Uluslararası İleri Doğa Bilimleri ve Mühendislik Araştırmaları Dergisi
Sayı 8, S. 183-193, 11, 2024

Araştırma Makalesi

IJANSER
https://as-proceeding.com/index.php/ijanser
ISSN:2980-0811

International Journal of Advanced Natural Sciences and Engineering Researches
Volume 8, pp. 183-193, 11, 2024

Research Article

Forecasting Global Network Traffic Trends: The Role of Virtual Reality

Raghad H. AlShekh [1], Qutaiba I. Ali [2]

[1]*Environmental Technologies/College of Environmental Science, University of Mosul, Iraq*

[2]*Computer Engineering/College of Engineering, University of Mosul, Iraq*

(raghad.h.alshekh@uomosul.edu.iq) Email of the corresponding author
(Qut1974@gmail.com) Email of the second author

(Received: 03 December 2024, Accepted: 06 December 2024)

(3rd International Conference on Recent Academic Studies ICRAS 2024, December 03-04, 2024)

ATIF/REFERENCE: AlShekh, R. H. & Ali, Q. I. (2024). Forecasting Global Network Traffic Trends: The Role of Virtual Reality, Lining and Earthworks. *International Journal of Advanced Natural Sciences and Engineering Researches*, 8(11), 183-193.

Abstract – Virtual Reality (VR) technology is a network intensive application, which needs reliable network performance for smooth and real like simulation. This study concentrates on the direct, simple and effective utilization of the User Datagram Protocol (UDP) Ethernet communication for VR system to investigate the networks that support the virtual environment.

To investigate the varied dependencies between the network parameters, the study performed the fcable length test, data rate test, packet processing rate PPR test. Researchers strove to identify the various advantages and disadvantages of UDP Ethernet communication of VR applications from the standpoint of the performance factors.

Advanced graphical techniques were applied for visual representation of the presented multi-scalar dependency of network properties and systems performance indices. The study enabled insight into the relationship between proportions of cable length and data transmission parameters to actual operational speed or delay or stability of the particular network.

The results may be informative and helpful for not only the people who work in the development of the VR system but also the network engineers, while UDP Ethernet is raised as a fast and low overhead communication strategy. In this way, considering the basic ideas of performance properties and optimizations, researchers can design systems of virtual reality networks that are more vital for a user.

Therefore, it presents practical contributions to the on-going and upcoming advancement of technology-based VR communication support and a deeper comprehension of the network performance enhancement approaches.

Keywords – Emerging Technologies, Virtual Reality, UDP, Modelling, Performance.

I. INTRODUCTION

The rate of development in new generation technologies is refacing how people interface with digital material thus resulting in exponential needs for more bandwidth. These innovations are adding new dimensions of complexity to the network platforms because of high data rates, low-latency demands and incorporation of complex application [1]. For future needs to be met by these networks, there is the need to use frameworks that predict traffic load [2].

This research is about predicting potential implications of new technology for networks and infrastructure. On the basis of the perspectives with regard to technology trends, traffic forecasts and the best industry practices, this work offers the practical means that can facilitate a transition to new paradigms in the sphere of network demands and the effective implementation of technologies.

Virtual reality (VR) is a relatively young idea that was developed in the late ’80s and ‘90. More specially, it is a three-dimension model of a synthetic environment from which; viewers can get the feeling that they are in a real world or a world more real than the actual world [3].

Tom Caudell designed augmented reality (AR) in 1990. It improves the real life or physical environment by adding further Augmented Virtual 3D stuffs that look like real life object [4].

As defined the term, Mixed Reality (MR) is the interface between VR and AR to incorporate both and blend real and virtual environments. Because it reproduces an interactive multi-object space in which the distinction of physical and virtual reality is blurred [5].

As mentioned before, the Metaverse is defined by ISO as a large scale, persistent and immersive multi user shared 3D virtual environment, and it automatically creates replicas of existing spaces in the physical world called digital twins that can be used to understand, test and improve the physical world before acting on it [6]. It is enabled by act of a combination with other technologies including AR, MR, and VR [7 As discussed in figure (1) Such technologies have been widely implemented within the various domains including medical, cultural, product development, online shopping and more [8].

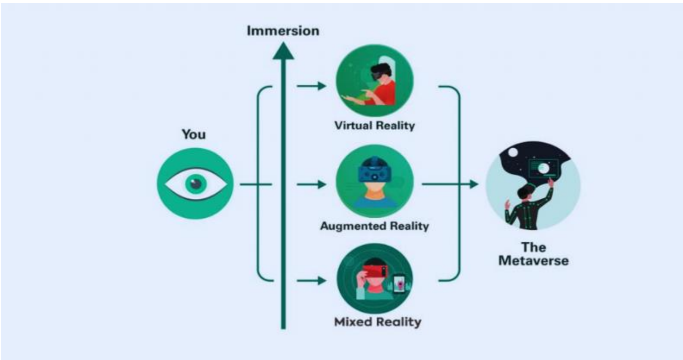

Fig .1. Trended technologies

The paper is organizing as follows: Section II shows the literature review. Section III presents a case study taken on VR technology performance. The results and discussion is described in Section IV. Finally, section V. summarizes the paper and suggests future works.

II. LITERATURE REVIEW

Table (I) at of this research summarizes thirteen research papers on different immersive technologies, with each paper representing a specific problem description, contribution, and outcomes.

Table 1. Literature Review Summary

Pager	**Problem statement**	**Objective**	**Tools**	**Contribution**	**Results**
Himanshu etal. 2020 [9]	VR enhancing training in health care and identify immersion breakpoints.	Define VR in healthcare, AI , discuss Immersion Breakpoints	VRTK, blender,Maya.	distance training and therapy options.	Effective treatment for psychological conditions.
Fengxian Guo et al. 2020 [10]	Ignoring real-time rendering and data correlation	catch MEC capability, performance improvement ,Maximize QOE	Deep reinforcement learning DRL, game theory	Enhance QOE,introduce distributed learning algorithm	outperforms the baseline algorithms in terms of QoE, latency, and convergence time
LIDIA M. ORTEGA etal 2020 [11]	Underground and indoor facilities lack real-time data and rely on outdated plans	manage 3D underground infrastructure networks	3D GIS and BIM,CityGML	topological data model	Successful execution of CRUD operations
Venkatakrishnan etal 2020 [12]	Multi-user VR needs high network performance, QoS, privacy ,and high image quality.	Evaluate multi-user VR application network	Oculus Rift,headset,Python	analyzes network conditions and user counts on VR performance.	More than 10 users degrade performance, improve smoothness
A. Hayes, et al 2021 [3]	Challenges and constraints in applying VR in education.	Improve 3D VR Learning Environments (VRLE).	-----	presents TPACK framework	supportingK16 teachers ,implement VR content into classrooms effectively
Chufeng Huang etal 2022 [13]	Insufficient data sharing and openness	propose a virtual reality scene modeling method that integrates IoT technology.	edge computing ,database dynamic loading management	large-scale data acquisition and modeling	Improved efficiency, Enhanced capabilities
Dimitrios Ververidis etal 2022 [14]	AEC industry needs better VR and BIM integration	state-of-the-art collaborative VR systems	Building Information Modeling ,Computer-Aided Design	proposed guidelines for collaborative VR system.	proposed a blueprint for an ideal system.
Saeed Safikhani et al., [15]	AEC industry can`t use BIM fully due to collaboration challenges	Identify VR-BIM use cases	PRISMA was performed VR and BIM terms.	Design and project management, on VR applications	Enhance understanding, decision-making, and collaboration.
Kai Zhang et al., 2023 [16]	accurate and real-time network traffic prediction,	Spatial-Temporal Graph Convolution Gated Recurrent Unit (GC-GRU)	GC-GRU Model	model (GC-GRU)	handling changing data and working well in various situations.
Francesca Bruni et al., 2024 [17]	create program using semi-immersive VR	Integrate VR with ML to help Parkinson's sick people	Cave Automatic Virtual Environment,(Full HD 3D UXGA DLP,dual-Task Exercises	establish a novel approach to dual-task rehabilitation that combines cognitive and motor training in realistic manner.	increase treatment's and individualized training.
Adedotun Adetunla 2024 [18]	Challenges of VR in education	integration of VR into educational settings ,enhance teaching	headsets	Highlighting diverse applications of VR in education	VR enhances student motivation

III. CASE STUDY: PREDICTING VR NETWORK DEMANDS

Virtual Reality (VR) networking plays a strategic role in guaranteeing continuous and engaging user interfaces. Bear in mind that in order to get the best out of VR, a number of network parameters, latencies as well as bandwidth are critical in the face of high data rates and low latency requirements [19].

A. *Case description*

The main objective of this case study is to develop a framework to estimate the traffic demands of VR, by considering factors like data rate, Packet processing rate, and cable length to avoid potential bottlenecks. The network consists of VR client and server connected via Ethernet cable.As shown in figure (2).

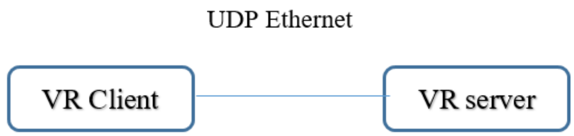

Fig .2. system block diagram

B. Research method

Create a computer simulation of an application and network to experiment with different behaviors of the network on various application and network conditions. Perform cable length analysis, data rate, and the Packet Processing Rate (PPR) analysis as they relate to the network.

C. Modelling implementation

Propose a VR system that employs UDP Ethernet network with parameters illustrated in the table II, it is noteworthy that the size parameters are in bytes.

Table (II) Suggested VR network specifications [18], [20]–[22]

Parameter	**Value**	**Parameter**	**value**
Ethernet frame header	14	MTU	1500
IP header	20	VR fps	60
UDP header	8	Max payload size	1432
VR Protocol base header	26	VR frame size	1 MB

The system was described as a sequence diagram that presents an overview of all the interactions between the VR Client and the VR Server of an application during a virtual reality session via UDP Ethernet networks. The sequence is divided into three major phases: It has three phases: Session Establishment phase, Active Video Streaming phase where real streaming of videos and client server communication occurs and Session termination phase.

Every phase has some mandatory signals to complete the session out there. It is however important to note that the above outlined three phases are not the only phases to be required in a process of executing a project that is complex, but there are more phases. Included in figure (3) The following system equations were used to determine the effect of each parameter on performance as shown: Then set two and alter the third and implement the graphs showing its impacts on the latency and throughputs.

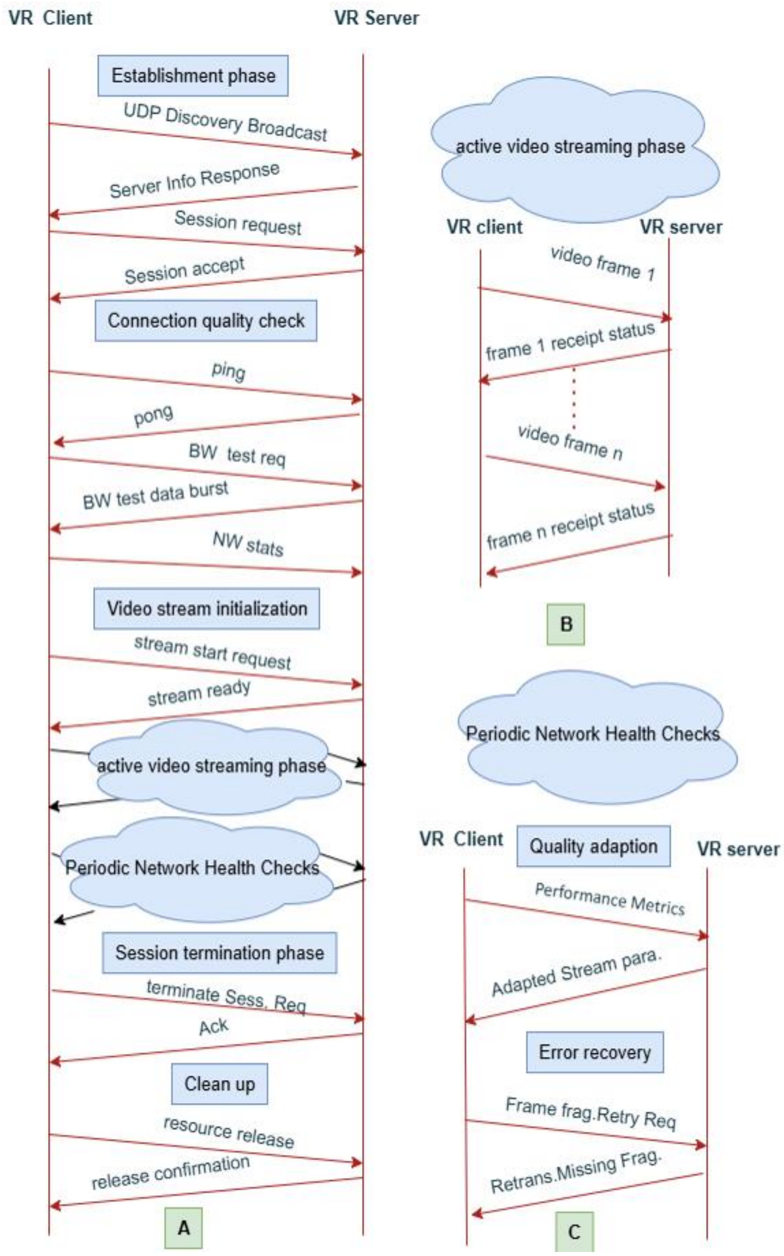

Fig .3. VR Sequence Diagram (a,b,c)

Assume periodic network health check is done every 50 ms , cable length is 10 m, data rate is 1GB and ppr is equal to 205k, and by combining stream signals and control signals in the sequence diagram in figure(3) we found that the mentioned signals impact on network latency does not exceed 0.19%, therefore we will neglect them when calculating whole system performance.

$$Maximum\ payload\ size = Ethernet\ maximum\ transfer\ unit - headers \quad ....equ.(1)$$

$$Max.payload\ size = MTU - IP - UDP - VR\ app. = 1500 - 14 - 20 - 8 - 26 = 1432\text{bytes}$$

$$Total\ latency = Ethernet\ data\ latency + Ack.latency \quad \ldots equ.(2)$$

$$Throughput = \frac{ethernet\ data\ frame * 8}{total\ latency} \quad \ldots equ.(3)$$

$$Ethernet\ data\ latency = Ethernet\ data\ network\ delay + switch\ delay + \frac{1}{packet\ processing\ rate} \quad \ldots equ.(4)$$

$$Ack.latency = network\ delay\ Ack. + swich\ delay + \frac{1}{packet\ processing\ rate} \quad \ldots equ.(5)$$

$$Ethernet\ data\ network\ delay = \frac{data\ packet\ length}{data\ rate} + \frac{cable\ length}{propagation\ speed} \quad \ldots equ.(6)$$

$$no.of\ ethernet\ frame\ for\ each\ VR\ frame = \frac{\text{VR frame size}}{\text{Max payload size}} = \frac{\text{IMB}}{1432} = 733 \quad \ldots equ.(7)$$

$$Network\ Utilization = \frac{(data\ packet\ length + ack\ packet\ length) * (\frac{VR\ frame\ size}{Ethernet\ frame\ size}) * (VR\ fps * 8)}{data\ rate} \quad \ldots equ.(8)$$

B. *Results and Discussion*

The system has high throughput if the number of packets processing rate is increased. This is most probably due to the fact that, total overhead is likely to be inversely proportional to the amount of data tackled per packet.Using more packets in every round probably decreases the chances of handshakes or re initializations thus enhancing the transmission rate as it is depicted in fig (4).

As an important indicator of signal quality, it shows that latency directly depends on the cable length – from 20 microseconds for cables shorter than 200 meters and reaching 35 microseconds at 1000 meters.Throughput is inversely proportional with the cable length and is approximately 0.60 Gbps for the short cable length (0-200 meters) and approximately 0.40 Gbps for 1000 meters cable length.The slow throughput is because of growing signal attenuation and higher error rate, which requires retransmission and error correction techniques as depicted in figure (5).rly with cable length, starting from ~20 microseconds for short cables (0-200 meters) and rising to ~35 microseconds at 1000 meters. Throughput decreases as the cable length increases, starting from ~0.60 Gbps at short cable lengths (0-200 meters) and dropping to ~0.40 Gbps at 1000 meters.The reduction in throughput is likely due to signal degradation and increased error rates over longer cable lengths, which necessitate retransmissions and error correction mechanisms , as shown in figure (5).

in figure (6) Throughput rises with the increasing data rate for every test as it forms a near perfect linear trend right up to the highest data rate possible (~2.5 Gbps). As the data rate increases there may be indication that the curve is reaching saturation (the curve may flatten out).The increase in throughput is expected because; more data is transferred per second with higher data rates . The latency reduces rapidly with the data rate as depicted at a lower latency value of ~ 20 micro Sec for a data rate of ~ 2.5Gbps.

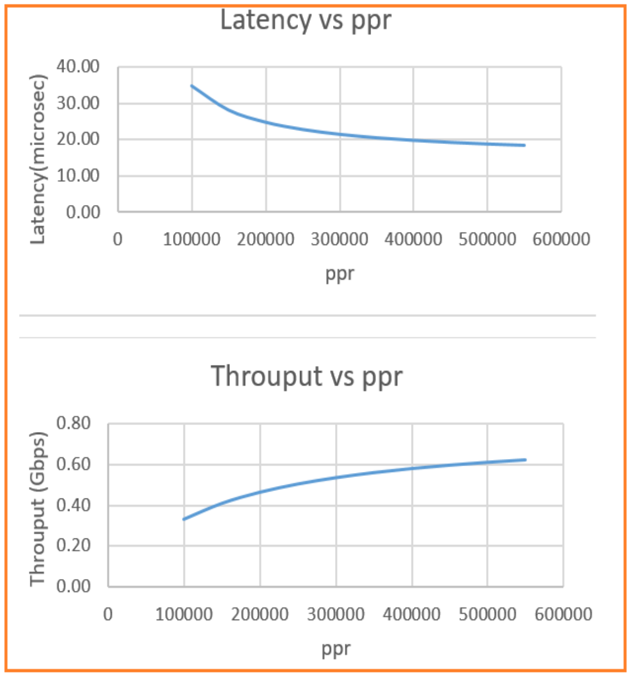

Fig .4. Latency and Throughput and vs ppr

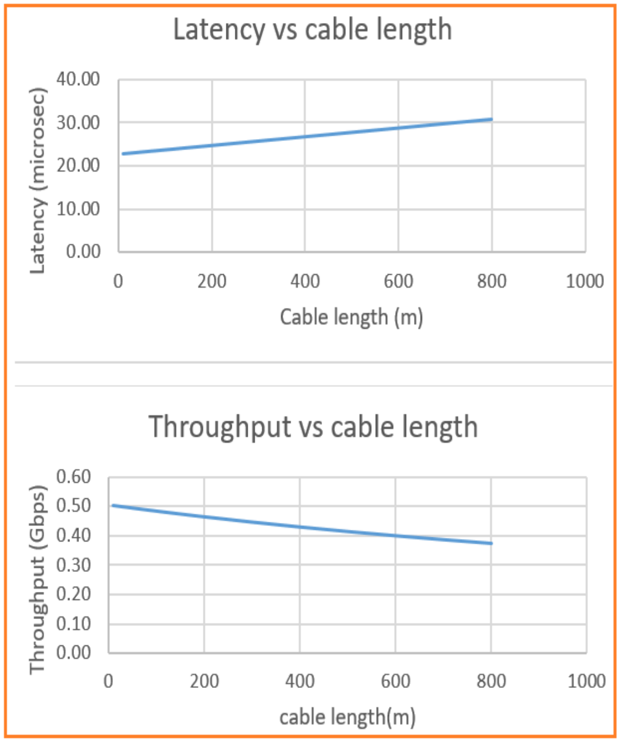

Fig .5.Latency and Throughput vs cable length

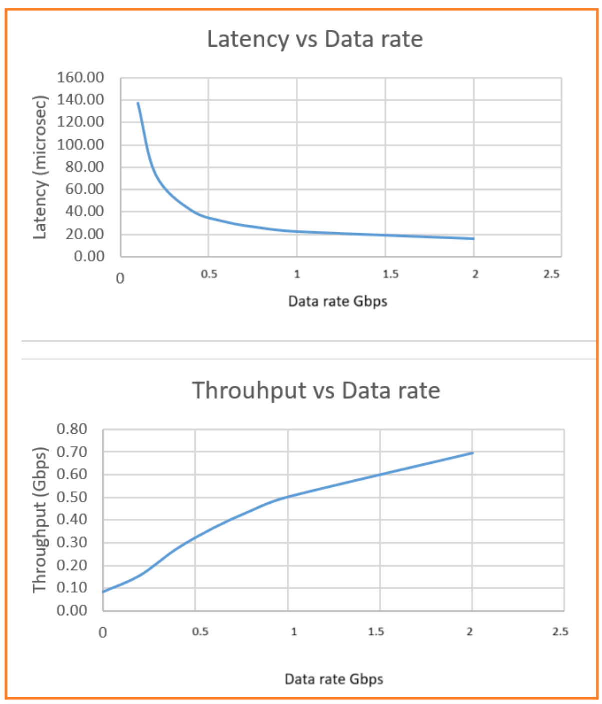

Fig .6.latency and Throughput vs data rate

IV. TRENDED TECHNOLOGIES CHALLENGES

Technologies face some difficult terrains as they evolve [23], [24]. The main challenges that the present technologies encounter are illustrated in Figure 7. [5].

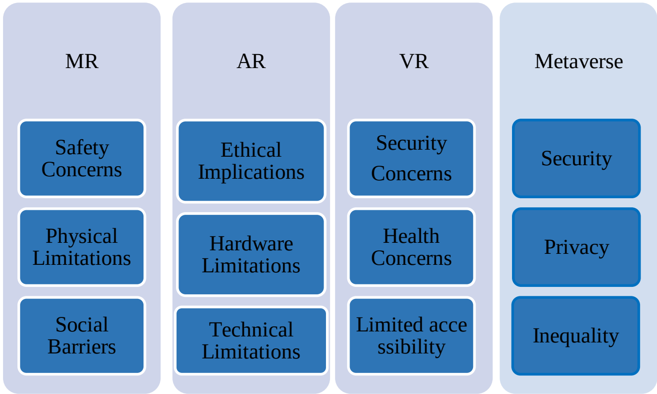

Fig .7. Trended Technologies Challenges

V. CONCLUSION

Dimensioning an actual network using virtual reality gives a new face to information sharing and accessing and at the same time, sustaining the current fast and far-aching growth of the current technologies.

This paper aims at studying the effects of the Advanced Technologies on the performance of the network with especial reference to virtual reality technology. This study also explains how UDP Ethernet communication plays a very central role in improving the performance of Virtual Reality (VR) systems. The experiments show that basic parameters within the network like cable length, data rate and packets per refresh have an impact on latency as well as through put. The results show that though the performance of the system becomes better with the increment in the number of packets, it is not without its drawbacks because it will also have bottlenecks as a result of system constraints. The results highlight the general neccessity to tune further the parameters of the network configurations to cope with the high-requirement needs of immersive technologies. Realisation of concept technologies: New technologies such as the VR provisional and can be used in gaming, commerce, and entertainment industries among others. However, because it engenders monumental amounts of data, networks have to be built and hardware has to meet the new parameters that include high ppr, high speed, and security.

Further The study further explored into the feasibility of implementing other forms of communication other than UDP while considering its effectiveness to the performance of immersion in virtual reality under different network conditions. An examination of the VR cost in combination with other related technologies like Augmented Reality (AR) and Mixed Reality (MR) in order to design complex systems for extended reality environments.

REFERENCES

[1] T. Mirza, N. Tuli, and A. Mantri, "Virtual Reality, Augmented Reality, and Mixed Reality Applications: Present Scenario," 2022 2nd Int. Conf. Adv. Comput. Innov. Technol. Eng. ICACITE 2022, pp. 1405–1412, 2022, doi: 10.1109/ICACITE53722.2022.9823482.

[2] Q. Ibrahim, "Design, implementation and optimisation of an energy harvesting system for vehicular ad hoc networks' road side units," IET Intell. Transp. Syst., vol. 8, no. 3, pp. 298–307, 2014, doi: 10.1049/iet-its.2012.0206.

[3] A. Hayes, L. A. Daughrity, and N. Meng, "Approaches to Integrate Virtual Reality into K-16 Lesson Plans: an Introduction for

Teachers," TechTrends, vol. 65, no. 3, pp. 394–401, 2021, doi: 10.1007/s11528-020-00572-7.

[4] E. Bottani and G. Vignali, "Augmented reality technology in the manufacturing industry: A review of the last decade," IISE Trans., vol. 51, no. 3, pp. 284–310, 2019, doi: 10.1080/24725854.2018.1493244.

[5] H. Orsolits, S. F. Rauh, and J. G. Estrada, "Using mixed reality based digital twins for robotics education," Proc. - 2022 IEEE Int. Symp. Mix. Augment. Real. Adjunct, ISMAR-Adjunct 2022, pp. 56–59, 2022, doi: 10.1109/ISMAR-Adjunct57072.2022.00021.

[6] S. Lazim Qaddoori and Q. I. Ali, "An embedded and intelligent anomaly power consumption detection system based on smart metering," IET Wirel. Sens. Syst., vol. 13, no. 2, pp. 75–90, 2023, doi: 10.1049/wss2.12054.

[7] P. Bhattacharya et al., "Towards Future Internet: The Metaverse Perspective for Diverse Industrial Applications," Mathematics, vol. 11, no. 4, pp. 1–41, 2023, doi: 10.3390/math11040941.

[8] H. M. MOHAMMED and Q. I. ALI, "E-Proctoring Systems: A Review on Designing Techniques, Features and Abilities Against Threats and Attacks," Quantum J. Eng. Sci. …, vol. 3, no. 2, pp. 14–30, 2022, [Online]. Available: https://www.qjoest.com/index.php/qjoest/article/view/66%0Ahttps://www.qjoest.com/index.php/qjoest/article/download/66/47.

[9] H. Ajmera and B. Gonen, "Virtual Reality in Health Care," 2020 Int. Conf. Comput. Netw. Commun. ICNC 2020, pp. 51–55, 2020, doi: 10.1109/ICNC47757.2020.9049769.

[10] F. Guo, F. R. Yu, H. Zhang, H. Ji, V. C. M. Leung, and X. Li, "An Adaptive Wireless Virtual Reality Framework in Future Wireless Networks: A Distributed Learning Approach," IEEE Trans. Veh. Technol., vol. 69, no. 8, pp. 8514–8528, 2020, doi: 10.1109/TVT.2020.2995877.

[11] L. M. Ortega, J. M. Jurado, J. L. L. Ruiz, and F. R. Feito, "Topological data models for virtual management of hidden facilities through digital reality," IEEE Access, vol. 8, pp. 62584–62600, 2020, doi: 10.1109/ACCESS.2020.2984035.

[12] V. Parthasarathy, A. A. Simiscuka, N. O'Connor, and G. M. Muntean, "Performance Evaluation of a Multi-User Virtual Reality Platform," 2020 Int. Wirel. Commun. Mob. Comput. IWCMC 2020, pp. 934–939, 2020, doi: 10.1109/IWCMC48107.2020.9148390.

[13] C. Huang, W. Zhang, and L. Xue, "Virtual reality scene modeling in the context of Internet of Things," Alexandria Eng. J., vol. 61, no. 8, pp. 5949–5958, 2022, doi: 10.1016/j.aej.2021.11.022.

[14] D. Ververidis, S. Nikolopoulos, and I. Kompatsiaris, "A Review of Collaborative Virtual Reality Systems for the Architecture, Engineering, and Construction Industry," Architecture, vol. 2, no. 3, pp. 476–496, 2022, doi: 10.3390/architecture2030027.

[15] S. Safikhani, S. Keller, G. Schweiger, and J. Pirker, "Immersive virtual reality for extending the potential of building information modeling in architecture, engineering, and construction sector: systematic review," Int. J. Digit. Earth, vol. 15, no. 1, pp. 503–526, 2022, doi: 10.1080/17538947.2022.2038291.

[16] K. Zhang, X. Zhao, X. Li, X. Y. You, and Y. Zhu, "Network Traffic Prediction via Deep Graph-Sequence Spatiotemporal Modeling Based on Mobile Virtual Reality Technology," Wirel. Commun. Mob. Comput., vol. 2021, 2021, doi: 10.1155/2021/2353875.

[17] K. Yu et al., "Mixed Reality 3D Teleconsultation for Emergency Decompressive Craniotomy: An Evaluation with Medical Residents," Proc. - 2023 IEEE Int. Symp. Mix. Augment. Reality, ISMAR 2023, pp. 662–671, 2023, doi: 10.1109/ISMAR59233.2023.00081.

[18] A. Adetunla, E. Akinlabi, T. C. Jen, I. P. Okokpujie, and S. S. Ajibade, "A review on the Challenges and Prospects in Harnessing Virtual Reality in Education," Int. Conf. Sci. Eng. Bus. Driv. Sustain. Dev. Goals, SEB4SDG 2024, pp. 1–5, 2024, doi: 10.1109/SEB4SDG60871.2024.10630094.

[19] Q. I. Ali, "An efficient simulation methodology of networked industrial devices," 2008 5th Int. Multi-Conference Syst. Signals

Devices, SSD'08, no. August, 2008, doi: 10.1109/SSD.2008.4632835.

[20] R. Weerawarna, "TCP / UDP Network Performance Evaluation of Various IPSec Algorithms," 2013.

[21] S. Salehi, A. Alnajim, X. Zhu, M. Smith, C.-C. Shen, and L. Cimini, "Traffic Characteristics of Virtual Reality over Edge-enabled Wi-Fi Networks," pp. 1–9, 2020, [Online]. Available: http://arxiv.org/abs/2011.09035

[22] R. I. T. Da Costa Filho et al., "Predicting the performance of virtual reality video streaming in mobile networks," Proc. 9th ACM Multimed. Syst. Conf. MMSys 2018, pp. 270–283, 2018, doi: 10.1145/3204949.3204966.

[23] Q. I. Ali, "Green communication infrastructure for vehicular ad hoc network (VANET)," J. Electr. Eng., vol. 16, no. 2, pp. 58–67, 2016.

[24] F. Bruni et al., "Beyond traditional training: Integrating data from semi-immersive VR dual-task intervention in Parkinsonian Syndromes. A study protocol," PLoS One, vol. 19, no. 2 February, pp. 1–13, 2024, doi: 10.1371/journal.pone.0294199.

Raghad H.AlShekh is graduated at B.Sc and M.S at Departement of Computer Engineering, University of Mosul, Iraq in 2004 and 2021 respectively , and now pursuing for PhD degree in computer engineering at College of Enginering, Mosul University .ng. She has been working in the Ministry of Ministry of Higher Education and Scientific Research in Iraq since2008 till date; she proposed to do research in Internet of Things, Network Cloud Computing field.

Qutaiba I. Ali: graduated from the Department of Electrical Engineering, University of Mosul, Iraq, with the B.S. and M.S. degrees in 1996 and 1999, respectively. He got his Ph.D. degree (with honour) in the Computer Engineering Department, University of Mosul, Iraq in 2006. Since 2000 he had been working with the Department of Computer Engineering, Faculty of Engineering, Mosul University, Mosul, Iraq in which at present he holds the designation of a lecturer. Its areas of interest are analysis and design of computer networks, real-time networks and systems, embedded network devices and network security and management. Dr. Ali have attended and participates in many scientific activities and awarded for his active participation.