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Development of an Interactive Android-Based Ayo-Olopon Game

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Abstract: *: One of the most widely acceptable means of entertainment all over the world is Games especially in Africa to ease the mind from stress after a rigorous day's work. Over the years, there have been several African games nearly going into extinction due to the advancement of more new smartphone-based games and the general public is more comfortable using the modern-day gizmo. This has brought about reduction in the number of people that understands and knows about African traditional games and ethics. A lot of effort has been put in place by many developers and researchers to digitalize these games (like Ayo-Olopon) to improve their popularity and expand their accessibility across the globe. The current versions of this Ayo-Olopon game does not provide room for Multi-player in real time nor presence of third party as viewer during the game session. This research developed an android-based Ayo-Olopon game using a stack of React Native for the frontend design and server-side scripting through Node.Js, Websocket was also incorporated which enables real-time communication for multi-players and a third party to join the game as a viewer. The game was evaluated using feedback from randomly selected user and more than 98% of them ascertained its uniqueness and excellent performance. Response speed and transfer time were also used as the evaluation metrics with varying network technologies and protocols, WLAN network technology with gave the shortest response time and transfer speed of 150ms and 0.263s respectively f. This shows that the developed Ayo-olopon game gave a very satisfactory user experience and good performance with good Computational time. Future work should focus on enabling viewers to use audio or chat to motivate the players and increase their morale.*

Keywords: *Ayo-Olopon, Multi-Player, Javascript, React Native, Africa Game.*

1. INTRODUCTION

The advancement of technology has helped in the digitalization of different parts of human life, entertainment inclusive. One of the most digitalized entertainment is gamification, which is the act of digitalizing games, to enhance globalization and sharing of different local and international games with the world. As a result of this, knowledge, trade and culture are shared with the world which in turn brings about peaceful coexistence. Technological advancement has helped with the development of different physical games into desktop or Android/IOS-based games like Chess, Nigeria Whott, Ludo, etc.
Several Indigenous African games have been proven to attract people's interest globally over the years with the "Ayo-Olopon" standing out as a unique ancient game. Ayo is a traditional game common among the Yoruba people, who dominates and originates from the South-Western states of Nigeria and occupies some areas of the Republic of Benin. It is played with a board with holes caved in it placed in between the players as two opposing rows of six pits on either side with four Caeselpinia crista seeds in each hole, summing to a total of forty-eight seeds on each board at the beginning [1]. The board games have been a source of entertainment and social interaction for centuries. They offer a unique opportunity for players to engage in strategic thinking and planning, decision-making with skilful moves and friendly competition, games like this were used to prove Westerners wrong when they belittled the intelligence capacity of Africans.

The digitalization of the game has led to new avenues for widespread, accessibility and enhanced gameplay, thus reaching a wider audience. However, a critical examination of existing solutions made it clear that they lack the initial and major motive for playing games which is the ability of players to come together from various locations to communicate and have good interaction with fellow human and not with Computer as the opponent [2]. There is a need for the players to be able to play the game from different locations and communicate with each other in real time. The digitalization of traditional games like Ayo-Olopon will help in the exportation of African culture to the world which showcases the depth of Africa's creativity, civilization and intelligence capacitation even before the African-Westerners' relationship.

This study aims to develop an Ayo-Olopon mobile-based game using HTML, CSS and Native React for the frontend development and Node.js for the backend development. The game introduced an advancement over the previously developed versions of the Ayo-Olopon game with the ability of the third party to serve as the viewer in real-time during the game session. Players can also play with each other from different locations via real-time communication using WebSocket.

This study will help to connect technology with ethics and tradition and, at the same time revitalize the youths' interest in the Ayo game as they can easily play it on their smartphones with their friends, which in turn creates a community of traditional ethics lovers.

2. RELATED WORKS

Ayo-Olopon, a traditional African board game, has gained popularity in the digital era with the rise of mobile gaming and the advancement in gamification due to the ease provided by Smartphones. This section examines and reviews some existing literatures on game development, to present the state-of-art in Ayo-Olopon game.

Martinez-Garza et al., conducted a systematic review of Digital Games used for Learning. Detailed review of the previous works on game development was reported. The authors developed a method to increase the meaningfulness and strategic influence of usability data. Data from four summative evaluations indicate that the model provided a versatile method that can be used to develop a single, standardized, and summated score for analysing and reporting usability metrics [3]. Akinyemi et al., presented a similar study that employed decision-making approach based on computer simulation for playing Ayo-Olopon game. They presented a simple Heuristic Decision Making (HDM) approach which is have an efficient computational performance and has the ability to predict the best move to be initiated within a short period of time. This simple HDM introduced by the authors incorporates a new approach and techniques for playing the game which improves the flexibility and acceptability of the game, which enhance fast sensitivity to identify possible mistakes and take fast decision and approach to either correct or avoid the mistake [1].

Bonako Developer developed a desktop-based Ayo-Olopon game, the motive of developing this game is to ensure users of desktop computers can also enjoy this game being played on their computer. This game was developed to be playable offline which involves the computer user and computer agent, this session with the computer agent enhances the player's understanding about the game. However, since the game is desktop based, I faces some cons like slow response time and disruption of game session due to playtime crashing. [4]. An updated version of the Ayo gave was developed by Bonako Developer, this version was a mobile-based Ayo-Olopon game based on the idea of a token reward system and contest. The game is modelled in a way that two random users online can bet some of theirs on a game session where the winner takes all. The idea is to make the game fun and competitive at the same time, but most users have complained about the in-app ads which pop out almost every time to distract the gameplay [5].

Chess.com developed a mobile version of chess game, the game is named Chess - Play & Learn, and this game offers a range of different skill levels, ranging from beginner to grand master. This gives room for players of different skill levels to find opponent that matches their level of expertise. There is also different chess and puzzle challenges that will enhance the players understanding and expertise. There is also an added feature that will help payers to keep track of their games history and wins. However, the user also complained of the slow response time of the game [6]. Moonbear developed a similar Ayo-Olopon game, this game imitate the cartoon character and animation in the gaming world. This game employs tokens as a means of rewarding the winning player, this token can be used for betting while playing in a session. This innovative idea increases the competition between players as they would not want to lose their tokens to their opponents [7].

Taytronik developed a distinct version of Ayo-Olopon game which aimed at enriching user's experience. The game can be played in two modes either with a computer or multiplayer. The game recorded more than 500,000 downloads with good users' reviews, the game was well accepted by the user due to its multi-player's functionality but the poor user interface made users to complain and suggest improvement [8]. A similar study was carried out by Ibiene who designed a version of Ayo-Olopon game called Awale, this game focused more on levels, and the level of the game's toughness increased as the player wins a level. There is also an option to either play with a computer agent or initiate a multi-player with a friend. You can play the game based on a computer player or multiplayer with friends. The major issue with the model is the user interface, which is the only complaint most users have with it [2].

From all the reviewed literature, none of these studies neither prioritized multi-player mode with possible session from different locations nor they considered the presence of third party as spectator and not just players. As widely known, the presence of fans as spectators in the game helps motivates the player(s) more and makes the game livelier and more fun. This great part of gaming was not considered by any of the researchers during the development of their respective Ayo and other games, this is what this study filled by making it possible to have people as spectators viewing the game in real-time via just an invitation link.

3. RESEARCH METHODOLOGY

Development of every software (game inclusive) involves employing the software development cycle for successful development, deployment and validation of such software. This research employed the waterfall software development cycle; Requirements Gathering, Software Design, Software Development, Test and Integration, Deployment and User feedback. Figure 1 shows these phases and some approaches used in achieving them.

3.1 Requirement Elicitation

This stage is also known as requirement gathering or analysis; where the users' requirements are identified, collected and documented to help in developing a system that suits their needs. Requirement Elicitation data was gathered from the Southern part of Nigeria, which gave a deep insight into the users' requirements for the design and development of the Android version of the game. Ayo-Olopon players in this geographical area were orally interviewed to know their

opinions and requirements for the Android Ayo-Olopon game. This was carried out by the development team. The scope of the game was defined to ensure the game was in line with the defined requirements, after which the requirements were redefined and prioritized so that the important ones were executed first to ensure the project was on track.

3.2 Software Design

After the software requirements had been well sourced, documented and analysed, this information was used to design the software by converting the user's requirements into a virtual design, to illustrate how the design would look and help serve as the first test case to get feedback from the users. The design was done using Figma; a cloud-based design and prototyping tool that is primarily used for creating user interfaces for websites and mobile applications. It offers a range of features such as vector editing, collaboration tools, and the ability to generate design systems. Figma was used for the design prototyping due to its ease of use and real-time collaboration capabilities, which make it popular among design teams. It's also a popular choice among developers because it allows them to directly access design files and assets, which can be useful for implementing designs in code. The software went through a series of design iterations, to give the best design that suits the user's requirements.

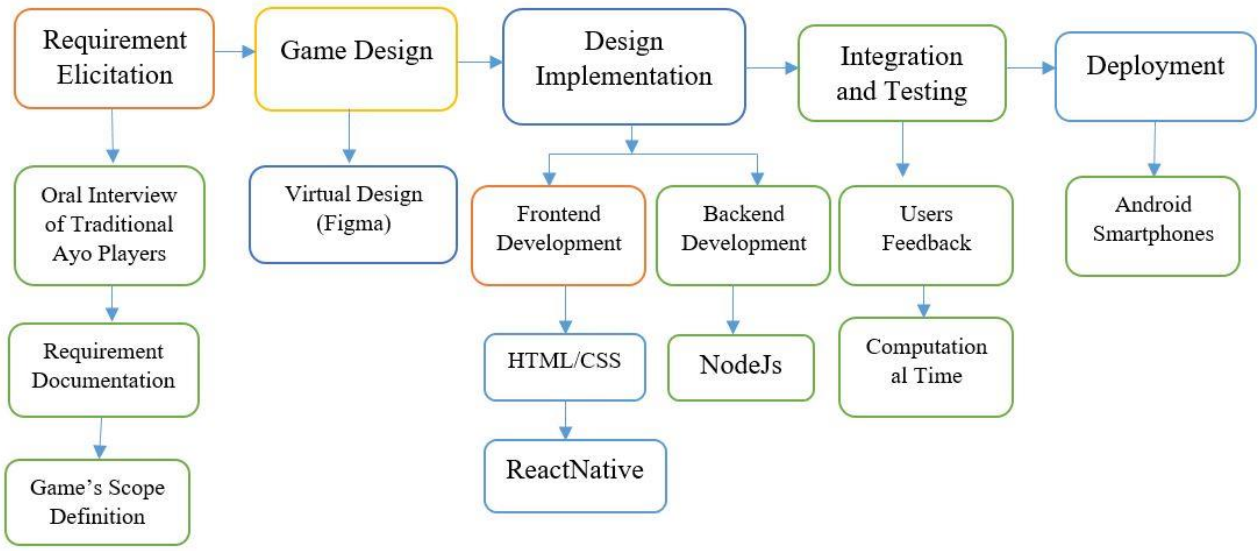


Figure 1: Block diagram of ayo-olopon development stages

3.3 Software Development

Software development also known as design implementation, this phase follows the design phase, once the design has met the requirement of the user(s). The development phase involves the teamwork of several developers- frontend and backend developers- to design and write code for the functionality of the software. The development phase is an iterative process, with developers making regular updates and improvements to the software as it is being built. This phase involves the combination of frontend and backend development as stated earlier; these two phases are explained in the following sub-sections.

3.3.1 Frontend development

Frontend development, also known as client-side development, is the practice of building the user-facing parts of a website or application. This typically involves working with client-side languages like HTML, CSS, and JavaScript to create the visual elements and user interactions of a website or application. Frontend developers are responsible for ensuring that the user interface is attractive, easy to use, and functional. React Native was used for the Client-side development of this game, it is a popular choice for mobile app development, it allows developers to create native mobile apps using the React JavaScript library, it also allows the reuse of code between different platforms, so developers can use the same codebase to create apps for both iOS and Android. This can save time and resources, and make it easier to maintain and update the app in the future.

After the React Native had been created and Nativebase had been installed, nativebase was imported into the project, after which other operations were carried out, like importing and using the Button component in the installed Nativebase as shown in Figure 2a.

3.3.2 Backend development

Backend development is a key aspect of software development that deals with the server side of an application, while Frontend deals with the client side as discussed earlier. It involves creating and maintaining the server side of the application and ensuring that it can communicate seamlessly with the front end. The backend is responsible for handling and processing all the data, logic and business rules of the application, and providing the frontend with the necessary data

to be displayed to the user. NodeJs a JavaScript runtime environment that allows developers to run JavaScript code on the server-side, was used for the server-side development of the game. It has a large and active developer community, which means that there are many libraries, frameworks, and tools available to help developers build and deploy their applications quickly and easily. It is also known for its good performance, making it well-suited for building scalable and high-traffic web applications. Figure 2b shows the Nodejs code snippet that imports the required modules, creates an express server, and sets up socket.io to work with the server.

```
import { Button } from 'nativebase';
render () {
  return (
    <Button>
      Click me!
    </Button>
  );
}
```

(a)

```
const express = require('express');
const app = express();
const server = app.listen(3000);

const io = require('socket.io')(server);

app.use(express.static('public'));
```

(b)

Figure 2: Code snippet for some frontend and backend development

The follow lines of codes represent a few line of NodeJs for game handler which enables a player to initiate game and create an invite link to be sent to co-player or spectator

```
const { v4: uuidv4 } = require("uuid");
const Room = require("../Models/Room");
const User = require("../Models/User");
const UserRoom = require("../Models/UserRoom");
const { successResponse, errorResponse } = require("../helpers/response");

module.exports = (io, socket) => {
  const onCreateGame = async ({ playerName }) => {
    try {
      const inviteCode = uuidv4().substring(0, 6);
      const user = await User.create({ name: playerName });
      let room = await Room.create({ inviteCode });
      await UserRoom.create({
        userId: user._id,
        roomId: room._id,
        role: "host",
      });

      const userRoom = await UserRoom.find({ roomId: room._id })
        .populate(["user"])
        .lean();

      room = room.toObject();
      room.users = userRoom;

      const roomId = room._id.toString();
      socket.join(roomId);
      io.in(roomId).emit("game:created", successResponse(room, "Game created"));
```

3.4 Integration and System Testing

The design implementation phase is followed by the integration stage, this is the stage where both the frontend and backend are integrated to form a complete software. After the integration of these two projects, the software was then tested. Testing in software development refers to the process of evaluating a software application to ensure it meets the required specifications and users' requirement documented and performs as expected. This is typically done by running the software through a series of tests that simulate different scenarios and user interactions. These tests can help to identify any errors or bugs in the software, and ensure that the software is working properly and meeting the needs of the user and to ensure the quality and reliability of the software. It is typically done at various stages of the development process, from initial unit testing to more comprehensive end-to-end testing.

3.5 Deployment

Deployment in software development refers to the process of making a software application available to users. This typically involves packaging the application and all of its dependencies and then deploying it to a server or other environment where it can be accessed and used by users. Deployment is an important step in the software development process, as it makes the software available for use and testing by real users. It is typically done after the software has been developed and tested, and may involve several different steps, such as configuring the server environment, setting up security protocols, and deploying the application. Deployment may also involve ongoing maintenance and updates to the software, to ensure that it remains stable and secure over time.

The backend server was deployed on a Heroku server which is a cloud-based platform-as-a-service (PaaS) that enables developers to easily deploy, run and scale their applications. The client-server will be deployed on the Playstore for user easy access. Playstore is the official app store for the Android operating system, it allows users to browse and download apps developed with the Android software development kit (SDK). Deploying the client-server on the Play Store makes it easy for users to find and download the application on their Android devices.

3.6 Working Principle of the Game

The game is built on a real-time connection principle where the users are added to a game room either as a player or a viewer, and a temporary room is created for every game session where users are added. This user can either be a Player; one of the two users that will be playing the game or a Viewer; a spectator willing to partake in the game but not as a player.

In the process of creating the game session, two invite links is been created for both players and viewers which will be sent to each user respectively, if there are two players in a game already and someone is trying to join as a player, they are automatically converted to a viewer and once one of the players leaves a game through the permission of the other player the game session is automatically concluded in favour of the other player i.e. if player 1 is interested in ending the game, a notification is sent to the other player to know if the player is on board with the decision. If the player accepts the request the game automatically ends in favour of the other player. If not, the game continues unless the whole app is been closed which will end the game due to the other player's non-availability.

The aforementioned working principle of the developed game is represented in Figure 3 from the stage of entering the game, through starting a game session, joining as a co-player or viewer, playing the game to ending the game.

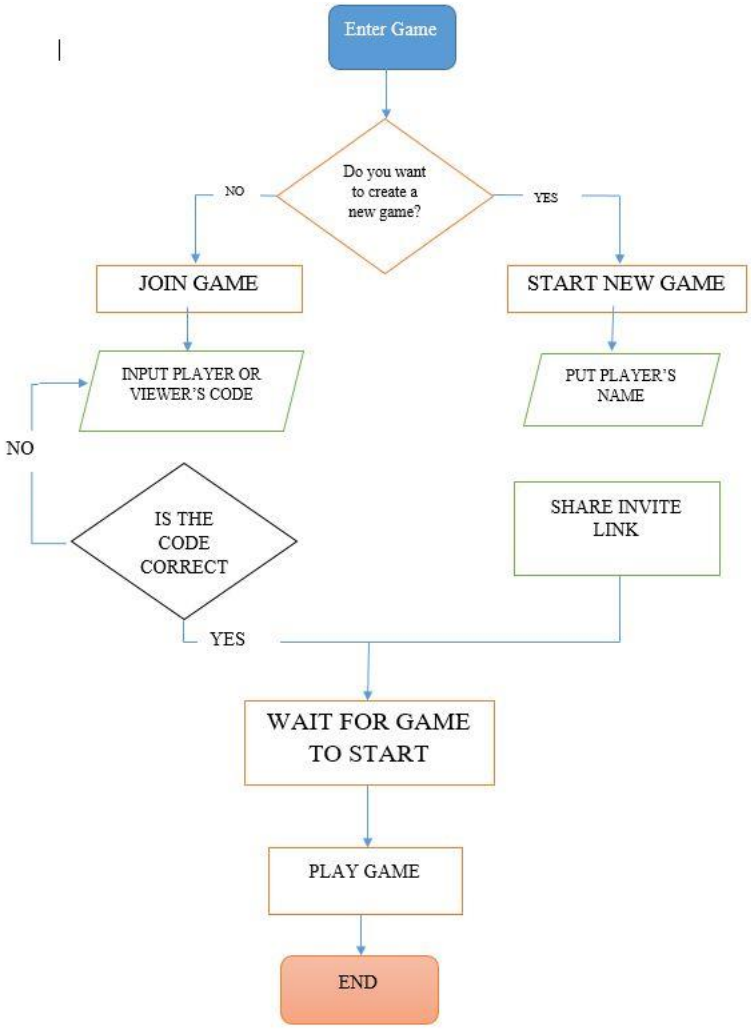


Figure 3: Flowchart of Ayo-Olopon game

3.7 Performance Evaluation.

The primary objective of studying the effectiveness of real-time games in wireless networks involved determining their true performance within an actual network setting. Consequently, relying on computer simulations to assess network performance was deemed unsuitable. Instead, the performance of the game was evaluate employing a server operating on a standard PC and mobile clients running on two Techno Camon 15 and Xiaomi Note 10 mobile phones. To ensure comprehensive data, performance tests were conducted multiple times throughout different periods of the day and various days, capturing typical fluctuations in data traffic.

Response time and transfer speed are the key metrics used to evaluate the performance of the developed real-time Ayo-Olopon game in a network.

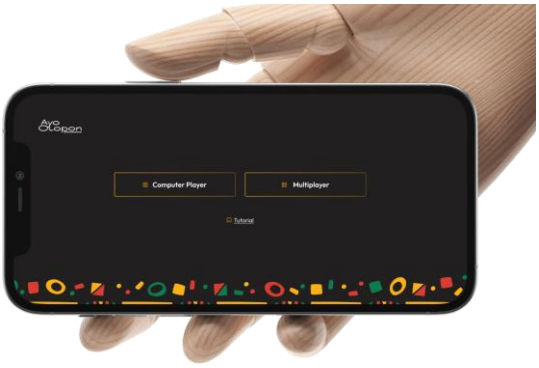
i. Response Time: The Round-Trip Time (RTT) assessment in the response time test involves measuring the duration taken by a small packet to travel from the server to a client and return. To conduct this test, a module is utilized that generates packets comprising only 4 bytes, consisting of an identifier and a separator character. The number of generated packets relies on the specified intervals and the number of packets sent within each interval. These packets are dispatched with a fixed delay in milliseconds, which progressively increases with each subsequent interval. The test then calculates the time values, extracting the highest and lowest recorded times, and computes the average based on the remaining test runs.

ii. Transfer Speed: The transfer speed test is designed to evaluate the duration (transfer speed) required for transmitting packets of various sizes between the server and a client. Similar to the response time test, this test employs the same interval configuration. Initially, a data packet of a predetermined size is transmitted, and with each subsequent transmission, the packet size is increased by a specified number of bytes. The packet itself consists of an identifier, a separator character, an end-of-message character, and additional characters to fill up the remaining space in the packet until it reaches the desired size. To maintain consistency, the delay between each packet is determined based on the optimal interval identified in the response time test. Notably, the packet size is incremented following the completion of a transmission from the server to the client and back.

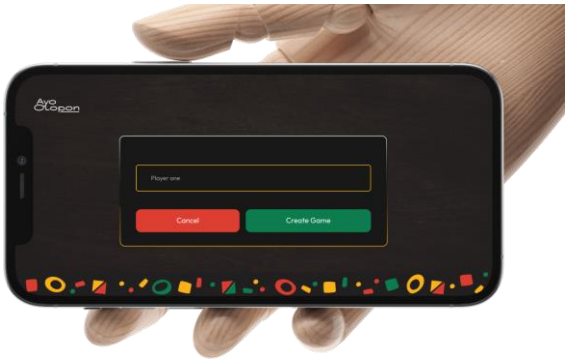
4. RESULTS AND DISCUSSION

This section comprises of results output of the developed Ayo game. As discussed in the methodology section React native and NodeJs were used for the Frontend and Backend development of this game respectively, while Figma was used for the Game design, Figures 4(a-f) show some screens from the developed Ayo-Olopon game during the user interface(UI/UX) design done in Figma, such as the home screen, and the game-creating screen; this is where the player creates a game session, joining page, game board screen and the viewer's screen.

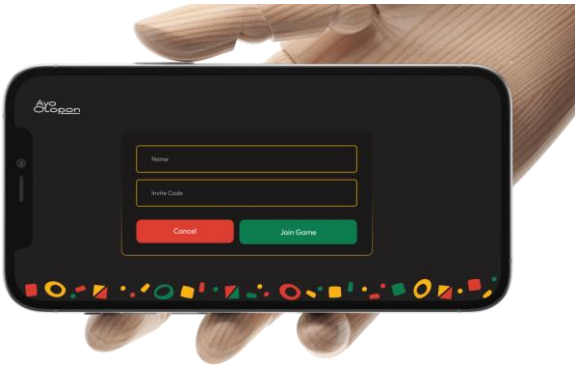
a:Welcome screen



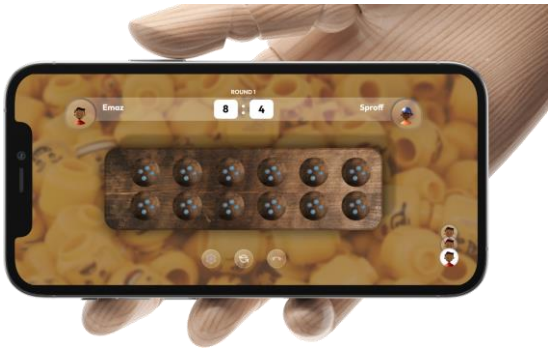
b: Home screen



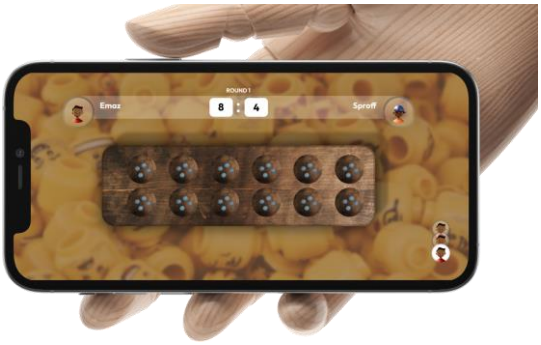
c: Session creation screen



d: Joining page



e: Game board



f: Viewer's screen

Figure 4: Some selected interfaces/Screens within the developed Ayo-game

4.1 User's Evaluation Feedback

The developed Ayo game was evaluated by randomly selecting 61players, co-players and viewers from the people who have played the games among the students of Federal University Oye-Ekiti, Ekiti State, Nigeria and other people nearby that have participated either as a player, co-player or viewer. The participants' evaluations/feedback were captured using Google Forms as the questionnaire. Figure 5 shows the users' rating of the developed Ayo game, 96.7% of the respondents rated the game to be excellently performing. Table 1 also shows some of the users' evaluation results from which it was observed that 53.3% of the respondents find the game's user Interface to be incredibly excellent and 46.7% responded that it is good, of which no one replied that it was bad, 66.1% of the Users also found the approach of the game to be excellent while 33.9% found it to be good. This user evaluation shows that the developed game meets the user requirements and was well accepted by the players. However, some of the Evaluation participants suggested that the viewers should be able to interact with the players via audio, to make the game more fun and interactive.

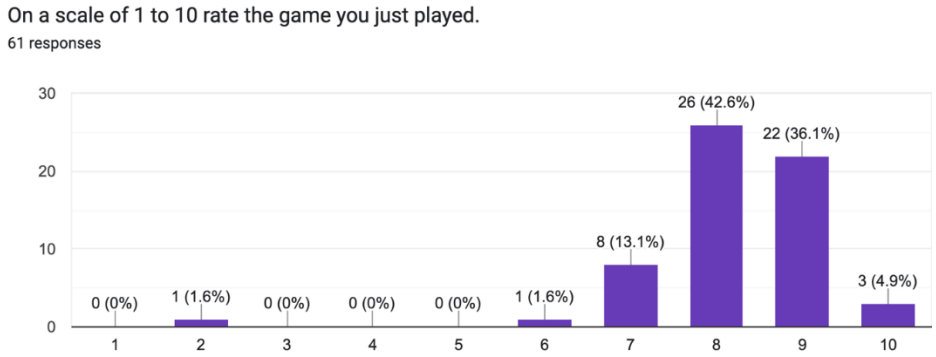


Figure 5: Player's rating of the developed gave

Table 1: Players' evaluation summary

S/N	Question	Bad (%)	Good (%)	Excellent (%)
1	How do you see the game's UI	0	46.7	53.3
2	How do you feel about the game approach?	0	33.9	66.1

4.2 Results of Response Time for various Network Technologies.

In the context of real-time multiplayer games like Ayo-Olopon, the response time holds significant importance due to the frequent transmission of small data packets required by the game. Hence, the response time values measured for various wireless network technologies in this test served as indicators of their suitability for hosting real-time multiplayer games. The performance evaluation was conducted on a server that operates on a standard PC and mobile Clients running on two smartphones namely: Techno Camon 15 and Xiaomi Note 10.

Figure 6 illustrates the measured response time for wireless network technologies such as GPRS, EDGE, UMTS, and WLAN, along with transport protocols TCP and UDP. The charts depicted in Figure 6 demonstrate that UDP outperforms TCP across all networks. Furthermore, the transmission interval resulting in the lowest response time varies between 150 and 200 milliseconds, depending on the specific mobile network technology employed. As anticipated, WLAN exhibits the lowest response time, followed by UMTS, EDGE, and GPRS. Comparatively, the lowest response times measured for other network technologies using UDP are 215ms for UMTS, 286ms for EDGE, and 442ms for GPRS. Notably, the UMTS response time is consistently lower than EDGE when using UDP. However, with TCP, the difference between UMTS and EDGE response times diminishes, and for certain intervals, EDGE exhibits even lower response times than UMTS. In the case of GPRS with UDP, its performance is similar to EDGE within the 100ms to 150ms range, but EDGE is more closely aligned with UMTS for other transmission intervals. With TCP, GPRS never achieves a response time below 1450ms, which can lead to unresponsiveness in turn-based multiplayer games.

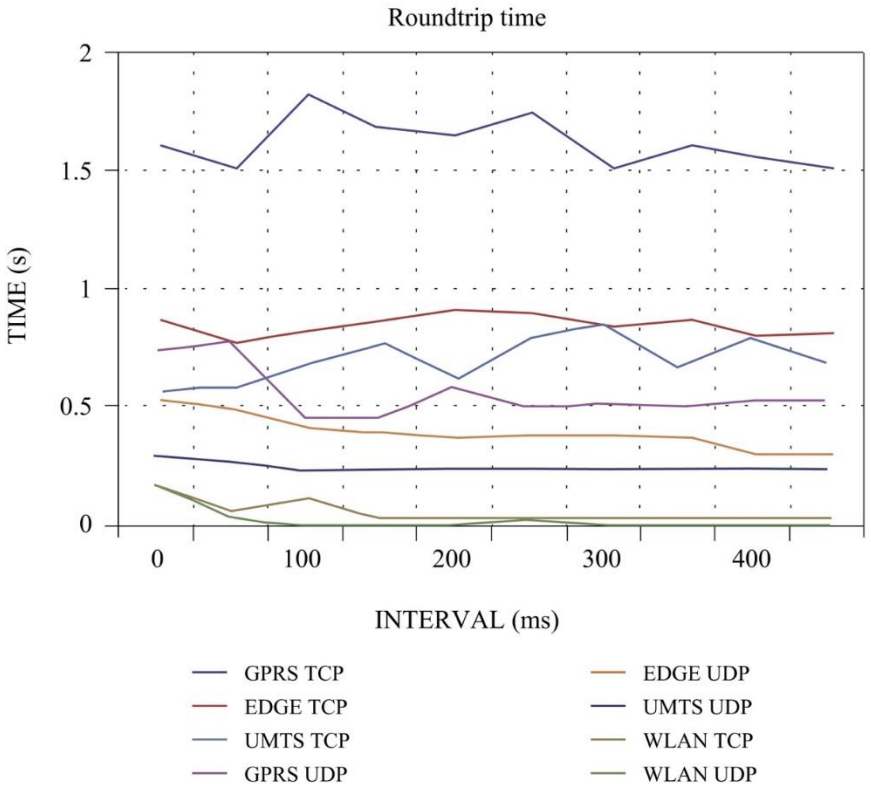


Figure 6: Response times for the developed Ayo-Olopon game

4.3 Results of Transfer Speed for Various Network Technologies

Transfer speed is one of the metrics used in evaluating the performance of the developed Ayo-Olopon game, this was carried out using various network technologies and transfer protocols like UDP and TCP, to know which protocol gives the best speed for the transfer of packets and over which network technology. Table 2 presents the outcomes of the transfer speed tests, with a shorter transfer time indicating better performance. The test results showcase the measured time required to transfer each packet size for a specific network technology utilizing either the UDP or TCP protocol. As shown in Table 2 WLAN has the shortest average response time of 0.263s and 0.291s for both UDP and TCP respectively and the highest response times of 0.748s and 1.001s were obtained when GPRS network technology was used for UDP and TCP respectively.

Table2: Response time including transmission intervals for various wireless networks

Protocol			**UDP**			**TCP**		
Network	**GPRS**	**EDGE**	**UMTS**	**WLAN**	**GPRS**	**EDGE**	**UMTS**	**WLAN**
Min	0.535s	0.506s	0.278s	0.078s	1.568s	0.813s	0.566s	0.107s
Max	0.961s	0.741s	0.664s	0.447s	1.970s	1.188s	1.185s	0.475s
Average	0.748s	0.624s	0.471s	0.263s	1.769s	1.001s	0.876s	0.291s

5. CONCLUSION AND RECOMMENDATIONS

The Ayo-Olopon was developed using React Native and Node.Js for Frontend and Backend development respectively. The game introduced new features to the existing game by making it possible to create a game session and send the link over to a co-player anywhere to join and a third party to also witness the game as a viewer, which is the peak of the game. The evaluation of the game through the feedback gotten from the users and the transfer speed and response time as evaluation metrics showed that the game gives a very satisfactory performance and lowest response time and transfer speed with WLAN and UDP combination. The game filled the gap of absence of viewer, which is the fun part of the game, by giving room for third party to join as a viewer, this greatly improved the user experience of the game and makes it lovelier. In the future, developers can ensure that the viewers can participate in the game via audio comment as it is done in real-life game sessions.

REFERENCES

[1] Akinyemi, I.O., Adebiyi, E.F. & Longe, H.C. (2009). Critical Analysis of Decision-Making Experience with a Machine Learning Approach in Playing Ayo Game. World Academy of Science, Engineering and Technology, International Journal of Computer, Electrical, Automation, Control and Information Engineering, 3(1), 1893-1898.
[2] Ibiene.com. (2019). Modern friendly awale game. Retrieved from https://ibiene.com/africa/what-will-shock-you-about-the-nigerian-ayo-board-game (accessed on February 2022)
[3] Martinez-Garza, M., Clark, D. B. & Nelson, B. C. (2013). Digital games and the US National Research Council's science proficiency goals. *Studies in Science Education, 49(2), 170-208*.
[4] Bonako Developer (2015). Ayo-olopon Desktop game. Retrieved from https://gameloop.com/game/board/ayo-game-on-pc (accessed on March, 2022)
[5] Bonako Developer. (2019). Ayo-olopon mobile game. Retrieved from https://appgrooves.com/app/ayo-game-by-bonako-digital-games-and-mobile-applications (accessed on March, 2022)
[6] Chess.com (2019). Retrieved From https://chess.com/play/online (Accessed on February, 2021)
[7] Moonbear. (2020). Character ayo olopon game. Retrieved from https://apk.support/app-amp/cn.moonbear.ayo (accessed on March, 2021)
[8] Taytronik. (2021). Multiplayer ayo olopon game. Retrieved from https://www.apk20.com/apk/com.topsoft.ayofree (Accessed on March, 2021)