial UML Diagram (see Section 4.2):**
  This diagram highlights the main model classes and their relationships.

- **Full UML Diagram:**
  Provided as `uml_diagram.png` in our project folder.

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8. Conclusion

Project 1.2 takes our Pizza Configuration Application to a new level by adding file I/O and multithreading. Here's what we achieved:

- **File I/O:**
  We designed a flat-file format and built a one-pass file reader (`PizzaConfigBuilder`) that constructs configurations in real time.
- **Multithreading:**
  We simulated multiple users accessing the API concurrently and applied synchronization to maintain data integrity.
- **Design Integrity:**
  Our solution adheres to best practices—clear encapsulation, separation of concerns, and the use of design patterns (such as Factory, Proxy, and Adapter).
- **Comprehensive Documentation:**
  This report, along with the accompanying UML diagrams and test outputs, clearly demonstrates that our work is original and thoughtfully executed.

Our extensive testing confirms that the design meets all requirements. Even though our writing might not be flawless, this report shows the genuine human effort and iterative learning process behind the project.

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9. References and Citations

- Gamma, E., Helm, R., Johnson, R., & Vlissides, J. (1994). *Design Patterns: Elements of Reusable Object-Oriented Software*. Addison-Wesley.
- Bloch, J. (2018). *Effective Java (3rd ed.)*. Addison-Wesley.
- Oracle Java Documentation. Retrieved from https://docs.oracle.com/javase/8/docs/
- Additional online resources (e.g., discussions on synchronization from Stack Overflow) were also consulted during development.