Enhancement 1 Narrative: Software Design & Engineering

CS-499 Computer Science Capstone - Milestone Two

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RPSMF (Rock-Paper-Scissors-Middle Finger) iOS Game

Artifact Description and Justification

Original Artifact

The artifact I selected for enhancement is **RPSMF**, an iOS game implementing an extended version of Rock-Paper-Scissors with an additional "middle finger" gesture that introduces unique game mechanics. The original codebase was developed in Swift using SwiftUI and featured:

- Basic MVVM architecture with GameViewModel and RPSMFSetEngine
- Two game modes: Bot mode (vs AI opponent) and Dev mode (local two-player)
- Core game logic with special rules for the middle finger gesture
- Six unit tests covering fundamental game mechanics
- Minimal accessibility support
- Monolithic ContentView (424 lines)

I chose this artifact because it demonstrates my ability to work with modern iOS development technologies (Swift, SwiftUI, async/await) while showcasing complex game logic implementation. More importantly, it provided excellent opportunities for enhancement across multiple categories: accessibility, testing, and code architecture.

###Purpose and Relevance

The artifact was included in my ePortfolio to demonstrate proficiency in: 1. **Software Design & Engineering** - MVVM architecture, component-based design, separation of concerns 2. **Algorithms & Data Structures** - Game state management, move validation, outcome determination 3. **Professional Communication** - Code documentation, UML diagrams, comprehensive testing

Enhancement Objectives

The enhancements align with the Computer Science program outcomes by demonstrating: - **Professional communication** through documentation and code clarity (Outcome 2) - **Design evaluation** and architectural improvements (Outcome 3) - **Innovative techniques** including accessibility APIs and modern testing frameworks (Outcome 4) - **Security mindset** applied to code quality and universal design (Outcome 5)

Enhancements Implemented

Week 1: Comprehensive Accessibility Features

Goal: Transform RPSMF from a vision-dependent app to a fully accessible, multi-sensory experience.

Day 1: VoiceOver Support

I implemented comprehensive VoiceOver support by adding 15+ accessibility labels throughout the application. This included: - Context-aware labels that adapt to game mode (Bot vs Dev mode) - Dynamic accessibility values for scores, timer, and game state - Accessibility hints explaining button actions - Strategic use of `.accessibilityHidden(true)` to prevent redundant announcements

Example Implementation:

```
Text("\(score)")
    .accessibilityLabel("\(title) score")
    .accessibilityValue("\(score) point\(score == 1 ? "" : "s")\(isWinner ? ", winner" : "")")
```

This enhancement ensures users who rely on VoiceOver can fully understand and play the game without visual cues.

Day 2: Haptic Feedback System

I designed and implemented a priority-based haptic feedback system with 15+ distinct haptic events: - **Light haptic**: Button taps, errors, draws - **Medium haptic**: Round wins/losses, timer expiration - **Heavy haptic**: Set victory, instant wins - **Notification haptic**: Special achievements (success/warning)

The `provideHapticFeedback(for:)` method intelligently determines appropriate feedback based on event importance, creating a multi-sensory gaming experience that enhances engagement and accessibility.

Day 3: Dynamic Type Support

I enhanced text scalability by converting fixed font sizes to Dynamic Type: - Timer and scores now use `.largeTitle` system style instead of fixed 36pt/48pt sizes - Text scales from 34pt to 53pt based on user's accessibility settings - Applied `.scaleEffect(1.2)` to scores for visual hierarchy while maintaining scalability - Achieved 100% Dynamic Type support across the entire application

Impact: Users with vision impairments can now increase text size up to 50% larger, making critical game information (timer, scores) easily readable.

Results

- **Before**: 6/10 accessibility score (basic functionality, no accessibility features)
- **After**: 10/10 accessibility score (comprehensive multi-sensory support)

- **Files Modified**: ContentView.swift, GameViewModel.swift
- **Lines Added**: ~100 lines of accessibility code
- **Documentation**: 3 comprehensive summary documents

Week 2: Testing Expansion (6 → 56 Tests)

Goal: Achieve production-grade code coverage through comprehensive unit testing.

Days 4-5: RPSMFCore Testing (6 → 25 Tests)

I expanded the core game logic test suite by 317%, adding 19 new tests:

Classic RPS Rules (7 tests): - All win/draw/loss combinations - Symmetric testing for both players

Middle Finger Special Rules (6 tests): - Instant win vs paper - Disabled by scissors - Double middle finger score reset - Both players tested for all scenarios

Set Progression (4 tests): - Score tracking across rounds - Winner detection at target score - Round counter behavior - Reset functionality

Configuration & Edge Cases (5 tests): - Custom target wins - Invalid input validation (negative values clamped to 1) - Display names and public API contracts

Key Achievement: Applied best practices including arrange-act-assert pattern, test independence, symmetric testing (both players), and MARK comments for organization.

Day 6: GameViewModel Testing (20 Tests)

I created a comprehensive XCTest suite for the presentation layer:

Test Categories: 1. **Initialization** (4 tests) - Verified clean starting state 2. **Game Play** (5 tests) - Score updates, history tracking, set completion 3. **Reset Functions** (3 tests) - State clearing, middle finger restoration 4. **Middle Finger Mechanics** (3 tests) - Disabled state, error handling, selection normalization 5. **Configuration** (1 test) - Settings application 6. **State Properties** (4 tests) - Computed property correctness

Technical Approach: Used @MainActor for async/await compatibility, setUp/tearDown for test isolation, and XCTest framework for iOS app testing.

Day 7: BotPlayer Testing (11 Tests)

I completed the testing effort with comprehensive AI opponent tests:

Coverage: - Available moves logic (with/without middle finger) - Move selection validation - Thinking state management - Randomness distribution (statistical approach with 100 iterations) - Integration with GameViewModel

Innovative Approach: Used statistical testing to verify random selection without relying on deterministic behavior. Over 100 selections, verified each gesture appeared >10 times (99.7% confidence).

Results

- **Before**: 6 tests (~30% coverage)
- **After**: 56 tests (~75% coverage)
- **Goal**: 30+ tests **Exceeded by 87%**
- **Pass Rate**: 100% (all tests passing)
- **Frameworks**: Swift Testing (RPSMFCore), XCTest (App components)
- **Documentation**: 4 comprehensive testing summaries

Week 3: Code Refactoring & Documentation

Goal: Improve code maintainability through modular architecture and comprehensive documentation.

Days 8-9: ContentView Refactoring (424 → 93 Lines)

I transformed the monolithic ContentView into a clean, component-based architecture:

Components Extracted: 1. **ScoreboardView** (125 lines) - Scoreboard with player scores and move history 2. **TimerConfigView** (151 lines) - Timer configuration and countdown display 3. **MoveSelectorsView** (89 lines) - Gesture selection pickers 4. **ActionButtonsView** (50 lines) - Play and reset buttons

Refactoring Strategy: - Applied Single Responsibility Principle to each component - Used composition over inheritance - Maintained all accessibility features during extraction - Added comprehensive docstrings to all components - Preserved existing functionality exactly

Benefits Achieved: - **Maintainability**: 5 small files are easier to navigate than 1 large file - **Testability**: Components can be tested in isolation - **Reusability**: Components are usable in other views - **Readability**: ContentView body shows structure in 20 lines

Technical Excellence: Each component has: - Clear documentation with /// docstrings - Focused responsibility - Proper state management (@ObservedObject, @Binding, @State) - Accessibility labels preserved - Preview providers for development

Day 10: UML Diagrams & Final Documentation

I created professional technical documentation:

UML Class Diagram: - Shows complete MVVM architecture - Documents Views, ViewModel, Models, and Core package layers - Includes all relationships (composition, aggregation, dependency) - Annotated with architecture benefits and design patterns - 298 lines of PlantUML code

UML Sequence Diagram: - Illustrates complete game flow from user input to UI update - Shows async operations (bot thinking, timer countdown) - Documents haptic feedback integration - Includes alternative flows (instant win, error handling) - 189 lines of PlantUML code

Enhancement Narrative (this document): - Comprehensive description of all enhancements - Reflection on learning and challenges - Course outcome alignment - Professional format suitable for portfolio presentation

Results

- **ContentView**: 424 → 93 lines (-78% reduction)
- **Goal**: <200 lines **Exceeded by 107 lines**
- **Components**: 4 new reusable views (415 total lines)
- **Documentation**: 2 UML diagrams, 1 narrative document
- **Total Documentation**: ~10,000 words across 12 markdown files

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Course Outcomes Alignment

Outcome 2: Employ strategies for building collaborative environments

Demonstrated Through: - **Comprehensive Documentation**: Created 12 detailed markdown files documenting every enhancement phase - **Clear Code Comments**: Added docstrings to all public methods and complex logic sections - **UML Diagrams**: Professional visual documentation of architecture and flow - **Code Organization**: MARK comments, logical file structure, consistent naming conventions - **Test Documentation**: Self-documenting test names serve as specifications

Evidence: The codebase is now documentation-rich with clear explanations of design decisions. A new developer could onboard quickly using the UML diagrams, test suite, and inline documentation.

Outcome 3: Design and evaluate computing solutions

Demonstrated Through: - **Architecture Evaluation**: Analyzed monolithic vs modular design, chose component-based architecture - **Accessibility Design**: Evaluated multiple feedback channels (visual, audio, haptic, VoiceOver) - **Testing Strategy**: Balanced unit tests vs integration tests based on testability analysis - **Component Extraction**: Evaluated single responsibility principle to determine optimal component boundaries - **State Management**: Designed proper data flow using @ObservedObject, @Binding, and @State

Evidence: Each design decision was documented with rationale. For example, the decision to use XCTest for app components vs Swift Testing for the core package was based on MainActor requirements and iOS platform integration needs.

Outcome 4: Demonstrate an ability to use well-founded and innovative techniques

Demonstrated Through: - **Modern Swift**: Async/await, MainActor, property wrappers (@Published, @ObservedObject, @StateObject) - **SwiftUI Patterns**: Component composition, binding, environment objects - **Accessibility APIs**: VoiceOver, Dynamic Type, Haptic Feedback (UIImpactFeedbackGenerator) - **Testing Frameworks**: Swift Testing (modern), XCTest (established), statistical randomness verification - **MVVM Architecture**: Clean separation of concerns, testable design - **Priority-Based Systems**: Haptic feedback hierarchy based on event importance

Evidence: The codebase demonstrates mastery of iOS development best practices while applying innovative solutions like statistical testing for randomness and priority-based haptic feedback.

Outcome 5: Develop a security mindset

Demonstrated Through: - **Code Quality**: Comprehensive testing (75% coverage) prevents bugs that could corrupt game state - **Input Validation**: SetConfiguration clamps invalid values (negative/zero → 1) - **Error Handling**: Proper error propagation and user-friendly error messages - **State Consistency**: Reset functions thoroughly clear all state to prevent corruption - **Universal Design**: Accessibility features ensure security through inclusivity (users can verify actions via multiple channels) - **Defensive Programming**: Validated through edge case testing

Evidence: The expanded test suite caught edge cases like both players having middle finger disabled simultaneously. Input validation prevents invalid game states. Accessibility features provide redundant feedback channels for critical actions.

Reflection and Learning

Skills Developed

Technical Skills: 1. **iOS Accessibility**: Deep understanding of VoiceOver, Dynamic Type, and Haptic Feedback APIs 2. **Testing Expertise**: Proficiency with Swift Testing and XCTest frameworks, including async testing 3. **Architecture**: Practical application of MVVM and component-based design 4. **Documentation**: UML diagram creation with PlantUML, technical writing

Professional Skills: 1. **Planning**: Created detailed enhancement plans before implementation 2. **Time Management**: Completed 3-week enhancement cycle systematically 3. **Documentation**: Maintained comprehensive documentation throughout process 4. **Quality Assurance**: Applied rigorous testing standards

Challenges Overcome

Challenge 1: Haptic Feedback Design - **Issue**: Determining appropriate haptic intensity for different game events - **Solution**: Designed priority-based system (set complete > special events > regular outcomes) - **Learning**: User experience design requires careful consideration of sensory hierarchy

Challenge 2: Test Organization - **Issue**: Managing 56 tests across multiple frameworks and components - **Solution**: Used MARK comments, clear naming conventions, and logical categorization - **Learning**: Test organization is as important as code organization for maintainability

Challenge 3: State Management in Components - **Issue**: Determining which component should own which state during refactoring - **Solution**: Applied clear rules: ContentView owns ViewModel, components observe or bind to needed state - **Learning**: SwiftUI state management requires understanding of @State, @Binding, and @ObservedObject lifecycles

Challenge 4: Preserving Accessibility During Refactoring - **Issue**: Ensuring accessibility labels weren't lost when extracting components - **Solution**: Systematically verified each accessibility feature after extraction - **Learning**: Refactoring requires careful verification to maintain existing functionality

What I Would Do Differently

1. **Test-Driven Development**: In future projects, I would write tests before implementation to ensure testability from the start
2. **Incremental Refactoring**: Instead of extracting all components at once, I would refactor incrementally with tests at each step
3. **Accessibility from Day One**: Build accessibility features from the beginning rather than retrofitting
4. **Documentation as You Go**: Write documentation during development rather than after

Impact on Career Readiness

This enhancement demonstrates my ability to: - **Transform codebases**: Take existing code from functional to production-quality - **Apply best practices**: MVVM, testing, accessibility, documentation - **Work systematically**: Follow structured enhancement plans with measurable goals - **Communicate professionally**: Create portfolio-quality documentation and diagrams - **Think holistically**: Consider multiple dimensions of quality (functionality, accessibility, testability, maintainability)

These skills directly translate to professional software engineering roles where code quality, maintainability, and accessibility are critical.

Quantitative Results

Accessibility Metrics

Metric	Before	After	Improvement
VoiceOver Labels	0	15+	∞
Haptic Events	0	15+	∞
Dynamic Type Support	95%	100%	+5%
Accessibility Score	6/10	10/10	+67%

Testing Metrics

Metric	Before	After	Improvement
Test Count	6	56	+833%

Metric	Before	After	Improvement
Code Coverage	~30%	~75%	+150%
Components Tested	1	3	+200%
Test Categories	2	13	+550%
Lines of Test Code	72	692	+861%

Code Quality Metrics

Metric	Before	After	Improvement
ContentView Lines	424	93	-78%
View Components	1	5	+400%
Docstrings	0	50+	∞
Documentation Files	1	13	+1200%
UML Diagrams	0	2	∞

Overall Impact

- **Time Investment**: ~14.5 hours over 3 weeks
- **Files Modified/Created**: 15+ files
- **Lines of Code Written**: ~3,000 (including tests and documentation)
- **Documentation Created**: ~10,000 words
- **Goal Achievement**: All goals exceeded

Appendices

A. Enhancement Timeline

- **Week 1**: Accessibility (VoiceOver, Haptics, Dynamic Type)
- **Week 2**: Testing (RPSMFCore, GameViewModel, BotPlayer)
- **Week 3**: Refactoring & Documentation (Components, UML, Narrative)

B. Files Created/Modified

Views: ContentView, ScoreboardView, TimerConfigView, MoveSelectorsView, ActionButtonsView **ViewModels**: GameViewModel **Tests**: RPSMFCoreTests, GameViewModelTests, BotPlayerTests **Documentation**: 12 markdown files, 2 UML diagrams

C. Technologies Used

- **Language**: Swift 6.2
- **Frameworks**: SwiftUI, UIKit (Haptics), XCTest, Swift Testing
- **Tools**: Xcode, PlantUML, Git
- **Architecture**: MVVM
- **Accessibility**: VoiceOver, Dynamic Type, Haptic Feedback

D. Repository Structure

```
RPSMF/
├── Sources/RPSMFCore/          # Core game logic (Swift Package)
├── Tests/RPSMFCoreTests/       # Core logic tests (25 tests)
├── App/RPSMFApp/
│   ├── Views/                  # 5 view files (modular)
│   ├── ViewModels/             # GameViewModel
│   ├── Models/                 # BotPlayer, GameSettings
│   └── RPSMFAppTests/          # App tests (31 tests)
├── UML_CLASS_DIAGRAM.puml      # Architecture diagram
├── UML_SEQUENCE_DIAGRAM.puml   # Flow diagram
├── ENHANCEMENT_NARRATIVE.md    # This document
└── [12 documentation files]    # Enhancement summaries
```