Journal for Research in Applied Sciences and Biotechnology

www.jrasb.com

ISSN: 2583-4053

Volume-2 Issue-2 || April 2023 || PP. 147-154

https://doi.org/10.55544/jrasb.2.2.21

Relationship between IoT Service User Quality and Network QoS Factors

Abdurauf Khamosh[1], Abdul Rahim Ahmadi[2], Mohammad Anwer[3], Javid Hamdard[4], Sadiq Aminzai[5] and Nasratullah Nasrat[6]

[1]Department of Information System, Faculty of Computer Science, Shaikh Zayed University (SZU), Khost, AFGHANISTAN.

[2]Department of Information Technology, Faculty of Computer Science, Shaikh Zayed University (SZU), Khost, AFGHANISTAN.

[3]Department of Information System, Faculty of Computer Science, Shaikh Zayed University (SZU), Khost, AFGHANISTAN.

[4]Department of Information Technology, Faculty of Computer Science, Shaikh Zayed University (SZU), Khost, AFGHANISTAN.

[5]Department of Information Technology, Faculty of Computer Science, Shaikh Zayed University (SZU), Khost, AFGHANISTAN.

[6]Department of Information Technology, Faculty of Computer Science, Shaikh Zayed University (SZU), Khost, AFGHANISTAN.

[1]Corresponding Author: raufkhamosh@gmail.com

www.jrasb.com || Vol. 2 No. 2 (2023): April Issue

Received: 26-03-2023	**Revised:** 16-04-2023	**Accepted:** 26-04-2023

ABSTRACT

The Internet of Things (IoT) is a complete network of networked computer devices, digital and mechanical equipment, and the capacity to send data over the Internet based on machine to machine interaction. It is also known as the Internet of Everything (IoE). The Internet is a packet-switched network, which means that the Quality of Service (QoS) elements (such as packet loss, latency, jitter, and so on) have an influence on the Quality of Experience (QoE) for the Internet of Things services. This research used a subjective evaluation method in order to evaluate the relationship between the quality of service (QoS) measures such as packet loss, latency, and jitter and the quality of experience (QoE) for Internet of Things services. In addition to that, a mapping model from quality of service to quality of experience was suggested. According to the results of this research, there is a close connection between the subjective opinion score and the quality of service (QoS) variables such as packet loss, latency, and jitter. The results of this investigation open up possibilities for additional research into the quality of experience of Internet of Things services.

Keywords- CCS Concepts, QoS Factors, IoT Services, Quality of Experience.

I. INTRODUCTION

1999 saw the birth of the phrase "Internet of Things," which refers to a widespread network of intelligent gadgets or other things that are linked to the internet. The Internet of Things (IoT) links disparate things and gives them the ability to communicate and share data through the traditional Internet [1]. The traditional Internet facilitates communication between people. In the modern day, all physical things will be equipped with their own unique IP addresses, allowing them to connect to the internet and carry on two-way conversations with the rest of the world [2]. The Internet of Things has been characterized in a variety of ways throughout the research done on it, but the core idea has remained the same. The phrase "Internet of Things" is composed of the two words "Internet," which refers to a worldwide network of linked computer networks that

ISSN: 2583-4053
Volume-2 Issue-2 || April 2023 || PP. 147-154
https://doi.org/10.55544/jrasb.2.2.21

makes use of the TCP/IP suite to connect objects on a global scale. The second concept is the phrase "Things," which refers to any item that is linked to the internet. These "Things" might be as little as sensors or as large as refrigerators, vehicles, aircraft, and buildings. "a world-wide network of interconnected objects that are uniquely addressable, based on standard communication protocols" [3] is the semantic definition of the Internet of Things.

The perception layer, the network layer, and the application layer are the three primary components that make up a typical Internet of Things architecture. The perception layer, which is also known as the physical/sensing layer, is the layer that is the lowest in the architecture of the Internet of Things. It consists of the sensors, actuators, and embedded software that are used to manage and control the capabilities of the objects [4]. The network layer, which is often referred to as the connection layer, is the most important layer in the architecture of the Internet of Things. The network layer incorporates a broad range of communication protocols and methods, including cellular, satellite, Wi-Fi, Bluetooth, and low-power wide-area networks (LPWAN), which may connect to the Internet either via a gateway/router or directly [4, 5]. The Internet of Things (IoT) system is composed of many layers, the highest of which is the application layer. The application layer communicates with the perception layer by way of the network layer. It acquires the data from the physical layer and then processes the data in order to deliver a variety of services and perform a variety of activities. Device software is used to interact with, provide, and manage the connected items at the application layer, whereas application platforms allow the development and execution of Internet of items applications [4]. The end-user interacts with the application layer, which offers a wide variety of Internet of Things services and applications such as smart homes, smart healthcare systems, smart cities, smart environments, smart grids, and many more. [3].

According to the findings of this research, Internet of Things services are application-layer functionalities that allow end users to manage electrical items (such as a refrigerator, air conditioner, light, automobile, window, door, etc.) by utilizing smart devices such as smartphones, tablets, and iPads. This improves the quality of life and makes it more efficient to carry out everyday tasks. For instance, customers of Internet of Things services may operate their household appliances using their smartphones, such as locking and unlocking doors, turning lights on and off, adjusting the temperature of their refrigerators, and so on. In the current research, Internet of Things services are not restricted to any one particular application for the Internet of Things; rather, they are dependent on the engagement of end users, who have power over the many electronic devices. In addition to the activities linked to smart homes that were discussed before, remote surgery, the use of agricultural drones, and the ability to start and stop a vehicle from a distance are three further instances related to other Internet of Things applications, including smart health care, smart agriculture, and smart cars.

The research of quality of experience is very significant for network service providers in order to lessen the amount of network resources that are used by offering services that are satisfying [6]. The quality of experience, or QoE, is described by the authors of the study [7] as "a kind of subjective perception generated by users in the interaction process between users and services or applications." The quality of experience (QoE) impact factors (IFs) may be broken down into three primary groups, namely the system influence factors (IFs), the context influence factors (IFs), and the human influence factors (IFs). The system impact elements that are regarded as QoS influence factors are further separated into three different categories, which are the network layer, the application layer, and the service layer [7].

"The ability of the network to provide a service with an assured service level" [8] is how Quality of Service (QoS) is defined. The quality of service (QoS) variables that occur at the network level, such as packet loss, delay, and jitter, are the exclusive focus of this study. In the field of multimedia, subjective evaluation of quality of experience (QoE) has been the topic of extensive research, but in the relatively new field of internet of things (IoT), only a small number of studies have been conducted [9]. Some of these studies proposed conceptual models for evaluating quality of experience while taking into account a wide variety of factors that influence quality of experience.

Only a few studies have conducted subjective tests to evaluate the Quality of Experience (QoE) of various Internet of Things applications. According to the authors' best knowledge, no attempt has been made as of yet to research the association between the quality of service aspects and the quality of experience of internet of things services. On the other hand, the connection between devices that are part of the Internet of Things is often accomplished via the use of wireless technology since these devices are typically situated in geographically dispersed places. Wireless networks are notorious for having unpredictable performance and high rates of distortion [6]. As a result, the Quality of Experience (QoE) of Internet of Things services may be impacted by QoS variables at the network level. These include packet loss, latency, and jitter. This study aims to investigate the link between the quality of service elements and the quality of experience of internet of things services. As a result, both a subjective test and a real-time Internet of Things services regulating testbed were built. Both the curve fitting toolbox supplied by Matlab (version R2019b) and the IBM SPSS Statistics Desktop version 26 were used in order to carry out the curve fitting and correlation analysis, respectively.

ISSN: 2583-4053
Volume-2 Issue-2 || April 2023 || PP. 147-154
https://doi.org/10.55544/jrasb.2.2.21

II. RELATED WORK

To the best of the authors' knowledge, there has not been a study conducted in the past that investigates how major performance QoS elements like packet loss, latency, and jitter affect the quality of experience of internet of things (IoT) services. This is despite the fact that the influence of QoS factors on QoE has been the subject of extensive research in the context of multimedia. As a result, we concentrate on the work that was done in the past for multimedia services.

It has been discovered that jitter may degrade the quality of video by the same amount that packet loss does, and that even a low-level impairment of jitter or packet loss can alter the way video is perceived to be of lesser quality [10]. Studies have been done on the effects of packet loss and latency, and the findings have shown that packet loss is a more relevant factor than delay in determining perceived quality [11]. The effect of latency and jitter on the quality of experience of playing the Call of Duty: Modern Warfare 2 game is shown, and it was discovered that jitter has a significant influence on the quality that is perceived [12]. Research was conducted in the multimedia delivery network to investigate the perceptual and attentive impact that delay and jitter have on users, and the findings reveal that delay and jitter have an important association with the quality of experience (QoE) of users [13]. Jitter and packet loss were shown to have a substantial impact on how video information is experienced, according to the findings of a research that investigated the influence of video content and transmission defects on quality of experience. The delay, on the other hand, does not seem to have a significant influence on the quality that is perceived [14]. According to the findings of a study on the Quality of Experience (QoE) of mobile video using the H.264 codec, the variation in packet loss and packet delay is very sensitive to the consumers' perceived quality [15].

III. METHODOLOGY

3.1. Subjective Test

An experiment that is carried out based on mental and physical activities is referred to be a subjective test. A group of individuals should utilize the Internet of Things services in order to evaluate and grade them as part of the subjective process, which is very important in the current research. It is not only expensive but also inconvenient and time-consuming in certain circumstances. However, these subjective tests are required before any objective measuring algorithms can be developed. This is due to the fact that objective measuring algorithms model subjective tests as well as human vision using data gathered from subjective measuring instruments. There are two different environments that may be used to conduct the subjective test: controlled environments and uncontrolled environments. This particular experiment was carried out in a controlled setting, which is typical for the administration of subjective examinations.

The number of people who can take the subjective exam might range anywhere from 4 to 40 at the most. In terms of statistics, a sample size of four is the basic least that may be used, while increasing the number to more than 40 hardly seems worthwhile [16]. As a result, thirty undergraduate students from the Computer Science department at Shaikh Zayed University (SZU) in Khost, Afghanistan engaged in the project on a voluntary basis. Their ages ranged from 18 to 25, and all of them were in the age bracket of 18–25. Thirteen of the individuals were female, whereas the other participants were all male. Nobody who took part in the study had any prior experience working as an expert for Internet of Things (IoT) services, and they also did not often interact with the technology that underpins the Internet of Things in the course of their jobs.

The participants were given a questionnaire and training materials (in the form of a demo film and power point slides) in order to get them ready for the actual exam by familiarizing themselves with the real test circumstances before the actual test was given. When the participants arrived, all of the activities related to the test were facilitated, and they were encouraged to perform in the following order:

- Take part in a short training session that lasts no more than a quarter of an hour.
- You will be given both a paper questionnaire and a smartphone to complete.
- Using your smartphone, you can take control of the electronic device (the light bulb).
- Using a scale that goes from 5 (Excellent) to 1 (Bad), please rate the quality of the light bulb function.
- Take a break after finishing one of the tests that is connected to the network parameter.

As a part of the subject's pre-experiment preparation, they were given the opportunity to do the turning-on-and-off-the-light-bulb and dimming-the-light activities several times. During the period of practice, the optimal and suboptimal experimental conditions were determined, during which the device may work correctly (in a manner that is imperceptible), it may work slowly (in a manner that is slightly annoying), or it may not work at all (in a manner that is very annoying). After then, all of the questions and suspects that were discovered by the participants throughout the period of practice were analyzed, and then they were solved. In the end, once the evaluators had gained confidence and were prepared, the actual exam was carried out.

As was explained in the part before this one, there are three primary QoS criteria that are taken into consideration for the network impairment settings. These are represented in Table I below. The needed number of light bulb on/off and dimming tests varied according to

ISSN: 2583-4053
Volume-2 Issue-2 || April 2023 || PP. 147-154
https://doi.org/10.55544/jrasb.2.2.21

the amount of network parameter distortion. Five different levels of network parameter distortion are available. The individual subject completed a total of fifteen tests, bringing the overall number of tests to fifteen.

The participants were free to exit the experiment at any time throughout the testing session; they were able to quickly cease what they were doing and disobey the instructions at any time. Everyone who had been asked to take part in the test did so with a great deal of excitement, and there was not a single person who was discovered to have left the experiment.

Table 1: Network Impairment Settings

Parameters	***Details***
Packet Loss in (%)	1, 3, 5, 10, 15
Latency in (ms)	150, 300, 500, 800, 1000
Jitter in (ms)	50, 140, 290, 420, 580

In order to avoid wasting time and to ensure that the tests could be carried out without a hitch, all of the network metrics and the impairment values that are linked with them had already been inserted and set up in the network emulator software. The only information provided to the individuals was on the network characteristics, and for each measure, the range impairments that were evaluated. They did not follow any precise guidelines about the distortion levels that should be considered for each of the three network characteristics. They were also kept in the dark about which network factor and impairment values are carried out first, second, and so on. As a result, in order to prevent biased studies, all fifteen tests were carried out in a random manner for each of the QoS factor impairments that were taken into consideration, as shown in Table II below.

Table 2: Randomly Execution Sequence of All Tests

Parameters	**Details**				
	1	**2**	**3**	**4**	**5**
Packet Loss in (%)	10	5	1	15	3
Latency in (ms)	500	1000	150	300	800
Jitter in (ms)	290	580	140	420	50

In order to carry out the assessment, we made use of the five-point scale that is recognized and used by the vast majority of people, as shown in Table III [16]. In the end, each record was checked again for any missing values, and any that were found were manually typed into the excel program.

Table 3: Five-Level Scale

MOS	**Quality**	**Impairment**
5	Excellent	Imperceptible
4	Good	Perceptible but not annoying
3	Fair	Slightly annoying
2	Poor	Annoying
1	Bad	Very annoying

3.2 Testbed

The primary objective of the testbed is to simulate a real-world situation in which a link may be established between a smart device (such as a smartphone) and an electrical equipment (such as a smart light bulb). The testbed consists of a controller (Dell Latitude E5550), a smartphone (Samsung Galaxy S5), a Wi-Fi smart light bulb (GB-WLB1), and two dual-band Wi-Fi access points (HUMAX T3ATv2) and (Mi router 3). As shown in Figure 1, the smartphone established a connection with the access point A, which in turn established a connection with the local area network. The Wi-Fi connection for the smart light bulb operates at 2.4 GHz, and it is paired with access point B. The controller is connected to the local area network, and it is this controller that is connected to the access point B. All of the other network components, with the exception of the smartphone and the light bulb, both of which use the Wi-Fi connection method, use Ethernet cables in order to give the highest possible quality connection and to avoid the signal from being wasted due to interference from other waves, such as radios and telephone signals.

In order to investigate how changes in network settings influence the subjective opinion score variation, a piece of software known as Network Emulator for Windows Toolkit (NEWT) is being installed on a computer. This program simulates the connection that exists between a mobile device and a smart light bulb. NEWT is software that may be used to replicate various wired and wireless network metrics such as packet loss, latency, jitter, disconnection, and packet reordering, among other things [17]. NEWT is a network emulator.
The specifications of the various pieces of test bed equipment are shown in Table IV.

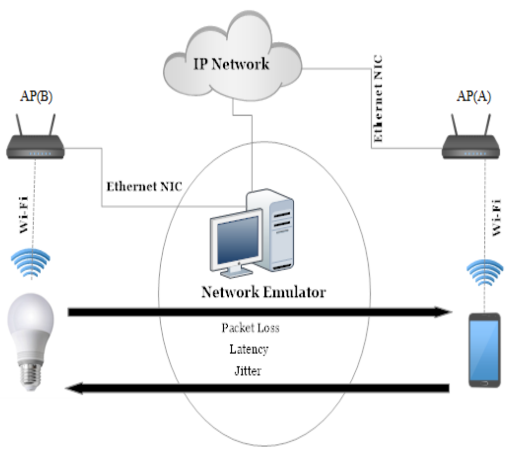

Fig. 1.

ISSN: 2583-4053
Volume-2 Issue-2 || April 2023 || PP. 147-154
https://doi.org/10.55544/jrasb.2.2.21

Table 4: Specification of the Equipments Used in the Testbed

Device	**Specification**
Access Point A	HUMAX T3ATv2, Wi-Fi Class - AC1200 (300Mbps at 2.4GHz, 900Mbps at 5GHz
Access Point B	Original Xiaomi Mi Router 3 Dual Band 2.4G/5GHz 128MB Wi-Fi Wireless Router
Controller	Dell Latitude E5550 Laptop, Intel(R) Core(TM)i7-5600U CPU @2.60GHz 2.59 GHz, 8.00 GB RAM
Smartphone	Samsung Galaxy S5, Quad-core 2.5 GHz CPU, 2GB RAM, Wi-Fi 802.11 a/b/g/n/ac, dual-band, Wi-Fi Direct, hotspot
SmartLight Bulb	GB-WLB1, Input Voltage: 110-260V 50/60Hz, Wi-Fi Type: 2.4GHz
NIC 1	USB3.0 ETHERNET ADAPTER 10/100/1000 Mbps,
NIC 2	Intel(R) Ethernet Connection (3) I218-LM, Speed: 100 Mbps

NIC: Network Interface Card

IV. RESULTS AND DISCUSSION

After completing the subjective exam, the scores based on the participants' subjective opinions were recorded for the purposes of analysis. To begin, the outlier was investigated to ensure that the data were accurate. If the score for the subject's subjective opinion is denoted by the letter S, then the subject will be considered an outlier if S is more than Q3 plus 1.5 (Q3 – Q1) or if S is less than Q1 minus 1.5 (Q3 – Q1), with Q1 and Q3 being the 25th and 75th percentiles of the score distribution, respectively. If a subject has more than 20% of his or her scores that are judged to be outliers, then the subject will be deemed an outlier, and all of his or her records will be removed [6]. In our experiment, which strictly adhered to the conditions outlined above, we did not discover any outliers. The score that represents one's subjective judgment has been computed using (1).

$$S = \frac{\sum_{n=1}^{N} R_n}{N} \quad \text{………. (1)}$$

Where Rn is the individual evaluations that N participants have provided for a specific stimulus. In order to propose the mathematical model, a fitted line plot and a residual plot were employed to pick between the linear and nonlinear regression options. These plots were also used to choose between the two types of regression. According to the fitted line plot as well as the residual plot, respectively, the data is linear; nevertheless, the residual plot did not exhibit any particular pattern. As a result, a method called linear regression was utilized in order to discover the greatest match between quality of service and quality of experience for each unique network parameter that was taken into consideration. When compared to nonlinear regression, linear regression is not only easy to apply but also simpler to carry out and interpret, and it provides access to a greater number of statistical parameters for comparison. In order to find the linear regression model that provided the greatest fit for the data while simultaneously avoiding problems associated with under fitting and over fitting, we selected, from among all of the regularly used linear regression models, the one that had the highest R2, adjusted R2, forecasted R2, and least amount of standard error as shown in Table VI.

After that, we look at each of the QoS elements on its own and attempt to establish a connection between it and the overall score for the subjective assessment.

4.1. Impact of Packet loss on QoE

As shown in Fig.2, there is a significant relationship between the quality of experience provided by Internet of Things (IoT) services and the packet loss metric. If the packet loss impairment value is low, then the subjective opinion score for the IoT services under consideration will be greater. However, this score will decline with each additional instance of packet loss. The fact that the Pearson correlation is rather high in table VI also demonstrates that the on/off and dimming IoT services have a very substantial association with the packet loss factor. This is proved by the fact that the correlation is extremely high. On the other hand, the performance of the on/off IoT service is superior than that of the dimming IoT service across the board for impairment values. The same fact has been reported in study [14], where it has been shown that large values of packet loss result in a significant decline in the subjective opinion ratings. As shown in Table VI, the P-value for the packet loss impairment is lower than the significance threshold. This indicates that the subjective opinion scores are substantially different for the various levels of packet loss impairment that were investigated for the on/off and dimming functions. Based on these findings, it can be deduced that the perceived quality of all of the Internet of Things services under consideration suffers a major hit when the packet loss is large. The following polynomial functions demonstrate the relationships between the packet loss (PL) and the quality of experience (QoEPL) for the on/off and dimming IoT services, respectively.

$$QoE_{PL} = \beta_0 + \beta_1 PL \quad \text{……….(2)}$$

ISSN: 2583-4053
Volume-2 Issue-2 || April 2023 || PP. 147-154

https://doi.org/10.55544/jrasb.2.2.21

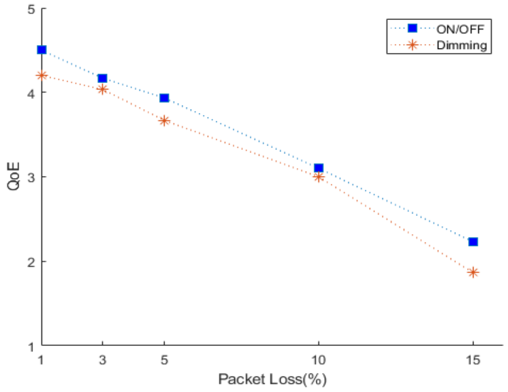

Fig. 2.

4.2. Impact of Latency on QoE

Network latency has a direct influence on user satisfaction depending on the service in terms of the time required to establish a specific service from the first user request and the time to get a response after the service has been established [18]. This is because network latency affects both the time it takes to create the service and the time it takes to receive a response once the service has been established. As can be seen in Figure 3, the subjective opinion scores change depending on which set of latency impairment is being evaluated. As seen in this figure, the value of the subjective opinion score increases as the latency is reduced. It suffers a progressive loss with each additional millisecond of delay. However, once it reaches 300 milliseconds, the subjective opinion score begins a gradual decline from that point on. Both of these Internet of Things services exhibit the exact same pattern. The fact that the P-value is lower than the significance threshold that was chosen demonstrates that the subjective opinion scores are substantially different for all of the latency impairment levels that were taken into consideration for the on/off and dimming IoT service types. In this particular instance, the polynomial model with a second degree is also the most appropriate option for determining the relationship between the latency (L) and the quality of experience (MOSL) as shown by equation 3.

$$QoE_L = \beta_0 + \beta_1 PL \quad \text{.......(3)}$$

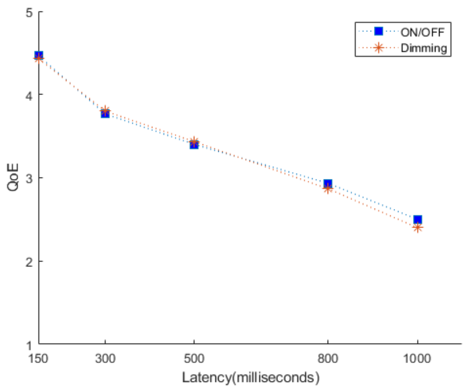

Fig. 4.

4.3. Impact of Jitter on QoE

Figure 4 depicts the shift in quality perception that occurs when jitter impairments are present. The quality of the image being seen deteriorates noticeably with each rise in the jitter impairment levels. The exact same conclusion can be drawn from Table VI, which shows that the Pearson correlation coefficients are quite high, and the P-values for the significance level are lower than 0.01 for both the on/off and dimming IoT service types. However, there is a difference for 290 impairments where the perceived quality of the dimming IoT service is very slightly better than the on/off IoT service. Aside from this, the on IoT service is superior to the dimming IoT service for all other impairment values. The jitter impact on the perceived quality is also confirmed by the work that was done for a mobile video streaming service that used the H.265/VP9 codec [8]. In the same way as other factors do, it provides one degree of polynomial models as the best fitting between the jitter (J) and quality of experience (QoEJ) for the on/off and dimming Internet of Things services, as shown by the following equation 4.

$$QoE_L = \beta_0 + \beta_1 PL \quad \text{..........(4)}$$

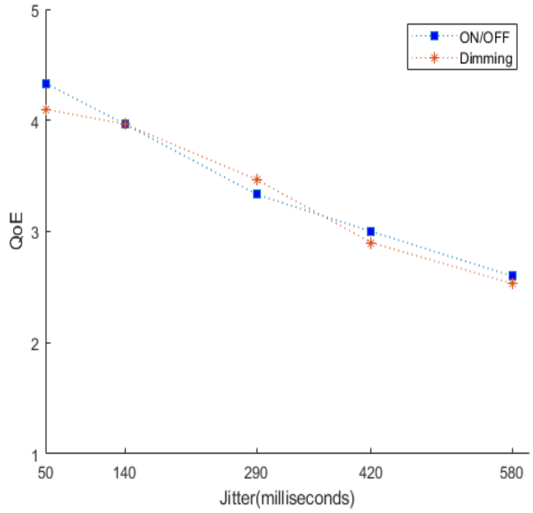

Fig. 4.

Table 5: Value of Coefficients for On/Off and Dimming IoT Services

IoT Services	Factor	B_0	B_1
ON/OFF	Packet Loss	4.6837	- 0.16134
ON/OFF	Latency	4.581	- 0.002122
ON/OFF	Jitter	4.4192	- 0.003285
Dimming	Packet Loss	4.482	- 0.1660
Dimming	Latency	4.619	- 0.002241
Dimming	Jitter	4.3245	- 0.003146

ISSN: 2583-4053
Volume-2 Issue-2 || April 2023 || PP. 147-154
https://doi.org/10.55544/jrasb.2.2.21

Table 6: QoS Factors Correlation Analysis

IoT Services	Factor	Pearson Correlation	R Square	R Square (Adj)	R Square (Pre)	Standard Error	Significance Level
ON/OFF	Packet Loss	-0.999	99.80%	99.74%	99.32%	0.046766	P < 0.01
ON/OFF	Latency	-0.979	96.01%	94.68%	87.14%	0.174894	P < 0.01
ON/OFF	Jitter	-0.991	98.34%	97.79%	94.02%	0.104751	P < 0.01
Dimming	Packet Loss	-0.991	98.24%	97.66%	91.23%	0.145485	P < 0.01
Dimming	Latency	-0.989	97.99%	97.32%	93.56%	0.129787	P < 0.01
Dimming	Jitter	-0.992	98.56%	98.09%	96.11%	0.0932379	P < 0.01

Last but not least, based on the findings and the discussion, we are able to draw the conclusion that the quality of service (QoS) characteristics such as packet loss, latency, and jitter have a high correlation with the quality of experience (QoE) of IoT services, as shown in Table VI. Packet loss is the most important of the three QoS parameters to consider from an on/off IoT service standpoint. This is followed by latency and throughput. Jitter is the most serious issue brought on by dimming IoT service perspective, even more so than packet loss and delay. Although latency also has a very significant relationship with the Quality of Experience provided by IoT services, it contains the weakest correlation of the three when viewed from the perspective of either turning on/off or dimming IoT services.

V. CONCLUSION

The major objective of this research was to investigate the effect that the QoS parameters packet loss, latency, and jitter have on the Quality of Experience (QoE) of Internet of Things (IoT) services. In addition, a mathematical model that can predict the Quality of Experience (QoE) of Internet of Things services based on Quality of Service factors was also suggested. In order to accomplish the goals of the study, a subjectivity test was carried out in a regulated setting at one of the computer labs located within the computer science department of SZU in Khost, Afghanistan. In order to conduct the subjective test, a testbed that included two access points that supported both bands, a smartphone, a smart light bulb, and a network simulator was set up. Tools from SPSS and Matlab were utilized in order to do analysis on the data and visualize the results. In a similar manner, a straightforward linear regression approach was used in order to construct the functional model.

The relationship between the quality of experience provided by Internet of Things (IoT) services and three essential quality of service measures, including packet loss, latency, and jitter, was investigated in this body of work. According to the findings, the Quality of Experience (QoE) of Internet of Things services is closely related to all important Quality of Service (QoS) variables. The findings also suggested that the packet loss had the most significant influence on the Quality of Experience (QoE) of IoT services from the standpoint of an on/off IoT service, and that the jitter metric association with QoE of IoT services was most important when viewed from the dimming IoT service angle. Latency showed the poorest link with the quality of experience of Internet of Things services when compared to the other two parameters: turning the IoT services view on and off.

In this particular research, the link between quality of service components and quality of experience of internet of things services was investigated using just three quality of service elements as bivariate variables. But in practice, the quality of experience ought to be studied using a multivariate approach. As a result, future work will consist of investigating the influence that is collectively caused by all of the elements that have been identified, putting forth bivariate and multivariate mapping models, and expanding the number of participants.

REFERENCES

[1] C.-L. Hsu and J. C.-C. Lin, "An empirical examination of consumer adoption of Internet of Things services: Network externalities and concern for information privacy perspectives," Comput. Human Behav., vol. 62, pp. 516–527, 2016.
[2] R. Falcone and A. Sapienza, "On the users' acceptance of IoT systems: A theoretical approach," Information (Basel), vol. 9, no. 3, p. 53, 2018.
[3] M. Atzori, "Blockchain-based architectures for the internet of things: A survey," SSRN Electron. J., 2017.
[4] J. Lin, W. Yu, N. Zhang, X. Yang, H. Zhang, and W. Zhao, "A survey on internet of things: Architecture, enabling technologies, security and privacy, and applications," IEEE Internet Things J., vol. 4, no. 5, pp. 1125–1142, 2017.
[5] B. E. El-Shweky et al., "Internet of things: A comparative study," in 2018 IEEE 8th Annual Computing and Communication Workshop and Conference (CCWC), 2018.
[6] P. Sethi and S. R. Sarangi, "Internet of Things: Architectures, protocols, and applications," J. Electr. Comput. Eng., vol. 2017, pp. 1–25, 2017.

ISSN: 2583-4053

Volume-2 Issue-2 || April 2023 || PP. 147-154

https://doi.org/10.55544/jrasb.2.2.21

[7] M. Yang, S. Wang, R. N. Calheiros, and F. Yang, "Survey on QoE assessment approach for network service," IEEE Access, vol. 6, pp. 48374–48390, 2018.

[8] D. Pal and V. Vanijja, "Effect of network QoS on user QoE for a mobile video streaming service using H. 265/VP9 codec," Procedia computer science, vol. 111, pp. 214–222, 2017.

[9] D. Pal, V. Vanijja, and V. Varadarajan, "Quality Provisioning in the Internet of Things Era: Current State and Future Directions," 2018, pp. 1 –7.

[10] M. Claypool and J. Tanner, "The effects of jitter on the peceptual quality of video," in Proceedings of the seventh ACM international conference on Multimedia (Part 2) - MULTIMEDIA '99, 1999.

[11] G. W. Cermak, "Multimedia quality as a function of bandwidth, packet loss, and latency," Int. J. Speech Technol., vol. 8, no. 3, pp. 259–270, 2005.

[12] R. Amin, F. Jackson, J. E. Gilbert, J. Martin, and T. Shaw, "Assessing the impact of latency and jitter on the perceived quality of call of duty modern warfare 2," in Human-Computer Interaction. Users and Contexts of Use, Berlin, Heidelberg: Springer Berlin Heidelberg, 2013, pp. 97–106.

[13] S. R. Gulliver and G. Ghinea, "The perceptual and attentive impact of delay and jitter in multimedia delivery," IEEE Trans. On Broadcast., vol. 53, no. 2, pp. 449–458, 2007.

[14] P. Paudyal, F. Battisti, and M. Carli, "Impact of video content and transmission impairments on quality of experience," Multimed. Tools Appl., vol. 75, no. 23, pp. 16461–16485, 2016.

[15] T. N. Minhas, O. G. Lagunas, P. Arlos, and M. Fiedler, "Mobile video sensitivity to packet loss and packet delay variation in terms of QoE," IEEE, 2012, pp. 83–88.

[16] P. Itu-T, "910, Subjective Video Quality Assessment Methods for Multimedia Applications." 2008.

[17] "Microsoft forums," Microsoft.com. [Online]. Available: https://social.microsoft.com/Forums/en-US. [Accessed: 20-June-2020].

[18] H. J. Kim and S. G. Choi, "A study on a QoS/QoE correlation model for QoE evaluation on IPTV service," 2010, vol. 2, pp. 1377–1382.