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Multi-User Virtual reality Model for Gaming Applications using 6DoF

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Abstract**—** More and more people are able to buy virtual reality (VR), which is driving its appeal. Google Cardboard and other low-end, affordable devices are available, as are more costly headgear like the HTC Vive and Oculus Rift. Virtual reality (VR) headsets eliminate outside distractions, making it a more engaging platform for information distribution than more conventional means. Users are able to converse and participate inside the same virtual environment with multiuser VR apps. However, issues with network speed, QoS, and session privacy are introduced by this shared environment. With the goal of evaluating network behavior in various circumstances, this study introduces a multi-user virtual reality application that uses both actual and simulated VR headsets, such as the Oculus Rift. Understanding how many virtual reality users can be connected at once while maintaining great picture quality relies on this quality of service study.

Keywords**—** *Virtual Reality, Multi-User, Network Performance, Quality of Service*

I. INTRODUCTION

Companies like Meta, Microsoft, or Clipo Labs have invested billions of dollars to make the "metaverse" a reality, where users may access virtual worlds for work, education, play, shopping, socializing, and entertainment. Additionally, metaverse users will soon be able to enjoy completely immersive experiences because to the fast development of virtual reality (VR) devices from companies like Microsoft, HTC, and Oculus [1]. A system that can detect where a person's body is in a virtual environment has been developed, tested, and validated. There are two separate parts to the system. One part is responsible for tracking the user's physical location and sending that information to a server. The other part shows that information in a virtual environment. In a nutshell, the system takes the user's location into account, analyzes the data, and then sends a set of instructions to the VR helmet to control the environment [2]. The advent of the tactile Internet and improvements in communication have cleared the path for haptic technology to be used in the study of human senses. Haptic technology allows for the use of VR across a network to provide tactile sensations and control. For use in telesurgery, a variety of industries, and other life-or-death situations, scientists are creating haptic devices that provide tactile feeling in real-time [3].

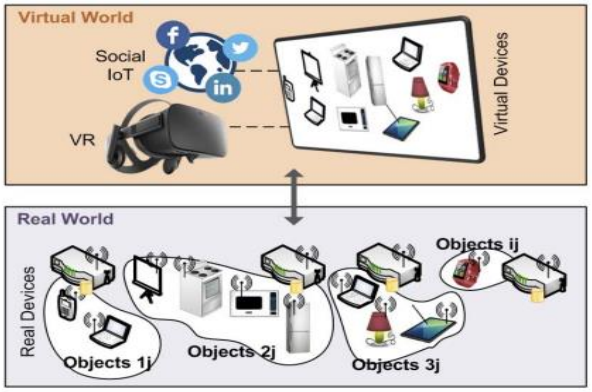

Fig.1. VR Model

VR and its potential uses in supplementary education are examined from an organizational, technological, and pedagogical perspective. Especially for the creation and implementation of an electronic radiography simulators for use in non-destructive evaluation of materials and products. Among the many applications of virtual reality technology, some of the most common include the following: the education and assessment of technical and engineering staff, the testing of goods and materials, and the technological preparation for very precise and intricate processes [4]. Advertising in today's fast-paced, always-connected world is essential for any company, but especially furniture retailers. Sales catalogues in print media are already ubiquitous, but consumers aren't always happy with them since they're one-dimensional and require them to physically visit the business. So, to boost a store's attractiveness and sales value, more creative and eye-catching advertising material is required [5]. Traditional means of communication like the telephone and letters are becoming less common among the elderly, who are increasingly living alone. There has been a reevaluation of

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people's reliance on telecommunications due to the current coronavirus outbreak and the rise of new technologies like virtual reality and video calling [6]. To many, Big Data is the most potent medium of exchange and the engine that powers cutting-edge innovations like blockchain, the IoT, and AI. A company's performance in BD is directly proportional to its maturity level. The telecommunications business is greatly affected by BD because of its significant contributions to optimizing network services as well as usages, boosting security, and enhancing the experience of customers [7]. Recent research has shown the significance of high-quality virtual education. Unfortunately, virtual education still has a ways to go before it can fully replace in-person instruction in certain subject areas. This is especially true when dealing with hands-on activities like lab work or operating complex pieces of equipment. Because of this, AR and VR apps are becoming crucial resources for online education [8]. In the modern digital age, the fields of XR—extended reality, which includes VR, AR, and MR—are changing the way people interact with computers. When it comes to telecommunications and distant cooperation, XR technologies have the potential to break down geographical boundaries and provide new ways to improve social and emotional connection [9]. The immense amount of new use cases for telecommunications services, such as the implementation of autonomous car technologies, digital medical services, virtual reality, as well as the IoT, poses a challenge to the 5G network. Each of these things requires a unique service on the backbone of the telecom network. The term "network slicing" refers to the practice of creating separate, independently managed, logical or digital networks that span from end to end (E2E) on an identical physical network platform. These networks are designed to keep user groups separate while yet sharing the same platform [10].

VR has been gaining interest of gamers and as well as for game developers day by day because of its uniqueness and simulated environment in which users can interact with different 3D objects. As to this day a vast number of games have been developed that consist VR technology. To share the gaming experience, the internet has been widely adopted because it allows users to interact with each other. According to the work presented above, we developed a carrom game that uses VR that allow users to interact with different 3D object. In this game a user can play with Artificial Intelligence (AI) opponent. For the purpose of creating a more fun game we introduce multiplayer gaming that allows users to play with each other without any need of physical carrom.

This paper is organized as follows. In section II, related works are presented and section III details the design and implementation of the testbed. Section IV presents testing and results. Section V finalises the paper indicating the conclusions and future work directions

II. RELATED WORK

The purpose of the research was to demonstrate the outcomes of the pilot program for Fiber Optic instructional modules in [11]. Scenario planning, low poly optimization 3D asset production, scenario integration, triggering each interaction, multiuser applications and then execution are the several steps that make up the module development process. It is necessary to conduct measurements with OVR metrics in order to construct a high-quality VR Fiber Optic application. The dependability of the application, which impacts the user experience, is the target of that assessment. The maximum frame rate measured in the OVR measure is 43, while the lowest is 27. Virtual reality applications that have a low poly asset architecture may operate well on the generated value. Use of the PIECES Framework is also used for the purpose of measuring user satisfaction. The measurement findings show that the VR FO program is well-received by users as a virtual learning assistance module, with values ranging from 3.4 to 4.91 for each variable. To aid telecom network operators in improving network provisioning and management for a positive user experience, the authors of the aforementioned publication conducted an empirical measurement investigation of the behavior of metaverse VR networks [12]. Authors classify user activity into different states, such as login home, streetwalking, event attendance, and asset trading, and analyze network traffic in detail for each state using hour-long network traces from the Oculus VR headset. That reveals unique service areas, procedures, flow profiles, as well as volumetric patterns, demonstrating how much more complicated a metaverse session is than video streaming or gaming. Their second contribution is the development of MetaVRadar, a real-time system for detecting metaverse sessions and classifying user activity states using defined flow signatures with volumetric parameters. That method is armed with network behavioral profiles. As a third contribution, they show how operators may utilize MetaVRadar in a big university network, assess its correctness in a controlled setting, and put it into practice to help users have a better metaverse experience. To achieve immersive virtual reality contact, the authors of the [13] study suggest a low-latency haptic opened glove that uses a rotating position sensor in conjunction with a min-max scaling filter. By using two position sensors situated in the metacarpophalangeal joint, the suggested apparatus is able to discern actions of flexion/extension and adduction/abduction of the fingers. An MMS filter is used to process the sensor data in order to achieve low latency and high accuracy. Additionally, in order to allow hand motion-tracking, the MMS filter processes object handling control data. Accuracy,

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latency, and resistance to changes in finger length are the metrics used to assess its performance. The processing delay per finger was 145.37 μs and the total latency for monitoring hand motion was 4 ms, which is quite low. In addition, they found that the suggested glove worked well for flexion/extension with an average average absolute error (MAE) of 3.091∘ and for adduction/abduction with 2.068∘ after testing it with 10 individuals. The study's stated goals are as follows: (1) developing a VR 360o experience for Christian University of Indonesia. (2) Displaying 360-degree photos on the Adventist Church of Indonesia's website. (3) Providing a more accurate virtual representation of the area around UNAI so that site visitors from Adventist University Indonesia may better understand where they are. That study's findings are as follows: (1) Adventist University of Indonesia's website is suitable for implementing the Virtual Reality 360o application. (2) Users may easily learn about the UNAI ecosystem with the help of the engaging, interactive, and user-friendly Virtual Reality 360o software. The waterfall development paradigm was used in the process of creating that VR application. First, they'll take a look at the evolution of many generations of systems in [15]. After that, they will go into the characteristics, design, problems, and solutions of 5G telecommunications networks. In order to accommodate the increased data rates required by networked devices and to deliver superior user experiences, the next generation of wireless networks, 5G, will need to incorporate key components like increased bandwidth, smart antennas, smaller cells, virtual reality, virtual applications, etc. Research on next-generation telecommunications systems to solve current problems is now at a high level of activity. The Republic of Yemen's information technology experts' views on the development and usefulness of business process management in the telecoms industry are evaluated in the research [16]. The questionnaire was carefully designed and subjected to multiple rounds of validity tests, including virtual, discriminatory, developmental, and subjective assessments. Finally, it underwent a reliability test to guarantee that it accurately captured the views of IT professionals regarding the development and significance of big data. Two hundred thirteen IT experts working in Yemen's telecom industry made up the study's de jure population. The thorough enumeration approach was used to pick the sample, and all six of Yemen's telecommunications firms were analyzed. The most noteworthy finding is the statistically significant connection (within a margin of 59.6%) between BD maturity with BD value in the Republic of Yemen's telecommunications industry, according to the study's findings. A mixed-sensational, physical-and-virtual installation is proposed in the article [17] under the umbrella term of Synchronous Reality. That study presents the findings from an investigation into the development of the practice work that constitutes the principles of a Synchronous Reality display. At the end of the day, the goal of the study was to make a cohesive whole that includes Synchronous Reality by developing a sensory environment to go along with the virtual component of the exhibit. All things considered, the results show that installation style may make the person feel more immersed and present. Additionally, the presentation covers the key factors to think about while constructing that kind of installation. The article delves a little more into the broader questions of how VR impacts the internet economy and communications. That research explores the use of artificial intelligence to power 3D talking heads in XR-based communication systems [18]. These digital representations of people allow for much less physical barriers in distant communication by mimicking human facial emotions, hand gestures, and voice. The study's contributions include a thorough analysis of audio-driven 3D head generating techniques and the creation of all-encompassing assessment criteria for 3D talking head techniques in SVEs. As virtual reality develops, 3D talking heads powered by artificial intelligence have the potential to completely change the way people work together remotely. They present an ensemble of virtual network embedding methods called ViNEYard in their paper [19] that use the Virne simulator to model and simulate virtual neural networks. These algorithms include DRVNE (deterministic), RD-VNE (randomly), and MIP (mixed integer programming). By taking a fresh approach, they used the Virne simulator to model and simulate network slicing for three 5G service scenarios: Improved Mobile Broadband (eMMB), Ultra Trustworthy Lower Latency Communications (uRLLC), along with Massive Machine Type Communications (mMTC). They were able to successfully test these three scenarios on that platform using the VineYard algorithm. In [20], researchers look at 5G's features, technology, and potential effects on many sectors. 5G's peak data speeds are ten times quicker than 4G's, allowing for real-time data sharing, HD video transmission, as well as immersive VR experiences. Possibilities in fields like automation in factories, remote surgery, as well as driverless automobiles are made feasible by 5G's millisecond latency, which allows for almost instantaneous communication. The purpose of that case study is to examine how a mobile infrastructure efficiency boost from 5G technology compares to that of 4G. An analysis of 10 devices' download speeds revealed a spectacular average speed increase, with 5G data rate averaging demonstrating the substantial efficiency boost that can be accomplished with the advent of 5G.

III. PROPOSED WORK

Figure 2 shows the solution architecture. Presented below are the specifics of the design and its execution. By putting the

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app into action, we can evaluate the solution's performance and test the suggested design.

A. Overall Architecture

The application server, the user launcher, with the VR application make up the whole solution for this project. Figure 2 shows the solution's architecture, which reveals how the parts work together. The virtual reality (VR) software and user launcher need to be installed on each user's PC and linked to their VR headgear. In either server or user mode, the user launcher initiates the virtual reality program and initiates cloud-based gaming sessions. It communicates alongside the application servers to authorize and authenticate users, establish gaming sessions, manage users, and collect data about the network to determine the best server settings for various network circumstances. A distinct REST service designed for cloud deployment is the application server. The video streams resource endpoint may access the multimedia data stored in it, and the data is served on virtual displays.

B. System Components

Application Server

With the use of RESTful APIs, the application server can handle user authentication, access, video streaming, and gaming sessions from anywhere in the cloud. Python and REST APIs were used in the development of the application server. For quicker reaction, the resource statuses are kept in memory.

You may access the following endpoints:

1. All users: All users who are currently accessible on the system may be obtained by making a GET call to this endpoint. The launcher program uses it to get a list of accessible users from which to construct a new gaming session using the graphical user interface.
2. The User endpoint allows users to add, edit, or remove themselves from the system.
3. Authentication: This endpoint verifies users by accepting a POST request with their username and password as the payload.
4. GameSession: This endpoint stores the creation of a gaming session along with its associated IP address, owner, and permitted users in its payload. Using a GET request, it may also get the server information needed to add users.
5. Video Stream: By using a POST request, users are able to submit new presentations or video files, which in turn enable the development of novel video stream connections. You may create a video slideshow from presentation files like.ppt and.pptx and then share it online. An object containing a connection to the video stream which will be presented in the virtual environment is returned when a GET request is made to this resource using the game session's ID on the URL.

Users

Python code powers the user launcher, a graphical user interface software. This component has many screens that were specifically designed for certain purposes. TABLE II

Network Status - Transmission Rate Table

Network Status	Time Taken for First Connection	Transmission Rate
1	> 30 seconds	$15\ Hz$
2	$10 - 30$ seconds	$30\ Hz$
3	$4 - 10$ seconds	$60\ Hz$
4	$1 - 4$ seconds	$80\ Hz$
5	< 1 seconds	$120\ Hz$

User authentication or creation is the starting point for all launcher usage cases. Passwords and usernames are requested on the screen using a form. Once logged in, players have the option to start a fresh gaming session or join an ongoing one.

Following the creation of a new gaming session, the launcher assigns a unique identifier to it and does a network analysis using the VR application servers. A network code of status is given according to the connection time and network speed. The network's status code determines the transmission rate, as shown in Table II. As an example, the user will be given the network status 3 if it takes 1 to 4 seconds to connect to the server. The transmission speed used throughout the gaming session is correlated with each network state. Given the user's first latency in reaching the server, the 60" "Hz transmission rate represented by network status 3 (for a first connection of 1-4s) is appropriate for this network.

The frequency at which player and server states synchronize is called the transmission rate. After the revised transmission rate is implemented, the virtual reality application is activated. The amount of frames per second (FPS) and the transmission rate are synonymous on a hosted server instance. Users with faster connection speeds to the server will see greater frames per second.

You may share the game sessions ID with other users after the launcher shows all the data about the freshly formed session. With the updated server IP number, game session ID,

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application's server URL, and transmission rate, the virtual reality app is then set up to begin using the data.

In order to join the virtual reality app, users must have a gaming session ID. To do this, go to the start menu and look for the "Join as a Customer" option.

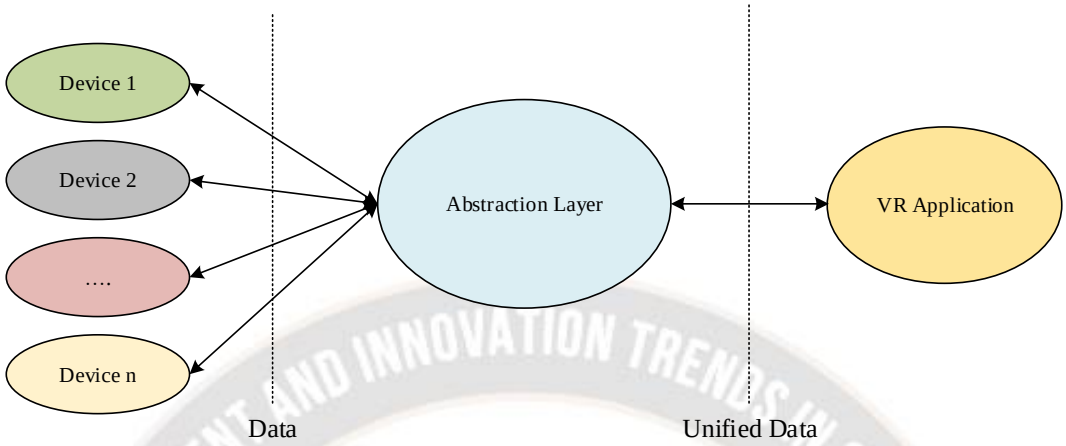

Fig.2. VR with Multi-Users Device Model

Wireless Node

Using wireless network devices, a wireless node collects data from the real world and regularly connects with the management node. In addition, wireless nodes should be able to alter their status via hardware and/or software switches. Our suggested method assigns a unique AR marker to every wireless node in order to generate the AR picture. Our intended audience consists of ad hoc network nodes, Wi-Fi-enabled PCs and appliances, and wireless sensor nodes that monitor environmental variables like humidity, light, and temperature.

VR Application

Users may share video footage with the tablet component in the virtual room after attending a session and interacting in the VR application.

Tablet Game Objects allow users to access a file browser where they can stream files simply by hovering their VR controllers over them. The program is capable of playing back several types of media files, including presentations (.ppt,.pptx) and videos (.mp4,.avi). After that, a multipart/form-data POST query is sent to the application servers with the selected file. The application server will automatically generate a slideshow video using the chosen file type (presentation) and provide the video's URL in response. After this is finished, the PlayerNetworkLink class tells the server to broadcast the movie to every user.

The virtual reality server software ran on the instructor's Oculus Quest head-mounted display (HMD), and it was built using the Mirror networking framework. Our five lessons gained from developing the MiReBooks VR system are based on the test findings and our expertise with developing multi-user VR environments. These lessons might be useful for researchers and application developers. Some of the suggested optimizations for the application layer include: pre-rendering virtual reality content on the server; representing both interactive as well as non-interactive content; and predicting the user's movement with six degrees of freedom. Adaptive content control would change the quality based on the network conditions.

IV. Results & Discussion

We made sure the network performance was consistent by using a local WiFi network, and we built 10 client programs in low resolution so they could all run on one PC without hogging the CPU. In addition, a script was built to mimic the actions of an active user in an HMD, including continual hand and body rotations that trigger a message to be transmitted at each synchronization. The Unity Profiler is one of the profiling applications that come with using Unity as your game engine of choice.

Application Scenario: In terms of visual quality, the app will be inferior to its PC counterpart; textures and models will not be as meticulously created.

3D Realistic Environment: Because virtual reality games rely so heavily on their settings, this covers the fundamentals of room design. Attracting the user is the primary goal of design. In 3ds max, we created a realistic room setting by designing a couch using the chamfer box command along with other items with the cylinder and line commands.

Carrom and its elements: The carrom board, pieces, and striker are all part of this. The user interacts with these fundamental items. Board is a hybrid of boxes and planes, whilst pieces with striker are created by modifying cylinders. By changing the sphere, we have also created some obstacles. Doing so limits the striker to its strip.

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Our team has created a gaming app for Android that allows users to compete in multiplayer mode via a local area network. Users also have the option to compete against an AI opponent. We used Unity 3D v5.4.2 for the app's design [17]. Using a virtual reality headset, players may engage with the game world and even guide the striker to their desired carrom piece. The striker may be moved inside the stripe using a Bluetooth controller, allowing the user to aim for the ideal shot and earn points. Once you've set your aim, you may hit the strike on the created route using the buttons on your bluetooth controller.

In order to evaluate the system, we built a number of user scenarios with simulated people moving in different ways. An algorithm for automatic user movement in virtual reality simulations has to be developed for this. The AutoHotKey (AHK) software was used to construct the simulation algorithm. It moves the simulated users by simulating key presses. As configurable parameters, the algorithm also requires the following: the amount of simulated clients, the number of movement loops, the number of movement steps, and the duration of the movement key. Each client window specifies the the amount of times a movement requires to be done. Figure 3 shows that the program can handle several customers. On one computer, a real user is looking via a virtual reality headset at material (the bottom monitor in Figure 3 reflects what the user sees in the headset), while on the other, simulated clients like the one seen on the top screen are generated. Critical quality of service metrics were taken into account before testing began. We looked at three different cases involving video material and virtual reality users ranging from one to ten. In each case, one of the users acts as the server, while the others act as clients.

The Windows 10 PC with an Intel i7 8200u from the eighth generation and 16 GB of LPDDR3 RAM was used for the testing. Network analysis was conducted using Wireshark.

A. Throughput Analysis

In order to do the throughput study, the application's virtual monitor displays multimedia material to all users. In addition, Algorithm 1 introduces mobility for the simulated consumers in order to conduct a realistic throughput study.

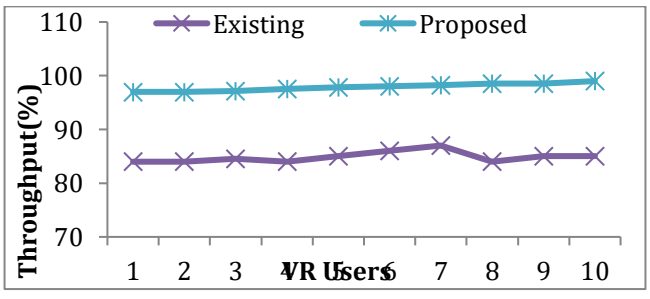

Fig.3. Throughput Analysis

Because of their demonstrated relevance in virtual reality settings, latency as well as frame rate were the criteria we used to evaluate the server's stability. In the setting of networks, latency is the time it takes for a message to travel from sender to receiver; an increase in latency has an adverse effect on the user. As an example, the latency governs the amount of time it takes to physically get to a certain area when a student wishes to teleport by pressing a button on the controller. Maintaining low latency across the experience is crucial to avoid frustrating the user, even with a little delay. The server's frame rate may control the latency. The frame rate is sensitive to the amount of disseminated messages and server load, both of which might decrease as the number of people connecting to the server increases. As a result, latency can become worse. lowering bandwidth utilization, which basically involves lowering the quantity of messages and/or improving their contents, is one technique to enhance the server's frame rate. You may find out when the server's performance begins to drop by adding users one by one. In order to determine the delay, the client has to communicate with the server in a straightforward manner, wait for a response, and then record the time it takes for this process to complete. This has to be tested with varying user counts; as the user count rises, more messages need to be sent, which might lead to an increase in latency if the server isn't prepared to manage the influx of requests.

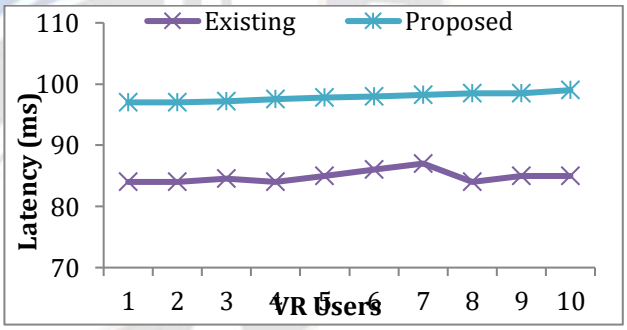

Fig.4. Latency Analysis

In light of the research done so far, we have laid up a plan for incorporating virtual reality into various board games. By integrating the first-person view (FPV) technique with the aid of a head-mounted display as well as motion detection technologies, this concept presents and encourages a novel approach to playing board games in a virtual setting. To back up our idea, we've also built an android app that uses the phone's sensors to track the player's head movement in all directions, allowing them to do things like see the virtual world and aim using the first-person view (FPV) method—essential features of virtual reality (VR) mobile games. In addition, we surveyed a number of players in two separate game modes; based on their comments and suggestions, we have identified a plethora of possible future improvements that would greatly increase the quality of our game.

Improving the game's visuals is one way for making it more appealing to players. This will allow us to show how virtual reality (VR) may be useful for playing various board games. We found that many individuals made outstanding comments about the concept of bringing carrom to a virtual setting, and after conducting experiments, we have obtained favorable feedback from the users. We computed a number of performance metrics, shown in Table 1, so that you can see how the experiment turned out. Table shows that users' accuracy was 92.5% and their precision was 69.5% based on our experiment findings for various shots. On the other side, you may help us improve our game in the future by providing feedback and recommendations.

Table.1. VR Models Comparison

	Precision	Accuracy	Recall
Existing	95.2%	95.7%	95.9%
Proposed	96.7%	96.9%	97.58%

As a whole, our results show that most users have a strong preference for carrom gaming-themed virtual environments. This is based on our extensive study.

V. CONCLUSION

This article detailed the planning, development, and testing of a multi-user virtual reality program for usage in different contexts. Users may connect with one another and exchange multimedia files like movies and presentations with this software. In order to assess performance, the software incorporates both actual and virtual users into the situations. Additionally, a VR user movement algorithm was shown. Performance issues, including increased buffering times and general slowdowns, were seen in tests conducted on the experimental machine when the total amount of users was equal to or higher than ten concurrent users. It was feasible to see which scenarios ran best on a machine with the specified specs thanks to a multi-user program that allowed both actual and virtual users to participate in the performance testing. Adding more kinds of shareable rich media content and user prioritization with varying degrees of quality are also items on the agenda for future development.

REFERENCES

[1] Baraković, S., & Baraković Husić, J. (2023). Quality of Experience of Future ICT-based Logistics and Transport Systems. Second International Conference on Advances in Traffic and Communication Technologies (ATCT 2023).

[2] Cai, X., Yang, Z., Dong, L., Ma, Q., Miao, X., & Liu, Z. (2023). Multi-User Mobile Augmented Reality with ID-Aware Visual Interaction. ACM Transactions on Sensor Networks, 20, 1 - 23..

[3] Sharma, T., Prasad, S.K., & Sharma, V. (2022). Research challenges of Blockchain in 6G Network. 2022 IEEE Delhi Section Conference (DELCON), 1-7.

[4] Sanaei, M.H., Machacek, M., Eubanks, J.C., Wu, P., Oliver, J., & Gilbert, S.B. (2022). The Effect of Training Communication Medium on the Social Constructs Co-Presence, Engagement, Rapport, and Trust: Explaining how training communication medium affects the social constructs co-presence, engagement, rapport, and trust. Proceedings of the 28th ACM Symposium on Virtual Reality Software and Technology.

[5] Palma, V., Spallone, R., Cicone, G., Lops, G., & Rinauro, R. (2022). SCALABLE AR FOR BIM ON TELECOMMUNICATION NETWORK SITES. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences.

[6] Ramkumar, G., P., S.B., Singh, D.P., Perwej, D., Deepa, S.T., & Sakthivel, D. (2022). 6G – Secure Data Cluster Approach with Blockchain. 2022 3rd International Conference on Intelligent Engineering and Management (ICIEM), 882-886.

[7] Su, X., Li, L., Jin, Y.Z., & Li, J. (2022). Coverage Performance Analysis of UAV Ultra Reliable Low Delay Communication System. Proceedings of the 2022 5th International Conference on Telecommunications and Communication Engineering.

[8] Madduru, P. (2021). ARTIFICIAL INTELLIGENCE AS A SERVICE IN DISTRIBUTED MULTI ACCESS EDGE COMPUTING ON 5G EXTRACTING DATA USING IOT AND INCLUDING AR/VR FOR REAL-TIME REPORTING. INFORMATION TECHNOLOGY IN INDUSTRY.

[9] Huang, Y.W., & Wang, Y. (2021). Design of Embedded Network Human Machine Interface Based on VR Technology. Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering.

[10] Fialho, J.R., Godinho, P.C., Costa, J.P., Afonso, R., & Regalado, J.G. (2020). Energy Efficiency in 5G Communications – Conventional to Machine Learning Approaches. Journal of Telecommunications and Information Technology.

[11] Sukaridhoto, S., Fajrianti, E.D., Haz, A.L., Budiarti, R.P., & Agustien, L. (2023). Implementation of Virtual Fiber Optic Module Using Virtual Reality for Vocational Telecommunications Students. JOIV : International Journal on Informatics Visualization.

[12] Lyu, M., Tripathi, R.D., & Sivaraman, V. (2023). MetaVRadar: Measuring Metaverse Virtual Reality Network Activity. Proceedings of the ACM on Measurement and Analysis of Computing Systems, 7, 1 - 29.

[13] Sim, D.H., Baek, Y., Cho, M., Park, S., Sagar, A.S., & Kim, H.S. (2021). Low-Latency Haptic Open Glove for Immersive Virtual Reality Interaction. Sensors (Basel, Switzerland), 21.

[14] Gea, S., & Maulany, R. (2020). Perancangan Aplikasi Virtual Reality 360 Berbasis Web di Universitas Advent Indonesia.

[15] Al-dujaili, M.J., & Al-Dulaimi, M.A. (2022). Fifth-Generation Telecommunications Technologies: Features, Architecture, Challenges and Solutions. Wireless Personal Communications, 128, 447-469.

[16] Qahta, I.Y., & Alsohybe, N.T. (2022). Maturity and Value of Big Data in the Telecommunications Sector in the Republic of Yemen from the Prospective of Information Technology Professionals. International Journal of Computer Science and Mobile Computing.

[17] Bailey, D.E. (2020). Synchronous Reality: Enhancing Sensory Perception in Immersive VR.

[18] Christoff, N., Neshov, N.N., Tonchev, K., & Manolova, A.H. (2023). Application of a 3D Talking Head as Part of Telecommunication AR, VR, MR System: Systematic Review. Electronics.

[19] Irawan, D., Ananda Kusuma, A.A., Hamdani, M., Giyana, R.F., Hartawan, A.R., Palokoto, T.B., Agastani, T., Pinastiko, W.S., & Anggraeni, S.P. (2023). Network Slicing Modeling and Simulation on 5G Networks Using Virne. 2023 International Conference on Computer, Control, Informatics and its Applications (IC3INA), 114-119.

[20] Kumar, M. (2023). 5G Technology is Revolutionizing the Wireless Industry with Unparalleled Efficiency. SciWaveBulletin.