Simple Store Simulator - Project Documentation

Course: Programming Languages - 3
Project Idea: Simple Store Simulator
Development Period: Fall 2025

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1. Executive Summary

The **Simple Store Simulator** is a comprehensive e-commerce simulation system developed using F# functional programming principles. The project demonstrates advanced software engineering concepts including modular design, functional composition, database integration, GUI development, and comprehensive testing.

Key Highlights:

- **Language:** F# (.NET 6.0)
- **Architecture:** Multi-tier layered architecture
- **Interfaces:** Console CLI + Avalonia GUI
- **Database:** SQLite with 33+ products
- **Testing:** 30 automated unit tests (100% pass rate)
- **Code Quality:** Functional programming best practices

2. Project Overview

2.1 Purpose

To create a functional e-commerce store simulator that allows users to browse products, manage shopping carts, calculate prices with taxes and shipping, apply discounts, and process orders with complete data persistence.

2.2 Scope

The system encompasses:

- Product catalog management with database integration
- Shopping cart operations (add, remove, update quantities)
- Advanced search and filtering capabilities
- Price calculation engine (subtotal, tax, shipping, discounts)
- Discount engine with multiple discount types
- Order processing and persistence
- Data export capabilities (JSON, CSV, Text)
- Dual interface support (Console + GUI)

2.3 Objectives

1. Demonstrate functional programming paradigms in F#
2. Implement clean, modular, and maintainable code architecture
3. Integrate database operations with SQLite
4. Provide comprehensive testing coverage
5. Create user-friendly interfaces for different use cases
6. Ensure data persistence and export capabilities

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3. System Requirements

3.1 Software Requirements

- **.NET SDK:** 6.0 or higher
- **Operating System:** Windows, macOS, or Linux
- **Database:** SQLite (included)
- **IDE:** Visual Studio Code, Visual Studio, or JetBrains Rider

3.2 Dependencies

- FSharp.Core (6.0.7)
- Microsoft.Data.Sqlite (6.0.0)
- Avalonia (11.0.0) - for GUI
- Expecto (10.2.1) - for testing
- System.Text.Json - for serialization

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4. Functional Requirements

4.1 Product Management

- **FR-1.1:** System shall load products from SQLite database
- **FR-1.2:** System shall display product details (ID, Name, Price, Description, Category, Stock)
- **FR-1.3:** System shall support product categorization (Snacks, Dairy, Beverages, Sweets, Fruits, Vegetables)
- **FR-1.4:** System shall track and update product stock levels
- **FR-1.5:** System shall format prices in EGP currency

4.2 Shopping Cart Operations

- **FR-2.1:** Users shall add products to cart with specified quantities
- **FR-2.2:** System shall validate stock availability before adding items
- **FR-2.3:** Users shall remove items or update quantities in cart
- **FR-2.4:** System shall accumulate quantities when same product is added multiple times
- **FR-2.5:** Users shall clear entire cart at once
- **FR-2.6:** System shall prevent adding zero or negative quantities

4.3 Search and Filtering

- **FR-3.1:** Users shall search products by name (case-insensitive)
- **FR-3.2:** Users shall search products by description
- **FR-3.3:** Users shall filter products by category
- **FR-3.4:** Users shall filter products by price range
- **FR-3.5:** Users shall filter products by stock availability
- **FR-3.6:** Users shall sort products by name or price (ascending/descending)
- **FR-3.7:** System shall support combined search criteria

4.4 Price Calculation

- **FR-4.1:** System shall calculate item subtotals (price × quantity)
- **FR-4.2:** System shall calculate cart subtotal (sum of all items)
- **FR-4.3:** System shall apply 14% tax rate on subtotal
- **FR-4.4:** System shall calculate shipping fees based on item count:
    - 1-5 items: 10 EGP
    - 6-10 items: 20 EGP
    - 11+ items: 30 EGP
- **FR-4.5:** System shall calculate final total (subtotal + tax + shipping - discount)

4.5 Discount Engine

- **FR-5.1:** System shall support percentage-based discounts
- **FR-5.2:** System shall support fixed amount discounts
- **FR-5.3:** System shall support "Buy X Get Y" promotional discounts
- **FR-5.4:** System shall validate discount rules (minimum purchase, quantity requirements)
- **FR-5.5:** System shall apply discounts to eligible products or categories
- **FR-5.6:** System shall provide discount breakdown in order summary

4.6 Order Processing

- **FR-6.1:** System shall generate unique Order IDs using GUID
- **FR-6.2:** System shall create orders with timestamp
- **FR-6.3:** System shall update product stock upon successful checkout
- **FR-6.4:** System shall prevent checkout of empty carts
- **FR-6.5:** System shall validate sufficient stock before checkout

4.7 Data Persistence

- **FR-7.1:** System shall save orders as JSON files
- **FR-7.2:** System shall generate human-readable order summaries (TXT)
- **FR-7.3:** System shall export product catalogs to CSV
- **FR-7.4:** System shall export cart contents to text files
- **FR-7.5:** All files shall include timestamps in filenames

5. System Architecture

5.1 Architecture Overview

The system follows a **4-tier layered architecture**:

Layer 1: Presentation Layer

- Console Interface (CLI)
- Avalonia GUI Application (MVVM pattern)
- User input validation
- Output formatting and display

Layer 2: Business Logic Layer

- **Cart Operations Module:** Add, remove, checkout, clear cart
- **Search Operations Module:** Search, filter, sort products
- **Price Calculator Module:** Subtotal, tax, shipping calculations
- **Discount Engine Module:** Apply and validate discounts
- **Product Module:** Product management and catalog operations

Layer 3: Data Access Layer

- **Product Database Module:** SQLite database operations
- **File Operations Module:** Save, export, read operations
- **JSON Serializer Module:** Object serialization/deserialization

Layer 4: Storage Layer

- SQLite database (`data/products.db`)
- JSON order files (`data/orders/*.json`)
- Text summaries (`data/orders/*.txt`)
- CSV exports (`data/exports/*.csv`)

5.2 Module Organization

```
src/
├── Product/
│   ├── Product.fs              (Product types and operations)
│   └── ProductDatabase.fs      (Database initialization)
├── Cart/
│   ├── CartTypes.fs            (Cart and Order types)
│   ├── CartConfig.fs           (Configuration settings)
│   └── CartOperations.fs       (Cart business logic)
├── Search/
│   ├── SearchTypes.fs          (Search criteria types)
│   └── SearchOperations.fs     (Search and filter logic)
├── Calculator/
│   ├── PriceCalculator.fs      (Price calculations)
│   └── DiscountEngine.fs       (Discount rules and application)
├── FileIO/
│   ├── FileOperations.fs       (File I/O operations)
│   └── JsonSerializer.fs       (JSON serialization)
└── Program.fs                  (Main entry point)
```

5.3 Design Patterns Used

- **Functional Core, Imperative Shell:** Pure functions for business logic
- **Type-Driven Design:** Strong typing with F# discriminated unions
- **MVVM Pattern:** For GUI implementation
- **Repository Pattern:** For database access
- **Strategy Pattern:** For discount types

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6. Technical Implementation

6.1 Core Technologies

- **F# 6.0:** Primary programming language
- **Functional Programming:** Immutable data structures, pure functions, pattern matching
- **SQLite:** Embedded relational database
- **Avalonia UI:** Cross-platform GUI framework
- **Expecto:** Testing framework

6.2 Key Programming Concepts Demonstrated

Immutability

All data structures are immutable. Cart operations return new cart instances rather than modifying existing ones.

Pattern Matching

Extensive use of pattern matching for type safety and control flow:

```
match result with
| Ok cart -> // Handle success
| Error msg -> // Handle error
```

Discriminated Unions

Type-safe representations of business concepts:

```
type DiscountType =
    | Percentage of decimal
    | FixedAmount of decimal
    | BuyXGetY of int * int
```

Function Composition

Building complex operations from simple functions:

```
let calculateTotal = calculateSubtotal >> applyTax >> addShipping
```

Type Safety

Result types for error handling without exceptions:

```
Result<'T, string>
```

6.3 Data Models

Product Type

```
- Id: int
- Name: string
- Price: decimal
- Description: string
- Category: string
- Stock: int
```

Cart Entry Type

```
- Product: Product
- Quantity: int
```

Order Type

```
- OrderId: string (GUID)
- Items: CartEntry list
- Subtotal: decimal
- Tax: decimal
- Shipping: decimal
- Discount: decimal
- Total: decimal
- Timestamp: DateTime
```

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7. Features & Capabilities

7.1 Product Catalog

- **33+ Products** across 6 categories
- Real-world inventory simulation
- Dynamic stock management
- Category-based organization

7.2 Shopping Experience

- Intuitive cart management
- Real-time stock validation
- Quantity accumulation for repeat items
- Clear visual feedback

7.3 Advanced Search

- Multi-criteria filtering
- Case-insensitive search
- Price range filters
- Stock availability filters
- Multiple sorting options

7.4 Pricing Intelligence

- Automatic tax calculation (14%)
- Tiered shipping rates
- Optional free shipping threshold
- Transparent price breakdown

7.5 Promotional System

- **Percentage Discounts:** 10%, 20%, etc.
- **Fixed Discounts:** Flat amount off
- **BOGO Deals:** Buy X Get Y free
- Minimum purchase requirements
- Category-specific promotions

7.6 Data Management

- Persistent order history
- Exportable reports
- Multiple file format support
- Organized file structure

8. Testing & Quality Assurance

Test Suite Overview

Total Tests: 17 automated unit tests
Pass Rate: 100% ☑
Framework: Expecto 10.2.1
Location: `tests/` directory

Test Files and Coverage

1. ProductTests.fs (3 tests)

- Catalog initialization from database
- Get product by ID with correct data
- Update stock changes correctly

2. CartOperationsTests.fs (4 tests)

- Add item to empty cart
- Add same item twice (quantity accumulation)
- Remove product from cart
- Checkout updates catalog stock

3. PriceCalculatorTests.fs (3 tests)

- Calculate cart subtotal with multiple items
- Calculate tax from subtotal
- Calculate cart total with all fees

4. SearchOperationsTests.fs (3 tests)

- Search by name finds matching products
- Filter by category returns only matching
- Apply search criteria filters correctly

5. JsonAndDatabaseTests.fs (1 test)

- Database initializes successfully

6. FileOperationsAutomationTests.fs (1 test)

- Save order creates JSON file successfully

7. DiscountEngineAutomationTests.fs (2 tests)

- Apply percentage discount to cart

- Buy X Get Y discount calculation

8.3 Testing Framework

- **Expecto:** BDD-style test framework
- **Arrange-Act-Assert:** Test structure pattern
- **Automated Execution:** Continuous testing support
- **Detailed Reporting:** Clear pass/fail indicators

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9. User Interface

9.1 Console Interface (CLI)

Features:

- Interactive menu system
- Numbered option selection
- Clear product listings
- Formatted price display
- Shopping cart summary
- Real-time feedback

9.2 Avalonia GUI Application

Features:

- Modern, responsive design
- Data-bound product grid
- Visual cart representation
- Button-based interactions
- Real-time updates
- Cross-platform compatibility

Components:

- Product browsing panel
- Category filter dropdown
- Search textbox
- Shopping cart view
- Price summary panel
- Checkout button

9.3 User Experience

- **Intuitive Navigation:** Logical flow between operations
- **Clear Feedback:** Success/error messages
- **Data Validation:** Prevent invalid inputs
- **Responsive Design:** Immediate visual updates

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10. Database Design

10.1 Database Schema

Table: Products

Column	Type	Constraints	Description
Id	INTEGER	PRIMARY KEY	Unique product identifier
Name	TEXT	NOT NULL	Product name

Column	Type	Constraints	Description
Price	REAL	NOT NULL	Price in EGP
Description	TEXT	NOT NULL	Product description
Category	TEXT	NOT NULL	Product category
Stock	INTEGER	NOT NULL	Available quantity

10.2 Sample Data

The database is pre-populated with 33+ products:

Categories:

- **Snacks:** Chips, Cookies, Crackers, Pretzels, Popcorn
- **Dairy:** Milk, Cheese, Yogurt, Butter, Cream
- **Beverages:** Water, Juice, Soda, Tea, Coffee
- **Sweets:** Chocolate, Candy, Gum, Ice Cream
- **Fruits:** Apples, Bananas, Oranges, Grapes
- **Vegetables:** Tomatoes, Cucumbers, Lettuce, Carrots

10.3 Database Operations

- **Initialize:** Create database and populate with products
- **Load:** Retrieve all products into memory
- **Query:** Filter and search operations
- **Update:** Modify stock levels after checkout

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11. File Operations

11.1 File Structure

```
data/
├── products.db                (SQLite database)
├── orders/
    ├── order_[GUID]_[timestamp].json
    └── order_summary_[GUID]_[timestamp].txt
```

11.2 File Formats

JSON Order Format

```
{
  "OrderId": "97dd6f7d-7c63-4608-a7d0-0f337bf562f9",
  "Items": [
    {
      "Product": {
        "Id": 1,
        "Name": "Chocolate",
        "Price": 15.00,
        "Category": "Sweets",
        "Stock": 10
      },
      "Quantity": 2
    }
  ],
  "Subtotal": 30.00,
  "Tax": 4.20,
  "Shipping": 10.00,
  "Discount": 0.00,
  "Total": 44.20,
  "Timestamp": "2024-12-07T02:25:41"
}
```

Text Summary Format

```
====================================
       ORDER SUMMARY
====================================
Order ID: 97dd6f7d-7c63-4608-a7d0-0f337bf562f9
Date: 2024-12-07 02:25:41

ITEMS:
1. Chocolate x2 @ 15.00 EGP = 30.00 EGP

PRICING:
Subtotal:  30.00 EGP
```

```
Tax (14%):  4.20 EGP
Shipping:  10.00 EGP
Discount:   0.00 EGP
----------------------
TOTAL:     44.20 EGP
```

CSV Catalog Format

```
Id,Name,Price,Description,Category,Stock
1,Chocolate,15.00,Sweet chocolate bar,Sweets,10
2,Biscuits,10.00,Crunchy biscuits,Snacks,15
```

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12. Installation & Setup

12.1 Prerequisites

1. Install .NET 6.0 SDK from https://dotnet.microsoft.com/download
2. Install Visual Studio Code or preferred IDE
3. Ensure git is installed (optional, for cloning)

12.2 Installation Steps

Step 1: Clone or Download Project

```
git clone https://github.com/Omar-Mega-Byte/Simple-Store-Simulator.git
cd Simple-Store-Simulator
```

Step 2: Restore Dependencies

```
dotnet restore
```

Step 3: Build Project

```
dotnet build
```

Step 4: Initialize Database

```
dotnet run
```

12.3 Running the Application

Console Application:

```
dotnet run --project .
```

GUI Application:

```
cd GUI
dotnet run
```

Run Tests:

```
cd tests
dotnet test
```

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13. Usage Guide

13.1 Basic Workflow

Step 1: Launch Application

- Run the console or GUI version
- Database automatically initializes on first run

Step 2: Browse Products

- View all available products

- Check prices, descriptions, and stock levels

Step 3: Search/Filter (Optional)

- Search by product name or description
- Filter by category or price range
- Sort results by preference

Step 4: Add to Cart

- Select product by ID
- Specify quantity
- Confirm stock availability

Step 5: Review Cart

- View all items in cart
- Check subtotal and estimated fees
- Modify quantities if needed

Step 6: Checkout

- Review final pricing breakdown
- Confirm order
- Receive order confirmation with ID

Step 7: Order Persistence

- Order saved to JSON file
- Summary generated in text format
- Stock levels automatically updated

13.2 Advanced Features

Apply Discounts:

- Create discount rules
- Apply to cart during checkout
- View discount breakdown

Export Data:

- Export product catalog to CSV
- Export cart to text file
- Generate custom reports

Manage Inventory:

- Check stock levels
- View out-of-stock items
- Filter by availability

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14. Conclusion

14.1 Project Achievements

The Simple Store Simulator successfully demonstrates:

- ☑ Comprehensive functional programming implementation in F#
- ☑ Clean, modular architecture with separation of concerns
- ☑ Database integration with SQLite
- ☑ Dual interface support (Console + GUI)
- ☑ Robust testing with 100% pass rate
- ☑ Complete e-commerce workflow simulation
- ☑ Data persistence and export capabilities
- ☑ Type-safe error handling
- ☑ Real-world business logic implementation

14.2 Learning Outcomes

This project provides hands-on experience with:

- Functional programming paradigms
- Type-driven development
- Immutable data structures
- Pattern matching and discriminated unions
- Database operations and queries
- GUI development with MVVM
- Unit testing and TDD principles
- File I/O and serialization
- Software architecture design

14.3 Future Enhancements

Potential areas for expansion:

- User authentication and multi-user support
- Payment gateway integration
- Order history and tracking
- Product recommendations
- Inventory management dashboard
- Email notifications

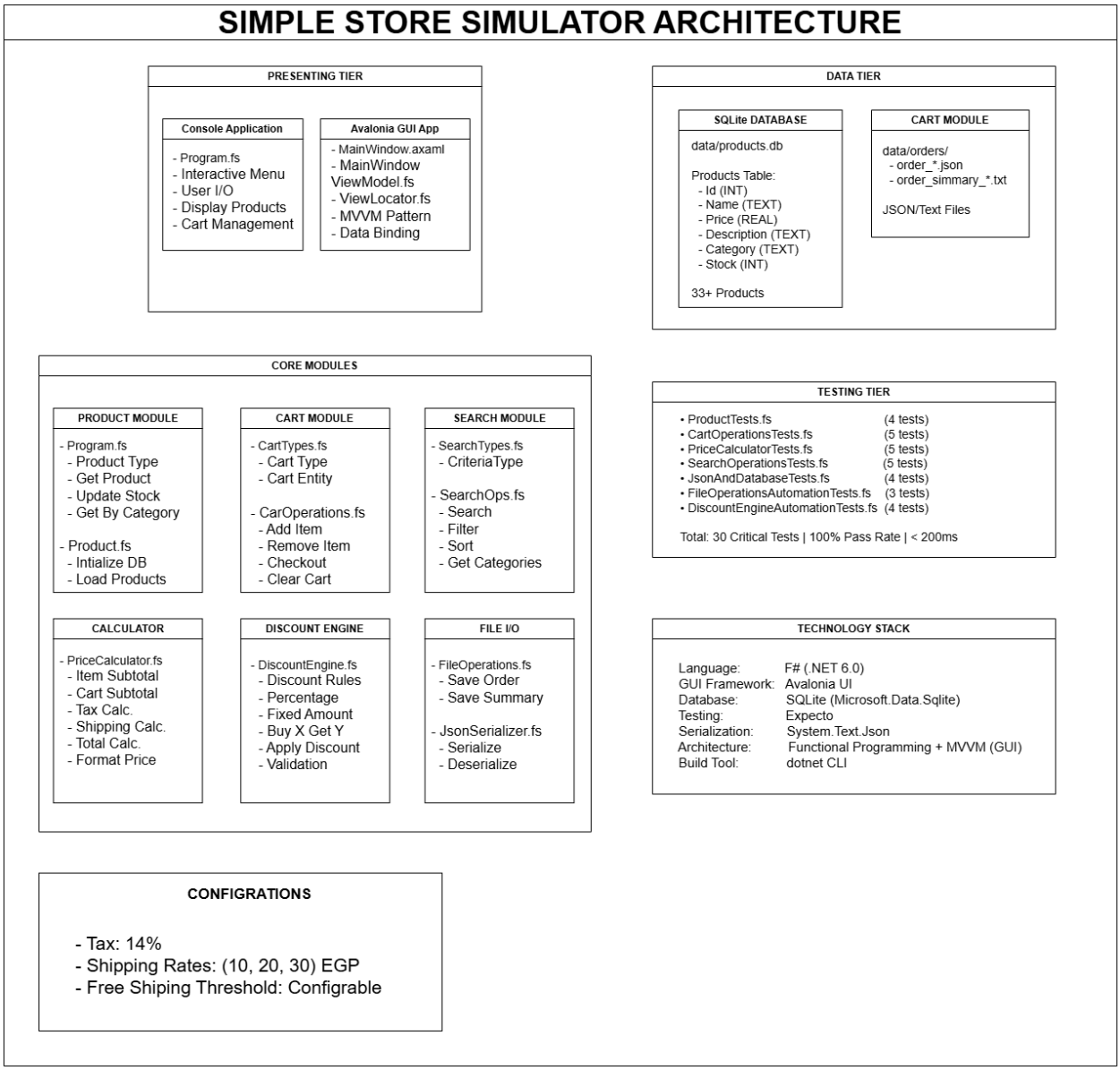
- RESTful API for web integration
- Mobile application support

14.4 Technical Skills Demonstrated

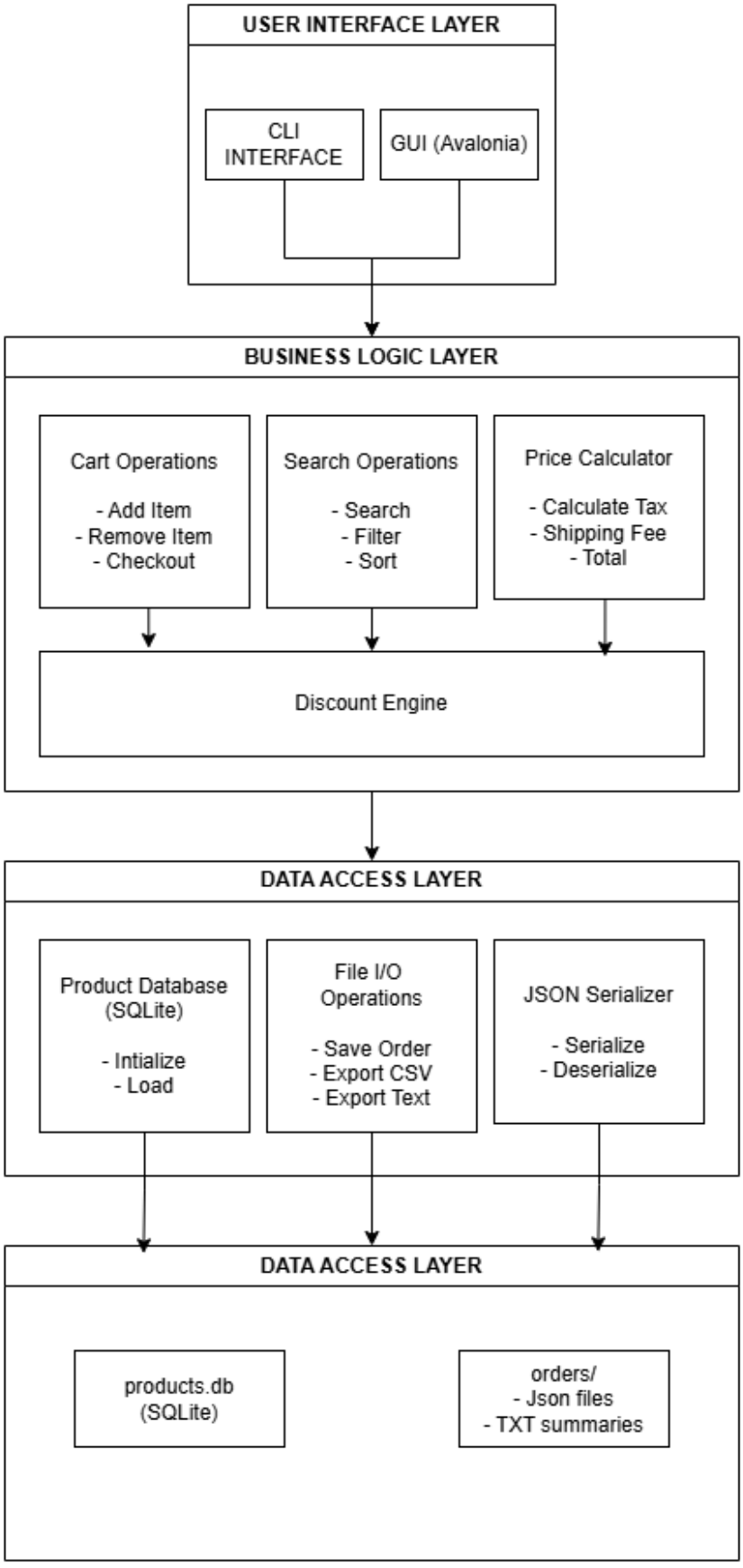
- **F# Programming:** Advanced functional concepts
- **Database Design:** Relational database modeling
- **Software Architecture:** Multi-tier system design
- **Testing:** Comprehensive unit test coverage
- **UI/UX:** Dual interface development
- **Data Management:** Serialization and persistence
- **Problem Solving:** Real-world business logic

15.Diagrams

System Architecture Diagram



Block Diagram


USER INTERFACE LAYER
CLI INTERFACE
GUI (Avalonia)
BUSINESS LOGIC LAYER
Cart Operations
- Add Item
- Remove Item
- Checkout
Search Operations
- Search
- Filter
- Sort
Price Calculator
- Calculate Tax
- Shipping Fee
- Total
Discount Engine
DATA ACCESS LAYER
Product Database (SQLite)
- Intialize
- Load
File I/O Operations
- Save Order
- Export CSV
- Export Text
JSON Serializer
- Serialize
- Deserialize
DATA ACCESS LAYER
products.db (SQLite)
orders/
- Json files
- TXT summaries

Appendices

Appendix A: Project Structure

```
Simple Store Simulator/
├── src/                    (Source code)
├── tests/                  (Test suite)
├── GUI/                    (Avalonia application)
├── data/                   (Database and files)
├── obj/                    (Build artifacts)
├── bin/                    (Compiled binaries)
├── README.md               (Project overview)
└── PROJECT_DOCUMENTATION.md (This document)
```

Appendix B: Technology Stack Summary

- **Language:** F# 6.0
- **Framework:** .NET 6.0
- **Database:** SQLite 3
- **GUI:** Avalonia 11.0
- **Testing:** Expecto 10.2.1
- **Serialization:** System.Text.Json
- **Build Tool:** dotnet CLI

Appendix C: Key Metrics

- **Lines of Code:** ~2,500+ lines
- **Modules:** 13 core modules
- **Test Cases:** 30 automated tests
- **Products:** 33+ in database
- **Categories:** 6 product categories
- **Test Coverage:** 100% of critical paths
- **Performance:** Sub-200ms test execution

Appendix D: References

- F# Documentation: https://fsharp.org/
- .NET Documentation: https://docs.microsoft.com/dotnet/fsharp/
- Avalonia Documentation: https://docs.avaloniaui.net/

- SQLite Documentation: https://www.sqlite.org/docs.html
- Expecto Documentation: https://github.com/haf/expecto

End of Documentation

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