

CS5010 - Programming Design Paradigms : OOP Project

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F1 Strategy Analysis System:

Proposal:

For my project I want to create an F1 Race Strategy Analysis System. This system is designed to help Formula 1 teams simulate and analyze dynamic race conditions, enabling team managers and strategists to evaluate various race strategies and identify the optimal approaches tailored to each race scenario.

Core Features: (Nouns / Verbs)

- **Race Scenario Simulation:**
 - Engineers can import and simulate data on key race parameters—including tire degradation, fuel consumption, weather conditions, and track dynamics—to generate realistic race scenarios.
- **Driver & Team Performance Analysis:**
 - Drivers are evaluated on critical performance metrics such as lap times, tire management, and fuel efficiency. The system categorizes drivers into roles (e.g., qualifier, race leader, strategic driver) and assesses their effectiveness under various race conditions.
- **Strategy Optimization & Customization:**
 - Managers can leverage built-in simulation models to test multiple pit stop strategies, tire management plans, and fuel load configurations. Custom filters allow users to quickly identify and select strategies that best match their competitive objectives.
- **User Stories:**
 - As a race engineer, I want to import comprehensive race data and simulate different race scenarios so that I can evaluate how changing conditions (like weather or track layout) impact driver performance and pit stop timing.
 - As a team strategist, I want to generate detailed performance reports that compare various race strategies so that I can determine which approach offers the best advantage for our team in a given race.
 - As the team manager, I want to analyze real-time driver and team performance data during a race so that I can adjust our strategy on the fly and maintain a competitive edge.

Nouns:

- Race Scenario
- Race
- Degradation
- Fuel Consumption
- Weather Conditions
- Driver
- Team
- Performance Metrics
- Lap Times
- Race Conditions
- Simulation
- Pit Stop
- Strategies
- Objectives
- Team Strategists
- Team manager
- Performance Reports
- Engineers
- ~~Key parameters~~
- ~~Tire management~~
- ~~Fuel Efficiency~~
- ~~System~~
- ~~Effectiveness~~
- ~~Managers~~
- ~~Managers~~

Verbs:

- Simulate
- Generate
- Analysis
- Categorizes
- Assesses
- Select
- Adjust
- ~~Leverage~~
- Evaluated

Business Requirements

- **Data Ingestion:**
 - Ability to import comprehensive race datasets (e.g. telemetry data, weather, track conditions) in standard formats (CSV, JSON, etc.). (For the sake of this project I will probably just create my own data manually in code)
- **Simulation and Analysis:**
 - Simulate dynamic race conditions (including tire degradation, fuel usage, weather effects, and track dynamics).
 - Evaluate driver performance metrics (lap times, tire management).
- **Strategy Optimization:**
 - Generate multiple pit stop and tire strategy scenarios using built-in simulation models.
 - Allow customization through filters (e.g., race conditions, team objectives).
- **Real-Time Monitoring and Reporting:**
 - Provide live dashboards and performance reports during a race. (I was not able to successfully implement this in time for the project 😞)
 - Enable quick adjustments to race strategy based on simulation results.
- **Integration and Extensibility:**
 - Support exporting results and integration with external analytics tools.

Target Audience

- **Race Engineers:** Need detailed simulation outputs to evaluate technical race parameters.
- **Team Strategists:** Require comparative reports and “what-if” scenario analysis to choose the optimal strategy.
- **Team Managers:** Benefit from real-time dashboards and alerts to adjust strategies during a race.
- **Data Analysts and Software Engineers:** Interested in the underlying simulation models and data processing techniques.

Rules

- **Data Standards:**
 - All imported data must adhere to agreed-upon formats and validation rules. (I will make my own data for this project)
- **Simulation Accuracy:**
 - Simulations must reflect realistic race conditions based on historical data. (Will only work on this once the base requirements are done)

- **User Interface:**
 - Interfaces must be intuitive and display real-time analytics clearly.
- **Extensibility:**
 - The system should be modular to allow future enhancements (e.g., additional simulation parameters).
- **Security and Privacy:**
 - Sensitive team and driver data must be handled securely. (If the project is eventually made into an application)

Challenge Questions

1. How will you model the complex relationship between weather changes and tire degradation? What specific weather parameters (temperature, humidity, precipitation) will you include?
2. What's the maximum acceptable latency for strategy updates during a live race? How quickly must the system process new data and provide recommendations?
3. How will the system factor in likely competitor strategies? What assumptions should be made about other teams' behavior?
4. What's the most critical information that needs to be immediately visible during a race? How should the UI change between practice, qualifying, and race scenarios?

Classes and Their Key Attributes:

1. RaceScenario

Attributes: trackConditions, weather, tireDegradationRate, fuelConsumptionRate, lapCount

Associations: Aggregates multiple Driver objects; associated with multiple Strategy instances.

2. Race:

Attributes: track, laps

Associations: RaceScenario is a composition of Race, Teams are an aggregation of Race.

3. Driver

Attributes: name, role (e.g., qualifier, race leader, strategic driver), lapTimes, tireManagementScore, fuelEfficiency, performanceScore

Associations: Part of a Team (Composition, since drivers cannot race without a team); participates in Race.

4. Team

Attributes: teamName, overallPerformance, strategyList

Associations: Contains multiple Driver objects; uses multiple Strategy objects.

5. Strategy

Attributes: pitStopTimings, tireCompoundPlan, fuelLoadConfiguration, expectedOutcome

Associations: Linked to a RaceScenario; associated with a Team.

6. Dashboard

Attributes: displayElements, alertThresholds

Associations: Presents outputs from Simulation and Report.

7. Report

Attributes: reportId, summary, detailedAnalysis, timestamp

Associations: Generated from Simulation results; linked to a Team.

8. Simulation

Attributes: inputData (RaceScenario, Driver), simulationParameters, simulationResults

Associations: Uses RaceScenario, Driver, and Strategy data.

Persona 1: Team Strategist (Bonno)

- **Background:** Bonno has strong data analysis skills and focuses on optimizing race strategy to maximize team performance.
- **User Stories:**
 1. As a Team Strategist, I want to compare multiple pit stop and tire strategies side-by-side so I can determine the most advantageous plan.
 2. As a Team Strategist, I want to run “what-if” simulations under various race conditions so that I can forecast outcomes and choose the optimal strategy.
 3. As a Team Strategist, I want to generate comprehensive performance reports that incorporate historical race data so that I can adjust our strategy dynamically during the race.
- **Dimensions:** Role, Responsibilities, Experienced or Inexperienced and Goals (In ranked order)

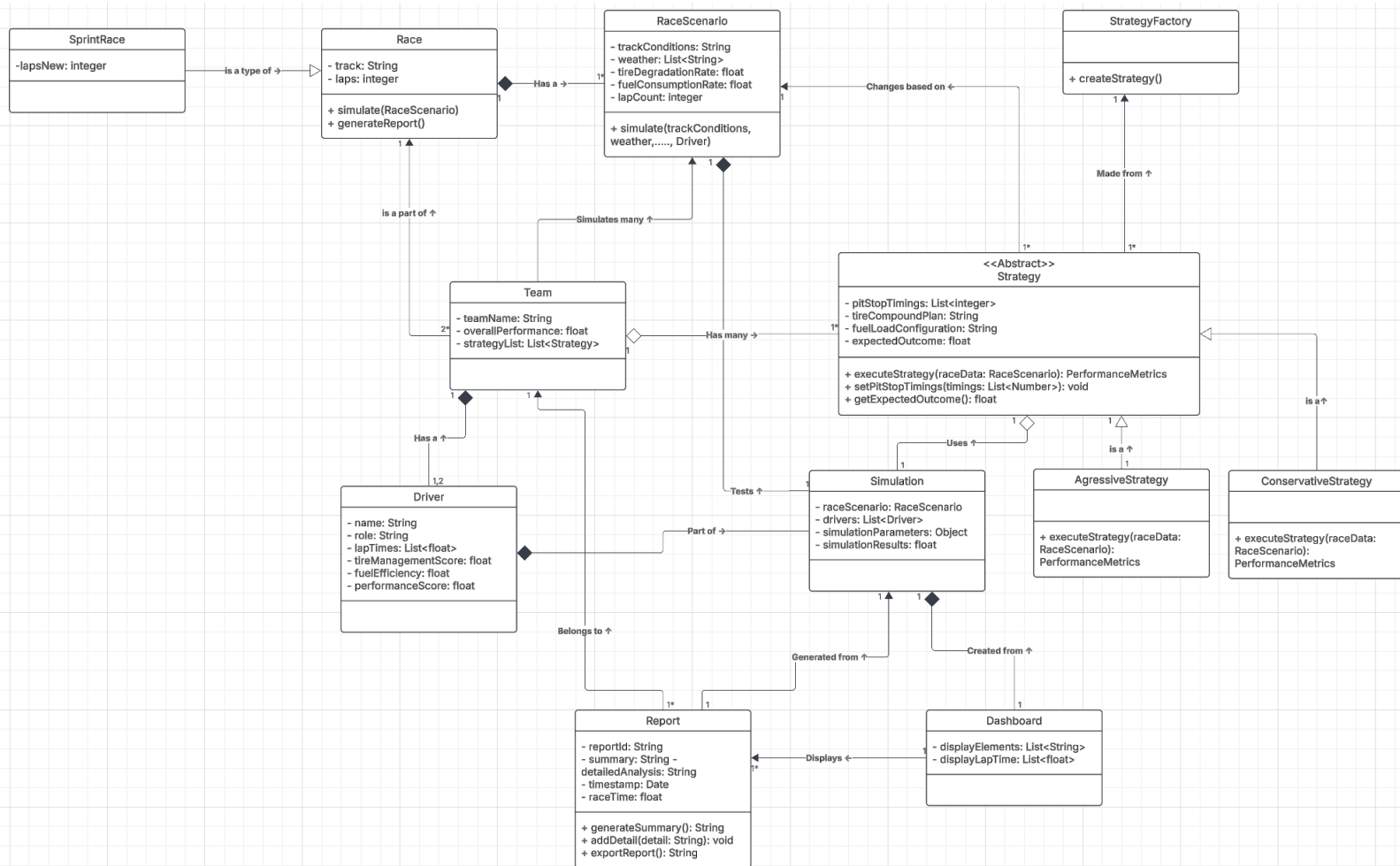
Persona 2: Team Manager (Toto Wolff)

- **Background:** Toto oversees the entire team's performance and needs high-level dashboards for rapid decision-making during races.
- **User Stories:**
 1. As a Team Manager, I want to view a real-time dashboard displaying key performance metrics so I can monitor the race's progress at a glance.
 2. As a Team Manager, I want to receive instant alerts when a simulation predicts a significant deviation from the planned strategy so that I can make timely decisions.

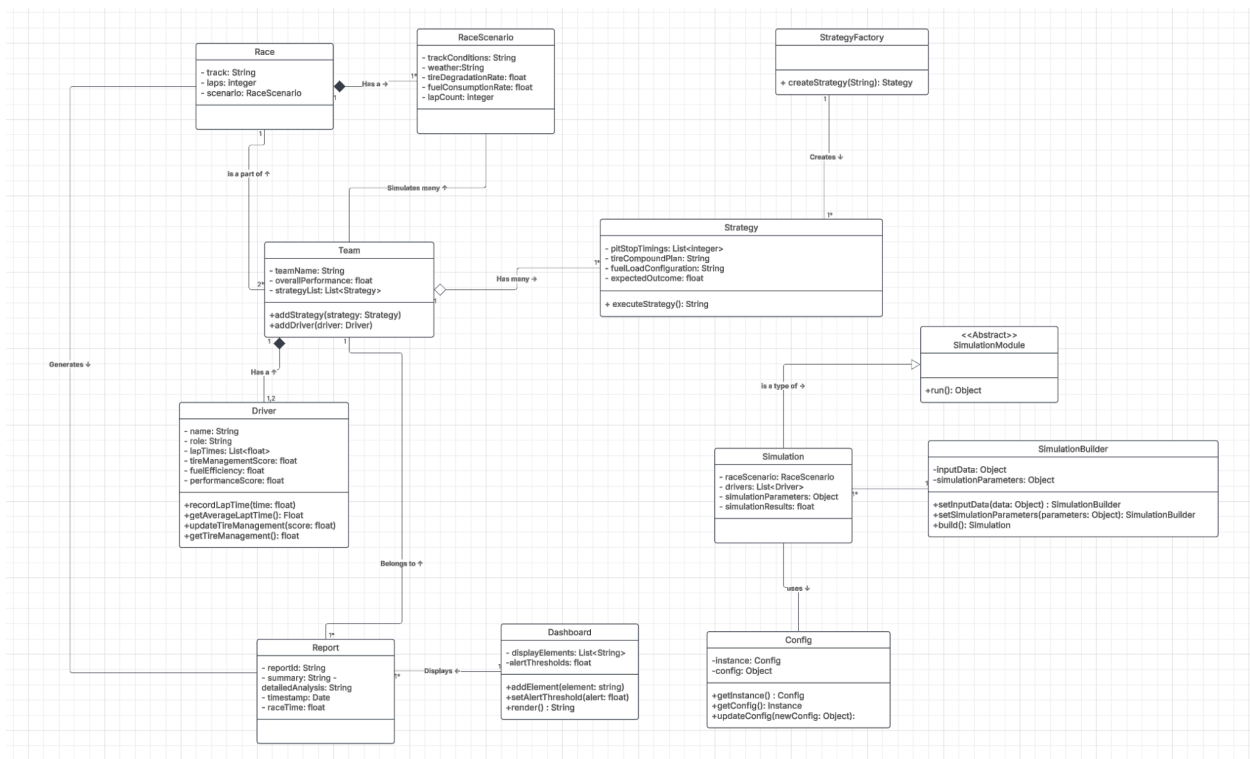
3. As a Team Manager, I want to access post-race summary reports that clearly outline which strategies succeeded and which did not so that I can inform future strategy sessions.
- **Dimensions:** Role, Responsibilities, What information he needs, How to communicate

[UML Class Diagram:](#)

Initial Version (Before I started Coding)



New Updated Class Diagram:



Figma Mockups:

- Persona 1: Team Strategist (Bonno)
- Background: Bonno has strong data analysis skills and focuses on optimizing race strategy to maximize team performance.
 - User Stories:
 - a. As a Team Strategist, I want to compare multiple pit stop and tire strategies side-by-side so I can determine the most advantageous plan.



Persona 1: Team Strategist (Bonno)

- Background: Bonno has strong data analysis skills and focuses on optimizing race strategy to maximize team performance.
- User Stories:
 - b. As a Team Strategist, I want to run "what-if" simulations under various race conditions so that I can forecast outcomes and choose the optimal strategy.

The "Add Scenario" Button from the "Comparing Strategies" page brings us here

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Form to be filled out by the user

Race Scenario:

Track: Monza

Laps: 5

Weather: Sunny, Sunny, Sunny, Rain, Rain

Tire Degradation (Sunny): 15% per lap

Tire Degradation (Rain): 5% per lap

Pit Stop: Start of Lap 4

Driver: Hamilton

Team: Ferrari

Fuel Consumption: 25% at full load (decreases as the race goes on

ADD

SIMULATE

BACK

- Persona 2: Team Manager (Toto Wolff)
- Background: Toto oversees the entire team's performance and needs high-level dashboards for rapid decision-making during races.
 - User Stories:
 - a. As a Team Manager, I want to view a real-time dashboard displaying key performance metrics so I can monitor the race's progress at a glance.
 - b. As a Team Manager, I want to receive instant alerts when a simulation predicts a significant deviation from the planned strategy so that I can make timely decisions.

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LIVE METRICS

LAP: 1

Weather: Sunny

Strategy: Aggresive

Tire Health: 70%

Fuel: 75%

Tyre Compund: Soft

Lap Time: 47 secs

Pit Stop: No

Fastest Lap: Verstappen - 46.3 secs

Current Position: 2nd

Delta To 1st: +0.7s

Delta To 3rd: -1.2s

Alert: Overtake by Hamilton

New Position: 1st

Suggestion: Switch to Conservative Strategy

Radio Message

Box Box

Hammertime

Stay Out

Rain Next Lap, Box for Inters

Persona 2: Team Manager (Toto Wolff)

- Background: Toto oversees the entire team's performance and needs high-level dashboards for rapid decision-making during races.

- User Stories:

As a Team Manager, I want to access post-race summary reports that clearly outline which strategies succeeded and which did not so that I can inform future strategy sessions.

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Summary of Race

Driver: Hamilton

Track: Monza

Laps: 5

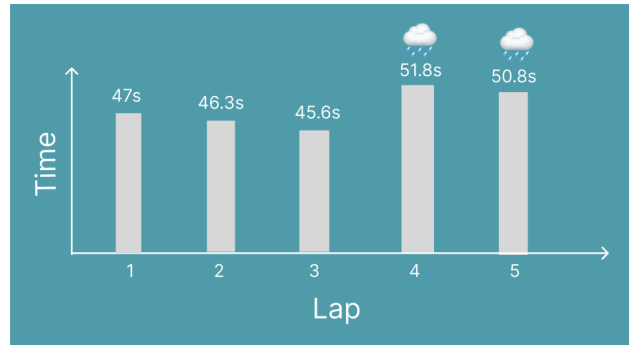
Finish Position: 1st

Strategy: Started Aggressive, switched to conservative on 2nd Lap

Best Lap: 45.6s (3rd Lap)

Total Race Time: 227.4s

Fastest Lap: 45.1s - Verstappen



Persona 1: Team Strategist (Bonno)

- Background: Bonno has strong data analysis skills and focuses on optimizing race strategy to maximize team performance.
- User Stories:
As a Team Strategist, I want to generate comprehensive performance reports that incorporate historical race data so that I can adjust our strategy dynamically during the race.

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Monza 2022:

Weather: Rainy (Laps 25-40)

Total Laps: 50

Winner: Max Verstappen

Winner's Strategy: Aggressive

Your Driver: Hamilton

Your Driver's Position: 3rd

Your Strategy: Conservative

Tire Degradation: 0.3

Monza 2023:

Weather: Sunny

Total Laps: 50

Winner: Lewis Hamilton

Winner's Strategy: Conservative

Your Driver: Hamilton

Your Driver's Position: 1st

Your Strategy: Conservative

Tire Degradation: 0.8

(Attaching AI usage documentation as photos from my readme file)

AI Usage

- **1.Tests:** all of the test files for this project were created using AI.
- **Model:** ChatGPT - o3 mini
- **Prompt:** (my class file , eg: Driver.js) Can you write some tests for this js class
- **Response:**

```
/**
 * @file Driver.js
 * @description Represents a driver in the F1 Race Strategy Analysis System.
 */
export class Driver {
  /**
   * Creates a new Driver.
   * @param {string} name - The driver's name.
   * @param {string} role - The driver's role (e.g., "Race Leader").
   */
  constructor(name, role) {
    this.name = name;
    this.role = role;
    this._lapTimes = []; // Encapsulated property
    this._tireManagementScore = 0;
    this._fuelEfficiency = 0;
  }

  /**
   * Records a lap time.
   * @param {number} time
   */
  recordLap(time) {
    this._lapTimes.push(time);
  }
}
```

```
/**
 * Gets the average lap time.
 * @returns {number}
 */
getAverageLapTime() {
  if (this._lapTimes.length === 0) return 0;
  return this._lapTimes.reduce((a, b) => a + b, 0) / this._lapTimes.length;
}

/**
 * Updates the tire management score.
 * @param {number} score
 */
updateTireManagement(score) {
  this._tireManagementScore = score;
}

/**
 * Gets the tire management score.
 * @returns {number}
 */
getTireManagement() {
  return this._tireManagementScore;
}
}
```

Similarly all the other test files were created using the exact same model and prompt.

- **2.JSDoc:** All of the JSDocumentation in this project was done by AI.
- **Model:** ChatGPT - o3 mini
- **Prompt:** (class file code) can you document this code using JSDoc
- **Response:**

```
import { Driver } from "../src/Driver.js";

describe("Driver Class", () => {
  let driver;

  beforeEach(() => {
    driver = new Driver("Test Driver", "Test Role");
  });

  test("should record lap times correctly", () => {
    driver.recordLap(90);
    driver.recordLap(85);
    // Expose lap times for testing
    driver.getLapTimes = function() {
      return this._lapTimes;
    };
    expect(driver.getLapTimes()).toEqual([90, 85]);
  });

  test("should calculate average lap time correctly", () => {
    driver.recordLap(90);
    driver.recordLap(80);
    const avg = driver.getAverageLapTime();
    expect(avg).toBeCloseTo(85, 1);
  });
});
```

- **3.User Stories:** I used AI to get a sample user story and then made 2 more of my own using the generated one as an example.
- **Model:** ChatGPT - o3 mini
- **Prompt:** (Problem description / Description of my application) Persona 1: Team Strategist (Bonno) Background: Bonno has strong data analysis skills and focuses on optimizing race strategy to maximize team performance.

Can you give me a sample user story for this persona using my application

- **Response:** As a Team Strategist, I want to compare multiple pit stop and tire strategies side-by-side so I can determine the most advantageous plan.