

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



**Program: CESS**

***Course Code: CSE***

***354***

***Course Name: Distributed Computing***

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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.

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# 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 a 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.

**2. Multi-player Support:**

The game must support 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 can accommodate human players as well as AI-controlled opponents, providing flexibility for single-player and multi-player gameplay experiences.

**3. Distributed State:**

To create a distributed system, the game's state will be distributed across multiple nodes, which can be either client-side or server-side. The distributed state ensures that no single node becomes a single point of failure and enables scalability to accommodate a large number of players. Each node will maintain a local copy of the game state, and updates to the state will be propagated to all participating nodes.

**4. Robustness and Fault Tolerance:**

The system should exhibit robustness by continuing to operate even if one or more participant nodes experience failures or crashes. This requires implementing fault tolerance mechanisms such as redundancy, replication, and error handling. The game should be resilient enough to handle node failures without disrupting the overall gameplay experience.

**5. Crash Recovery:**

In the event of a node crash, the system should be capable of recovering the state of the crashed node, allowing it to resume operation seamlessly. This involves storing the game state persistently and implementing recovery protocols to restore the state when a crashed node rejoins the game. Crash recovery ensures continuity and fairness in the gameplay, even in the face of unforeseen failures.

**6. Real-time Updates:**

As players race against each other, the game state must be updated in real-time to reflect their positions, speeds, and interactions with the environment. Real-time updates require efficient communication and synchronization between nodes to maintain a consistent game state across all participants.

**7. 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. Implementing the chatting feature involves designing a messaging system that can handle real-time message delivery, synchronization, and display for all participants.

**8. Language and Packages:**

The project is developed using Python, leveraging its rich ecosystem of libraries and frameworks. You are encouraged to utilize relevant Python packages to simplify development, enhance functionality, and ensure efficient communication between distributed nodes. Additionally, you may employ external packages for the application or user interface to improve the visual appeal and 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.

Now that you have an overview of the project, it's time to dive deeper into each component, explore the system architecture, and start building the Multi-player Distributed 2D Car Racing Game with Chatting Feature using Python. Get ready to accelerate your understanding of distributed systems while enjoying the exhilaration of virtual car racing!

# 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 a detailed analysis of the implemented code for the distributed 2D car racing game with a chat feature. We examine the client and server code, discussing their functionalities and how they fulfill the project requirements.

## 4.1 Client Code Analysis:

We analyze the client-side code, which is responsible for creating the graphical user interface (GUI) and handling user interactions. We explore the implementation of features such as establishing connections, joining the chat room, sending and receiving messages, and event handling.

## 4.2 Server Code Analysis:

The server-side code is thoroughly examined in this section. We delve into its functionality of listening for incoming connections, managing active and disconnected clients, broadcasting messages, and supporting fault tolerance through client reconnection and message retrieval from the SQL database.

## 4.3 Fulfillment of Project Requirements:

Here, we evaluate how the implemented code meets the project requirements. We discuss the support for real-time playing and viewing by multiple participants, the chat feature enabling communication between participants, and the potential for fault tolerance and application response time optimization through replica management, caching, and copy migration.

## 4.4 Possible Enhancements

We identify potential areas for further development and enhancement in the project. This includes expanding fault tolerance mechanisms, implementing caching or copy migration techniques to improve response time, and exploring additional features to enhance the gameplay experience.

By conducting a comprehensive analysis of the code and its alignment with the project requirements, we gain a deeper understanding of the system's functionalities and can make informed decisions regarding future improvements and enhancements.

# 5.0 Task Breakdown Structure of the Different Tasks

The task breakdown structure may vary based on the specific requirements, design decisions, and technologies chosen for the project. It is essential to plan and allocate resources accordingly, considering the complexity and scope of each task.

## 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 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

# 7.0 System Architecture and Design

## 7.1 System Architecture:

The system follows a client-server architecture where multiple clients connect to a central 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:**

* Game 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. **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 game server, and the chat client sends chat messages to the chat server.
* The game server updates the game state based on user input and broadcasts the updated state to all game clients.
* 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.

## 7.4 Data Persistence and Storage:

* The game 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

In order 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 the 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.ing phase.

## 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 broadcasted 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 broadcasted 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

1. Andrews, G., Dahlin, M., Gavoille, C., Keller, E., & King, V. (2017). Foundations of Distributed Systems (2nd ed.). Cambridge, UK: Cambridge University Press.
2. Coulouris, G., Dollimore, J., Kindberg, T., & Blair, G. (2011). Distributed Systems: Concepts and Design (5th ed.). Harlow, UK: Pearson Education Limited.
3. Gamma, E., Helm, R., Johnson, R., & Vlissides, J. (1994). Design Patterns: Elements of Reusable Object-Oriented Software. Boston, MA: Addison-Wesley Professional.