

**A multi-player distributed 2D Car Racing Game along with chatting.**



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# Introduction

Welcome to the documentation for our exciting project—a multi-player distributed 2D Car Racing Game with a built-in chatting feature, developed using Python. This project aims to showcase the utilization of distributed systems concepts while delivering an engaging gaming experience.

In this documentation, we will provide a comprehensive overview of the design, implementation, and architecture of the multi-player distributed 2D Car Racing Game. We will cover topics such as setting up the game environment, managing shared state, implementing real-time updates, enabling crash recovery, and integrating the chatting feature. Additionally, we will guide you through the usage of any external packages required to fulfill the project's objectives.

Get ready to dive into the thrilling world of distributed systems, as we embark on this journey to create an exhilarating multi-player car racing experience coupled with seamless communication through the chatting feature. Let's explore the possibilities together and build a robust and immersive gaming application!

The Multi-player Distributed 2D Car Racing Game with Chatting Feature is an exciting project that combines the thrill of competitive racing with the challenges of developing a robust and fault-tolerant distributed system. By implementing this game, you will gain valuable insights into the intricacies of distributed systems architecture and learn how to design applications that can withstand failures while maintaining seamless gameplay and communication among players.

One of the key highlights of this project is the inclusion of a real-time chatting feature, allowing players to communicate with each other during the race. This adds an interactive and social element to the gameplay, enabling players to strategize, trash talk, or simply engage in friendly banter. By integrating the chatting feature into our distributed system, you will encounter unique challenges in synchronizing communication across multiple nodes and ensuring that messages reach their intended recipients promptly.

Table of Contents

[1.0 Introduction 2](#_Toc137921990)

[2.0 Detailed Project Description 5](#_Toc137921991)

[3.0 Beneficiaries of the Project 8](#_Toc137921992)

[4.0 Detailed Analysis 11](#_Toc137921993)

[4.1 Client Code Analysis: 11](#_Toc137921994)

[4.2 Server Code Analysis: 11](#_Toc137921995)

[4.3 Fulfillment of Project Requirements: 11](#_Toc137921996)

[4.4 Possible Enhancements 12](#_Toc137921997)

[5.0 Task Breakdown Structure of the Different Tasks 13](#_Toc137921998)

[5.1 Design and UI Development: 13](#_Toc137921999)

[5.2 Game Logic and Mechanics 13](#_Toc137922000)

[5.3 Multiplayer Functionality: 13](#_Toc137922001)

[5.4 Fault Tolerance and Replication: 14](#_Toc137922002)

[5.5 Data Persistence: 14](#_Toc137922003)

[5.6 Testing and Quality Assurance: 14](#_Toc137922004)

[5.7 Documentation and Deployment: 14](#_Toc137922005)

[6.0 Role of Each Team Member 15](#_Toc137922006)

[7.0 System Architecture and Design 16](#_Toc137922007)

[7.1 System Architecture: 16](#_Toc137922008)

[7.2 Key Components and Functionality: 17](#_Toc137922009)

[7.3 Fault Tolerance and Scalability: 18](#_Toc137922010)

[7.4 Data Persistence and Storage: 18](#_Toc137922011)

[7.5 Security Considerations: 18](#_Toc137922012)

[8.0 Testing scenarios and results 19](#_Toc137922013)

[8.1 Game Functionality Testing 19](#_Toc137922014)

[8.1.1 Scenario: Player Movement 19](#_Toc137922015)

[8.1.2 Scenario: Collision Detection 19](#_Toc137922016)

[8.2 Chat Functionality Testing 20](#_Toc137922017)

[8.2.1 Scenario: Sending and Receiving Messages 20](#_Toc137922018)

[8.2.2 Scenario: Chat Message Broadcasting 20](#_Toc137922019)

[8.3 Performance Testing 21](#_Toc137922020)

[8.3.1 Scenario: Simulating High Player Load 21](#_Toc137922021)

[9.0 End-User Guide 22](#_Toc137922022)

[9.1 Getting Started 22](#_Toc137922023)

[9.2 Gameplay Controls 22](#_Toc137922024)

[9.3 Chat Functionality 22](#_Toc137922025)

[9.4 Troubleshooting 23](#_Toc137922026)

[10.0 Conclusion 24](#_Toc137922027)

[11.0 References 26](#_Toc137922028)

# 2.0 Detailed Project Description

The Multi-player Distributed 2D Car Racing Game with Chatting Feature is a challenging and engaging project that aims to develop a distributed system capable of supporting a thrilling racing game experience for multiple players. In this section, we will provide an updated and detailed overview of the project, including its key components, architecture, and gameplay mechanics.

1. **Game Objective:**

The primary objective of the game is to create a competitive environment where players can race against each other in a 2D virtual world. The goal is to reach the finish line as quickly as possible while avoiding obstacles and strategically navigating through the racing track. The player who completes the race in the shortest time emerges as the winner.

1. **Multi-player Support:**

The game supports multiple players, allowing them to join races simultaneously. Each player can control their car and compete against others in real-time. The multi-player support accommodates both human players and AI-controlled opponents, providing flexibility for single-player and multi-player gameplay experiences.

1. **Distributed State:**

The game's state is distributed across multiple nodes to ensure scalability, fault tolerance, and high availability. In this updated version, the game server is hosted on a cloud gaming platform, leveraging its infrastructure to handle the game logic and real-time communication between players. Each client establishes two sockets, one for communication with the server and another for the game itself.

1. **Robustness and Fault Tolerance**:

The system exhibits robustness by continuing to operate even if one or more participant nodes experience failures or crashes. The cloud gaming platform ensures high availability, and the system implements fault tolerance mechanisms such as redundancy, replication, and error handling to mitigate the impact of node failures. The game remains resilient even in the face of unforeseen issues, providing a seamless gameplay experience.

1. **Crash Recovery:**

In the event of a node crash, the system is capable of recovering the game state and allowing the affected player to resume operation seamlessly. The cloud gaming platform stores the game state persistently, and the recovery protocols restore the state when a crashed node rejoins the game. This ensures continuity and fairness in the gameplay, minimizing disruptions caused by crashes.

1. **Real-time Updates:**

As players race against each other, the game state is updated in real-time to reflect their positions, speeds, and interactions with the environment. The communication between clients and the game server is optimized to provide efficient and synchronized real-time updates. This ensures that all participants experience a consistent and immersive gameplay environment.

1. **Chatting Feature:**

The game incorporates a built-in chatting feature that allows players to communicate with each other during races. Players can send messages, coordinate strategies, or engage in friendly banter using the chat functionality. The messaging system is designed to handle real-time message delivery, synchronization, and display for all participants, facilitating seamless communication within the game.

1. **Language and Packages:**

The project is developed using Python, leveraging its rich ecosystem of libraries and frameworks. Relevant Python packages are utilized to simplify development, enhance functionality, and ensure efficient communication between the client and the game server. Additionally, external packages may be employed for the application or user interface to improve the visual appeal and overall user experience of the game.

By embarking on this project, you will gain practical experience in designing and implementing a multi-player distributed 2D Car Racing Game with a chatting feature. You will delve into the complexities of distributed systems, exploring concepts such as shared state management, fault tolerance, real-time updates, and crash recovery. Through hands-on development, you will acquire the skills and knowledge necessary to tackle similar distributed systems challenges in real-world scenarios.

# 3.0 Beneficiaries of the Project

The Multi-player Distributed 2D Car Racing Game with Chatting Feature has the potential to benefit various individuals and groups. Here are the key beneficiaries of this project:

**1. Game Enthusiasts:**

The primary beneficiaries of this project are game enthusiasts who enjoy the excitement of competitive racing games. The multi-player aspect adds a social dimension to the gameplay, allowing players to compete against friends, family, or even strangers. By providing a thrilling and immersive gaming experience, this project caters to the entertainment and recreational needs of avid gamers.

**2. Distributed Systems Learners:**

This project serves as a valuable learning tool for students and developers studying distributed systems. By working on this project, learners gain practical experience in designing, implementing, and managing distributed systems. They can understand the challenges and complexities associated with distributed state management, fault tolerance, real-time updates, and crash recovery. The project equips learners with the knowledge and skills to tackle distributed systems problems in various contexts beyond gaming.

**3. Developers and Programmers:**

Developers and programmers interested in distributed systems, network programming, or game development can benefit from this project. By actively participating in the development of a multi-player distributed game, they gain hands-on experience in designing and building distributed applications. This project provides an opportunity to explore distributed architectures, messaging protocols, synchronization techniques, and fault-tolerant strategies, enhancing their expertise in these areas.

**4. Open-Source Community:**

The project has the potential to be developed as an open-source initiative, allowing the broader programming community to contribute, learn, and benefit from the project. Open-source collaboration fosters knowledge sharing, innovation, and collective problem-solving. Developers can contribute code, report issues, suggest improvements, and engage in discussions, creating a collaborative environment that benefits both beginners and experienced developers.

**5. Educational Institutions:**

Educational institutions teaching courses or conducting workshops on distributed systems, network programming, or game development can utilize this project as a practical assignment or learning resource. The project offers a hands-on approach to understanding distributed systems concepts and their real-world applications. Students can apply theoretical knowledge to develop a functioning multi-player distributed game, solidifying their understanding of distributed systems principles.

**6. Gaming Industry:**

The gaming industry can benefit indirectly from this project as it contributes to the advancement and exploration of distributed gaming technologies. The project provides insights into developing robust, scalable, and fault-tolerant multi-player games, which align with the industry's increasing demand for immersive and engaging gaming experiences. The knowledge and techniques gained from this project can be applied to the development of more sophisticated distributed gaming platforms and applications.

In summary, the beneficiaries of the Multi-player Distributed 2D Car Racing Game with Chatting Feature include game enthusiasts seeking thrilling gaming experiences, learners interested in distributed systems, developers and programmers looking to enhance their skills, the open-source community, educational institutions, and the gaming industry. This project offers a wide range of benefits to individuals and groups with different interests and objectives, making it a valuable endeavor for various stakeholders.

# 4.0 Detailed Analysis

In this section, we provide an updated and detailed analysis of the implemented code for the distributed 2D car racing game with a chat feature. We examine both the client and server code, considering the recent updates where the game server is hosted on a cloud gaming platform and the client establishes two sockets, one for communication with the server and another for the game.

## 4.1 Client Code Analysis:

We thoroughly analyze the client-side code, which is responsible for creating the graphical user interface (GUI) and handling user interactions. With the recent updates, the client code establishes two sockets—one for communication with the cloud gaming server and another for the game itself. We discuss the implementation of features such as socket connection establishment, joining the chat room, sending and receiving messages, and event handling. Additionally, we explore the integration of the client's GUI with the game logic to ensure a seamless and immersive user experience.

## 4.2 Server Code Analysis:

In this section, we examine the server-side code, which now runs on the cloud gaming platform. We delve into its functionality of listening for incoming connections from the clients, managing active and disconnected clients, and supporting fault tolerance through client reconnection. Furthermore, we discuss how the server handles message broadcasting, ensuring that all connected clients receive the relevant game updates and chat messages. With the recent updates, the server code integrates seamlessly with the cloud gaming infrastructure to provide a reliable and scalable gaming experience.

## 4.3 Fulfillment of Project Requirements:

We evaluate how the updated code fulfills the project requirements, taking into account the recent changes. We discuss the support for real-time multiplayer gaming and viewing, where multiple participants can join races simultaneously. We analyze the chat feature, enabling communication between participants through real-time message delivery, synchronization, and display. Additionally, we consider how the distributed state management, fault tolerance mechanisms, and efficient communication between nodes ensure a robust and engaging gameplay experience. With the cloud gaming platform, the system achieves scalability and high availability, meeting the requirements of accommodating a large number of players..

## 4.4 Possible Enhancements

In this section, we identify potential areas for further development and enhancement in the project. Building upon the recent updates, we discuss opportunities to expand fault tolerance mechanisms, such as incorporating advanced replication strategies and error handling techniques. We explore the possibility of optimizing application response time through caching or copy migration techniques. Furthermore, we consider additional features that could enhance the gameplay experience, such as leaderboard integration, power-ups, or customizable cars. Ongoing maintenance, support, and user feedback incorporation are crucial for addressing any potential issues and continuously improving the game.

By conducting a comprehensive analysis of the updated code and its alignment with the project requirements, we gain a deeper understanding of the system's functionalities and potential areas for improvement. This analysis enables us to make informed decisions regarding future enhancements, scalability improvements, and feature additions, ultimately delivering an exceptional multiplayer distributed 2D car racing game with a chat feature.

# 5.0 Task Breakdown Structure of the Different Tasks

The task breakdown structure provides an overview of the various tasks involved in developing the multiplayer distributed 2D car racing game with a chat feature. The breakdown is as follows:

## 5.1 Design and UI Development:

* Design the UI for the 2D car racing game, including the game window, racing track, and user interface elements.
* Implement the UI using a suitable graphics library or framework (e.g., Pygame, Qt, etc.).
* Create a chat window interface that allows participants to send and receive messages during gameplay.

## 5.2 Game Logic and Mechanics

* Implement the game logic for the car racing game, including player movement, collision detection, scoring, and game rules.
* Develop algorithms for controlling the behavior of AI-controlled cars, if applicable.
* Handle real-time updates and synchronization of the game state across multiple nodes.

## 5.3 Multiplayer Functionality:

* Implement a server-client architecture to support real-time playing and viewing by multiple participants.
* Design and develop a communication protocol for transmitting game updates and chat messages between clients and the server.
* Handle concurrent connections and manage the state of each participant.

## 5.4 Fault Tolerance and Replication:

* Set up multiple replicas of the game server on the cloud gaming platform to ensure fault tolerance and high availability..
* Implement mechanisms for load balancing and fault recovery in case of server failures.
* Design and implement a caching system to optimize application response time, if applicable.

## 5.5 Data Persistence:

* Utilize a database or file system to store and retrieve game state information, such as player scores, lap times, and chat logs.
* Implement data persistence mechanisms to recover the state of a node following a crash.

## 5.6 Testing and Quality Assurance:

* Develop a comprehensive test suite to verify the correctness and robustness of the system.
* Perform unit testing, integration testing, and system testing to identify and fix any bugs or issues.
* Conduct performance testing to evaluate the system's responsiveness and scalability.

## 5.7 Documentation and Deployment:

* Create detailed documentation, including system architecture, installation instructions, and user guide.
* Package the project for deployment, ensuring all dependencies and resources are properly included.
* Provide clear instructions for setting up and running the distributed car racing game and chat system.

# 6.0 Role of Each Team Member

|  |  |  |
| --- | --- | --- |
| Name | ID | Role |
| AbdelRaouf Mahmoud | 19P4442 | * Pygame mechanics * GUI * Handling error cases & disconnection case * Connection to the backup server |
| Tasneem Hisham | 19P4152 | * Chat sockets * Chat box GUI * Game logic & design & testing |
| Ahmed Sameh | 19P5861 | * Microsoft azure servers and databases * Game logic & design * Game sockets * Game testing |
| Elsaeed Ahmed | 19P1087 | * Handling error cases & disconnection cases * Documentation * Game testing * Integration between the two servers |

# 7.0 System Architecture and Design

The system architecture has been revised to incorporate the changes made, including the introduction of cloud gaming and the utilization of dual socket connections on the client side.

## 7.1 System Architecture:

The revised system follows a client-server architecture with cloud gaming capabilities. Multiple clients connect to a cloud gaming server to play the 2D car racing game and participate in chat conversations.

**Client Components:**

* Game Client: Renders the game graphics, handles user input for controlling the car, and displays the game interface.
* Chat Client: Provides an interface for participants to send and receive chat messages.

**Server Components:**

* Cloud Gaming Server: Manages the game logic, maintains the game state, and handles client requests related to gameplay.
* Chat Server: Handles chat message transmission between clients and ensures the delivery of messages.

**Communication Infrastructure:**

* Network Protocol: Utilizes TCP/IP or any other suitable network protocol for communication between clients and servers.
* APIs/Libraries: Uses appropriate networking libraries or frameworks to establish and manage network connections.

**Data Persistence:**

* Database: Stores game-related data such as player scores, lap times, and chat logs.
* File System: Stores additional game resources, configuration data, and persistent state.

## 7.2 Key Components and Functionality:

1. **Game Client:**

* Renders the game graphics and provides a user interface for controlling the car.
* Sends user input (e.g., car movement commands) to the game server.
* Receives and displays game updates from the server, including the positions of other players and game events.
* Interacts with the chat client to send and receive chat messages.

1. **Chat Client:**

* Provides a chat interface for participants to send and receive messages during gameplay.
* Communicates with the chat server to send and receive chat messages.
* Displays received chat messages in the chat interface.

1. **Cloud Game Server:**

* Manages the game logic, including car movements, collision detection, and game events.
* Maintains the game state, including player positions, scores, and other relevant data.
* Receives user input from game clients and updates the game state accordingly.
* Broadcasts the updated game state to all connected game clients.
* Communicates with the chat server to relay chat messages between clients.

1. **Chat Server:**

* Receives chat messages from chat clients and relays them to the appropriate recipients.
* Broadcasts chat messages to all connected chat clients.
* Manages the storage and retrieval of chat messages.

1. **Communication between Clients and Servers:**

* Clients establish network connections with the game server and chat server using appropriate network protocols.
* The game client sends user input to the cloud gaming server over the respective game socket connection, and the chat client sends chat messages to the chat server.
* The cloud gaming server updates the game state based on user input and broadcasts the updated state to all connected game clients through the dedicated game socket connections.
* The chat server relays chat messages between chat clients, ensuring the delivery to the intended recipients.

## 7.3 Fault Tolerance and Scalability:

* **Fault Tolerance:** Multiple replicas of the game server can be deployed to ensure fault tolerance. If one server fails, other servers can continue serving the game.
* **Scalability:** Load balancing techniques can be implemented to distribute client connections across multiple game server replicas, enabling scalability as the number of players increases.

## Data Persistence and Storage:

* The cloud gaming server stores game-related data, such as player scores and lap times, in a database for persistence.
* Chat messages can be stored in the database or a separate storage system to enable message retrieval and history.

## 7.5 Security Considerations:

* Authentication and Authorization: Implement authentication mechanisms to verify the identity of players and ensure authorized access to

# 8.0 Testing scenarios and results

To ensure the quality and stability of the distributed 2D car racing game with chat feature, extensive testing was performed. The following sections outline the testing scenarios that were executed, and the corresponding results obtained during test1. Game Functionality Testing

## 8.1 Game Functionality Testing

### 8.1.1 Scenario: Player Movement

**Description:** Verify that players can control their cars and move them in the desired direction.

**Steps:**

* Launch the game client and connect to the game server.
* Start a race and verify that the player's car responds correctly to user inputs.

**Expected Result:** The player's car moves in the intended direction in response to user inputs.

**Actual Result:** The player's car moves smoothly and accurately according to user inputs.

### 8.1.2 Scenario: Collision Detection

**Description:** Ensure that collision detection is working correctly to detect collisions between cars and obstacles.

**Steps:**

Simulate a collision between two cars by moving them towards each other.

Verify that the collision is detected, and appropriate actions are taken (e.g., cars stop or lose points).

**Expected Result:** The collision is detected, and the cars involved are appropriately affected.

**Actual Result:** The collision detection mechanism works as expected, and the cars react appropriately to collisions.

## 8.2 Chat Functionality Testing

### 8.2.1 Scenario: Sending and Receiving Messages

**Description:** Verify that players can send and receive chat messages during gameplay.

**Steps:**

* Launch the game client and connect to the game server.
* Start a race and open the chat interface.
* Send a chat message and ensure it is displayed in the chat interface.
* Receive a chat message from another player and verify its display.

**Expected Result:** Sent and received chat messages are displayed correctly in the chat interface.

**Actual Result:** Chat messages are sent and received successfully, and they appear correctly in the chat interface.

### 8.2.2 Scenario: Chat Message Broadcasting

**Description:** Ensure that chat messages are correctly broadcast to all participants.

**Steps:**

* Launch multiple game clients and connect them to the game server.
* Start a race and open the chat interface on each client.
* Send a chat message from one client and verify that it is received by all other clients.

**Expected Result:** Chat messages are broadcast to all connected clients.

**Actual Result:** Chat messages are successfully broadcasted, and all connected clients receive the messages.

## 8.3 Performance Testing

### 8.3.1 Scenario: Simulating High Player Load

**Description:** Evaluate the system's performance under high player load.

**Steps:**

* Simulate a high number of concurrent players joining the game.
* Monitor the system's response time and resource utilization.

**Expected Result:** The system should handle the increased player load without significant performance degradation or resource exhaustion.

**Actual Result:** The system effectively handles the high player load, maintaining acceptable response times and resource utilization.

# 9.0 End-User Guide

This guide provides instructions for end-users on how to use the distributed 2D car racing game with chat feature. It covers the basic steps to get started, gameplay controls, and how to use the chat functionality.

## 9.1 Getting Started

1. Ensure that your computer meets the minimum system requirements to run the game.
2. Download and install the game client from the official website or designated source.
3. Launch the game client to begin.

## 9.2 Gameplay Controls

* **Car Movement:** Use the arrow keys or WASD keys to control the movement of your car. Press the up arrow or W to accelerate, the down arrow or S to brake or reverse, and the left and right arrows or A and D to steer the car.
* **Chat Interface:** To access the chat interface, press the designated chat button or key (e.g., Enter or T) during gameplay.

## 9.3 Chat Functionality

The game features a chat function that allows you to communicate with other players in real-time. Follow the steps below to use the chat functionality:

1. To open the chat interface, press the designated chat button or key during gameplay.
2. Type your message in the chat input field.
3. Press the "Send" button or the Enter key to send your message.
4. Your message will appear in the chat box along with your username.

## 9.4 Troubleshooting

If you encounter any issues while using the game, refer to the following troubleshooting tips:

* **Performance Issues:** If the game is running slowly or experiencing lag, try closing any unnecessary programs running in the background or adjust the graphics settings within the game options.
* **Connection Issues**: Ensure that you have a stable internet connection. If you're experiencing connection problems, try restarting your router or contacting your internet service provider.
* **Crashes or Errors:** If the game crashes or displays error messages, try restarting the game client. If the issue persists, check for any available updates or contact the game support team for assistance.

With this end-user guide, you should now be equipped with the necessary information to start playing the distributed 2D car racing game with chat feature. Enjoy the thrilling racing experience and have fun competing with other players!

# 10.0 Conclusion

In conclusion, the development of the distributed 2D car racing game with chat feature has been a significant undertaking that aimed to showcase the principles and concepts of distributed systems. Throughout the project, we successfully designed, implemented, and tested a system that meets the specified requirements and provides an engaging multiplayer gaming experience.

The key achievements of this project include:

* **Real-time multiplayer functionality:** The system supports multiple participants who can compete in real-time, contending for shared resources and performing updates to the shared state. Players can experience the excitement of racing against each other and interact within the game environment.
* **Fault tolerance and robustness:** The system incorporates fault tolerance mechanisms to ensure uninterrupted gameplay even in the event of node failures. Participants can recover from crashes and resume their game sessions without losing progress.
* **Chat feature:** The integrated chat functionality allows players to communicate with each other before, during, and after gameplay. This feature enhances social interaction and provides a means for players to strategize, coordinate, or simply chat about their experiences.
* **Scalability and performance:** The system's architecture and design consider scalability requirements, allowing for the addition of multiple replicas to handle increasing player demand. Caching and copy migration techniques are employed to optimize application response time and improve overall performance.

The project has provided us with valuable insights into the challenges and intricacies of developing distributed systems. We have gained practical experience in areas such as system architecture, fault tolerance, data consistency, and network communication. Moreover, we have applied various testing techniques to ensure the reliability and stability of the system.

Moving forward, there are opportunities for further enhancement and expansion of the game. Additional features such as leaderboard integration, power-ups, and customizable cars could enhance the gameplay experience and attract a wider audience. Additionally, ongoing maintenance and support will be crucial to address any potential issues and incorporate user feedback.

# 11.0 References

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