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An Opinion Paper:
Investigating Quality of Service Concerning the RFB Protocol and its Application in Cloud Gaming

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ABSTRACT

Remote Framebuffer (RFB) protocol is a simple protocol for remote access to graphical user interfaces. The use of the RFB protocol has been developed as a means of streaming content, alleviating much of the processing requirements of games for the end user. Cloud gaming is currently an area of the gaming industry gaining large amounts of ground with respect to the potential viability in the future. Understanding how QoS can affect the development of cloud gaming, as well as the metrics involved, and how these metrics affect areas surrounding QoE could help aid developments in cloud gaming as an extremely viable process in the future.

KEYWORDS

Cloud Gaming, Gaming, Remote Framebuffer (RFB), Quality of Experience (QoE), Quality of Service (QoS)

1. INTRODUCTION

Cloud gaming is an area of the gaming industry gaining large amounts of ground with respect to the potential viability in the future. Takahashi (2014) explains that the demand for cloud gaming could increase in the future, he further states that those involved in the cloud gaming market, such as Nvidia and Sony, could gain 120 million users by the end of 2016. Yao and Chang (2014, 2015) explain the rising of gaming industry in China and they have developed a survey-based case studies to investigate the correlation between trust and community building in a selected online game in China. Cloud gaming gives the users the main benefit of being able to run both graphical and standard processor intensive games on many different types of devices. It also has green benefits, as much of the processing is not done on the end user device, Mines (2011) elaborates on the benefits of using the cloud in respect to virtualization. It is stated that because less equipment is required to run many different workloads, ultimately this means that less equipment will be plugged in. This is beneficial in respect to reducing the overall carbon footprint on a global scale. Therefore cloud technology in general can be extremely beneficial in reducing the gaming industry's carbon footprint. McGonigal (2011) states that the world spends three billion hours per week playing video games. It therefore makes a lot of sense to aid the development of such changes which could help reduce the carbon footprint in such a huge industry.

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However, the success of cloud gaming depends on the quality of the service received and quality of user experience. Yin-Poole (2012) stated that there are issues regarding cloud gaming which has hindered the growth in regards to those companies who are currently developing cloud gaming services. Takahashi (2014) stated that demand for cloud gaming will most probably depend on pricing and quality. This paper aims to provide an overview of RFB protocol, its application in cloud gaming, quality of service (QoS), QoS metrics, quality of user experience (QoE) in cloud gaming and the correlation between QoS metrics and QoE.

2. REVIEW OF LITERATURE

In this section a review of literature will commence, including a number of different types of literature. These will include scholarly literature such as journals, as well as trustworthy articles, blogs, and magazines for instance. The literature used will support what research is required to begin to understand the processes behind the investigation.

2.1. The RFB Protocol

Firstly, it's important to begin to understand how the main protocol in question works, so that later on simulations can be carried out mirroring how the protocol functions.

The RFB protocol (Also known as the VNC Protocol) was firstly developed as a means viewing graphical user interfaces remotely. As suggested by Richardson (2011) because it is used at the frame-buffer level, it can be used on a wide ranging number of systems and devices, including both Windows and Macintosh. He goes on to suggest that there are two main areas in respect to how this works. This Protocol works between an RFB client and server, the user side being the client; whereby users can control what they see being sent by the RFB server via their input hardware e.g. keyboard and mouse on the client side. Pixel data is sent via the server side, and is updated via a 'frame-buffer update' which constantly updates the client from the server side, in conjunction with inputs from the client side.

Figure 1 shows the RFB protocol in action in a simple form Quazoo.com (2013).

From the diagram it can be understood how the protocol works in essence.

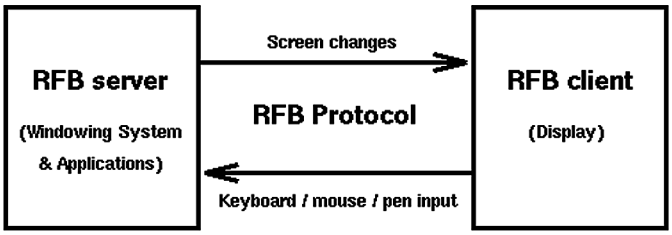
The process can run over any type of reliable transport, for instance by means of TCP/IP as suggested by AT&T Laboratories Cambridge (1999).

As further stated by AT&T Laboratories Cambridge (1999) which goes onto support that the protocol has been designed in such a way as to mean that requirements to run the process can be done on a range of hardware, and involving the client on such hardware has been designed with simplicity in mind.

2.2. Application in Cloud Gaming

Cloud gaming applications such as Onlive have incorporated the workings of the protocol into their systems, adapting them to stream online games. O'Callaghan (2011) suggests that a user only

Figure 1. RFB protocol in action, Quazoo.com (2013)



requires the computing power enough to run the client itself. Therefore the user only requires having a computer which can run the application which executes the client. This further backs up the idea that cloud gaming can be potentially run on a huge range of systems, and devices. No longer will users have to have a certain specification of the system to run certain games, this due to as suggested by Dyzre (2014) the majority of the processing is done on the server side.

However, it is also suggested that to ensure that there is no latency in respect to packets transferred between the server and client, an internet connection of at least 2Mbps needs to be maintained. Ideally an internet connection above 6Mbps for more graphical demanding games. It can be understood from this that cloud gaming can be difficult for some users to access. However, as suggested by Etherington-Smith (2014) recently the global average connection speed has passed 4Mbps for the first time, and therefore more and more users globally will be able to access such services. This is possibly a strong indication of cloud gaming's potential in respect to the possibility of it being rolled out globally; if not right now in the future.

2.3. Quality of Service

Quality of Service in regards to networking and communications, relates to ensuring a network complies with a number of metrics which can be improved, and potentially guarantee these metrics are set at a level, whereby network traffic can communicate effectively without any issues being apparent to the network itself, and potentially the user, as suggested by Menasce (2002). However, Stanford (2011) suggests that QoS is used with some ambiguity as it's a term to describe a network traffic being provided with a better standard of performance. For instance, prioritizing of packets within a network, would certainly help ensure that QoS was being accomplished in terms of the network. However, this doesn't particularly mean that a user's experience will be directly affected as a result. This is due to the strong probability that the packets being transferred are being done at a speed that at a human level may not be noticed by users. However, this in a networking sense would be of importance.

In relation QoS is of importance in respect to cloud gaming because as previously stated in terms of bandwidth, and as suggested by Yin-Poole (2012) issues surrounding bandwidth were the main issues holding cloud gaming back in terms of growing as a popular service globally. Therefore, it is of extreme importance that QoS is achieved by services that depend on adequate levels of latency for instance.

As suggested by Microsoft (2003) the main 'goals' that ensuring QOS is implemented successfully are latency, bandwidth, jitter, as well as reliability. They further state that ensuring that traffic within a network conforms to rules set out by QoS can have a number of benefits to applications running on networks. These benefits include a number that are beneficial in relation to services run via cloud gaming.

It can be concluded that QoS is an important area to look at in respect to cloud gaming, as if not implemented effectively it can have potential repercussions in respect to affecting the network traffic involved in cloud based services. Therefore, these repercussions could have a direct impact on the overall user experience with respect to latency for instance.

2.4. Quality of Service Metrics

The metrics used in regards to QoS surround what is measured in terms of QoS. There is a vast amount of metrics that involve QoS, however, it is a small proportion of these that are really required in respect to the investigation being partaken, as suggested by Techsoup(unknown). It further suggests that a number of these metrics include latency, bandwidth, jitter, and reliability; these also previously suggested by Microsoft (2003).

2.5. Latency

Measured in milliseconds, latency is the time taken for packets to travel from one location to another. For instance the time taken for a packet being sent from the client to the cloud servers. Stated by O3bNetoworks (unknown) the main areas that affect latency is the route taken between sender and receiver, as well as reliability. Chang and Wills (2016) have identified network latency as an issue that can dampen the performance for big data processing, transfer and storage in the cloud. Hence, network latency can play a vital role.

2.6. Bandwidth

As suggested by Sevcik (2010) bandwidth is not the overall speed of a internet connection, but to be used as the minimum capability across all links within the network. Therefore, bandwidth is a measurement in regards to the minimum speed of transfer being achieved by the network.

2.7. Reliability

The reliability of a network is measured by two main aspects as suggested by Ahmad (2010) It has been suggested that the first metric of note is performing baselines of a network. Analyzing baselines by carrying out different configurations will allow those investigating to further understand how those changes will affect a network.

The second method discussed is analyzing the flow within a network environment. The flow of traffic can be broken down into individual areas, such as the different protocols at work within the process. Therefore, allowing a more detailed view of the data available.

Latency, bandwidth, and reliability are not necessarily actual metrics concerning QoS, however, it does have an effect on streaming based scenarios such as this one. Therefore, discussing these areas are beneficial to the investigation, as to gain a further understanding in areas required to carry out the project.

2.8. Jitter and Packet Loss

Valter (2013) suggests that 'Jitter' is an issue that is only experienced in packet based networking. Timings of packets sent are generally sent and the expected time they are received at intervals. If one packet interval differentiates from the norm, then this is classified as jitter. In many respects measuring the amount of these jitters occurring in a certain time period could develop a strong consensus in understanding how these could potentially affect the QoS.

Losing packets within the network could pose significant issues that could potentially affect the user, as well as being of interest from a QoS perspective. Packet loss is described by Serral-Gracià et al (2010) as a loss of a packet that has been created at a node, which subsequently has been lost due to network issues.

2.9. Disaster Recovery

All the services should be able to protect users from data loss, hacking and fraudulent activities. In the event of serious security breaches and hacking, the client organisations and service providers have to recover all the data and restore services as soon as possible. Chang (2015) explains the unique methodology to recover terabytes of data across three sites in London, Leeds and Southampton that can demonstrate very useful lesson learned for organisations seeking a high level of QoE and QoS.

2.10. One Way Delay

One way delay is defined by Leinen (2007) who suggests one way delay is part of the concept of end- to-end delay which entails calculating the delays between sender and receiver. However, at times measuring end to end delay may not be wholly suitable due to it measuring the entire transfer of a packet, instead of where the delay has occurred. One way delay refers to the delays between two

different nodes, which can be measured by sending time-stamped packets from a node to another, and recording the time received; as suggested by Leinen (2007).

It is of importance that an understanding of these metrics is gained to fully understand their inner workings, so that as to know how they can be applied in theory to the investigation. Furthermore the understanding of how these metrics are measured is important to develop ways of analysing the data usefully.

3. QUALITY OF EXPERIENCE

QoE as a part of QoS is described by Karan et al (2014) as an important area in regards to the successful development of current and future computing systems. Therefore, its relative importance to this investigation is one that needs to be outlined.

Quality of Experience therefore needs to be addressed, as cloud gaming being viable partly depends on users' experiences being understood. As opposed to QoS which relates to measuring and analysing gathered data on hardware, software, and guaranteeing communications within the network.

QoE is described by University of Surrey (2014) as measuring a user's overall experience. Also suggested is the relation between QoE and network performance, as well as the areas of note that could potentially relate to QoS. These include reliability, availability, as well as clarity.

However, is there any correlation between QoE and QoS? This question is worth for scientists, service providers and users think about since the user experience can affect the rating of the QoE. I the example conducted by Chang, Walters and Wills (2016), they use their proposed Organisational Sustainability Modelling (OSM) to define, measure and present the extent of QoE with respective to the quality of teaching and QoS of the educational services.

3.1. Correlations between QoS and QoE

Understanding potential correlation between QoS and QoE is a subject that is currently a popular topic among scholars, as there has been great difficulties in respect to providing a model which shows a direct correlation between the two.

In terms of streaming, Thompson (2009) states that QoE concerns the audio and video quality. He goes on to suggest that QoS has a part to play at several different levels in respect to the client, the networks involved in the process. For instance, he suggests that VOIP communications require at least 150m/s with respect to the end to end delay, in order to function effectively. The main issues regarding to QoS that could strongly relate to QoE include the bandwidth, packet buffering, as well as the overall packet service achieved.

He also describes issues arising from contention within networks, which occurs often when packets move from a WAN to a LAN, especially so when packet bursts arise. Packet bursts are when many packets are sent at any one time, and this can potentially cause packet loss. This is usually due to LAN network, for instance, not having the capability to handle the number of packets received.

Wijnants et al (2009) suggests that during their investigations, flow of traffic, as well as controlling bandwidth are kept at a level acceptable to ensure they do not pose issues to the investigation.

They go on to suggest that by deploying probes within the scenario will aid the investigation in respect to understanding the performance of the network, especially in terms of latency. A user study was undertaken to investigate the QoE data involved with the QoS scenario. This took the form of qualitative testing in regards to interviewing, observing test subjects, and by collecting a user's feedback.

It can be understood that QoE can be directly affected in terms of packet issues, bandwidth, as well as bad latency which can have a direct effect on the client.

4. PROPOSED METHODOLOGY

4.1. Opnet

Opnet will be used to create simulations regarding the process of cloud gaming, focusing on the involvement of the RFB Protocol. Erwin (2011) suggests that Opnet is a simulation tool which has a number of benefits in regards to the investigation being carried out. Compared to other tools, its superior in such ways in regards to simulate and analyse network performance.

Features of Opnet that aid in the investigation is as follows as suggested by Riverbed Technologies (2014) and as suggested the suite is used for network simulation and modelling.

The software will model and analyse all types of network, as well as a huge number of networking technologies that exist. These include a number of interest for the investigation at hand, such as TCP and Ipv6. Protocols that follow current standards can be simulated and analysed via the software, and the software contains a number of elements that speed up the processes of modelling.

These are useful to the investigation as time, and budget constraints mean that simulations are the only option in regards to the methodology involved in the investigation, as producing the servers, and other hardware would be costly.

Furthermore, carrying out the simulation outside of software such as Opnet wouldn't be realistic in terms of time. This is because the investigation is being carried out by an individual not a large team. Therefore, Opnet is wholly suitable to carry out the required purpose for a number of reasons.

4.2. Framework Approaches

Frameworks are popular options to define the scope of the proposed method and present a list of guidelines useful for organisational adoption with two examples. Firstly, Chang et al. (2013) present Cloud Computing Business Framework (CCBF) that can help different types of organisations to design, implement and provide support for the cloud computing services that can be blended with business models, strategies and operations of organisations that have adopted cloud computing. There are case studies of various types to support the validity of such services. Secondly, Chang and Ramachadran (2016) have developed Cloud Computing Adoption Framework (CCAF) to offer the real-time and robust security services. They have explained their system design and the way to implement services to perform penetration testing of using 2012 known trojans and viruses against the security defences in an ethical hacking environment. Framework approaches can be adopted and blended well together with QoE and QoS to maximise the impacts, outputs and quality of the overall user and organisation satisfaction (Safdari and Chang, 2014). This can be further supported by Chang, Kuo and Ramachandran (2016) whereby they have developed the previous work into a real time security service that can blend with Openstack and achieve a high level of integration, robustness, QoE and QoS.

5. CONCLUSION

From the research carried out. A number of important findings, recommendations, and conclusions have been understood.

Researching the RFB Protocol has been of importance. As gaining an understanding of how the protocol works, in essence, has allowed the research to further be developed in such a way as to begin to understand the background behind how this is potentially used within the cloud gaming environment.

Understanding the concept in regards to what types of transport it can run on is of significance, in respect to the simulations later on in the project. As previously stated the protocol can run on any reliable type of transport, such as TCP.

Its applications in the cloud gaming environment is of importance. This is because the RFB Protocol began as a way of viewing desktops remotely, and as this has developed over recent times due to certain factors is one of interest. Areas such as increased average bandwidth has aided these

developments as more and more user base now can access such high bandwidth requirements. This further relates to the simulations due to be carried out as experimenting with different bandwidths may be of note in respect to how this can affect the QoS and QoE metrics discussed.

Research into QoS and the metrics that are related to the study is important due to the nature of the project. Understanding key areas that form QoS has aided the project, in respect to those such as one way delay, and has allowed further understanding of end to end delay and the usefulness of researching one way delay, and its differences from end to end delay. Furthermore, understanding the fundamentals behind Jitter and Packet Loss will aid further research into how to analyse the effects of these issues, with respect to creating the simulations in such a way as to understand these effects in terms of QoS.

Understanding QoE and the ways that QoS could have a direct correlation, has been explored. This has aided the project in terms of beginning to delve into the complex area between correlations between the two, which many scholars have a divided opinion on. However, it can be concluded that while Jitter may not necessarily directly affect QoE, Packet Loss and One Way Delay could potentially affect the QoE. Overall, it seems that researching this has given an understanding that certain constants may be required in any simulation, such as a suitable bandwidth to allow simulations to run under certain conditions.

Research into the simulation tool to use, has resulted in Opnet been the preferred choice over other alternatives. This is due to it being so broad in terms of simulation, as it has been developed as to allow networking specialists to simulate huge amounts of protocols and physical areas of a network environment, as well as having an expansive capability to analyse QoS metrics discussed. Framework approaches can be blended together with QoS, QoE, Opnet and all other existing services.

REFERENCES

o3bnetworks.com. (n. d.). *What is Network Latency and Why Does it Matter.* Retrieved from http://www.o3bnetworks.com/media/40980/white%20paper_latency%20matters.pdf

Ahlund, C., Mitra, K., Zaslavsky, A. (2014). Abstract: Context-Aware QoE Modelling, Measurement and Prediction in Mobile Computing Systems. *Computer.org*. Retrieved from http://www.computer.org/csdl/trans/tm/preprint/06679038-abs.html

Ahmad, B. (2010). Top 3 Ways to measure network reliability. Retrieved from http://www.techmaish.com/top-3-ways-to-measure-network-reliability/

AT&T Labaratories Cambridge. (1999). VNC - How it works. Retrieved from http://www.hep.phy.cam.ac.uk/vnc_docs/howitworks.html

AT&T Labaratories Cambridge. (2010). RFB Protocol. Retrieved from http://www.realvnc.com/docs/rfbproto.pdf

Chang, V. (2015). Towards a Big Data system disaster recovery in a Private Cloud. *Ad Hoc Networks*, *35*, 65–82. doi:10.1016/j.adhoc.2015.07.012

Chang, V. (2016). Review and discussion: E-learning for academia and industry. *International Journal of Information Management*, *36*(3), 476–485. doi:10.1016/j.ijinfomgt.2015.12.007

Chang, V., Kuo, Y. H., & Ramachandran, M. (2016). Cloud computing adoption framework: A security framework for business clouds. *Future Generation Computer Systems*, *57*, 24–41. doi:10.1016/j.future.2015.09.031

Chang, V., & Ramachandran, M. (2016). Towards achieving data security with the cloud computing adoption framework. *IEEE Transactions on Services Computing*, *9*(1), 138–151. doi:10.1109/TSC.2015.2491281

Chang, V., Walters, R. J., & Wills, G. (2013). The development that leads to the Cloud Computing Business Framework. *International Journal of Information Management*, *33*(3), 524–538. doi:10.1016/j.ijinfomgt.2013.01.005

Chang, V., Walters, R. J., & Wills, G. B. (2016). Organisational sustainability modelling—An emerging service and analytics model for evaluating Cloud Computing adoption with two case studies. *International Journal of Information Management*, *36*(1), 167–179. doi:10.1016/j.ijinfomgt.2015.09.001

Chang, V., & Wills, G. (2016). A model to compare cloud and non-cloud storage of Big Data. *Future Generation Computer Systems*, *57*, 56–76. doi:10.1016/j.future.2015.10.003

Cisco. (2014). Quality of Service (QoS). Retrieved from http://www.cisco.com/c/en/us/products/ios-nx-os-software/quality-of-service-qos/index.html

Dzyre, N. (2014). A Look Into: Cloud Gaming. *Hongkiat.com*. Retrieved from http://www.hongkiat.com/blog/cloud-gaming/

Erwin. (2011). What is OPNET? Retrieved from http://www.qwhatis.com/what-is-opnet/

Etherington-Smith, J. (2014). Broadband Internet: Global Average Connection Speed Passes 4Mbps for First Time. *IBTimes.co.uk*. Retrieved from http://www.ibtimes.co.uk/broadband-internet-global-average-connection-speed-passes-4mbps-first-time-1469297

Fiedler, M., Moller, S., & Reichl, P. (2012). Quality of Experience: From User Perception to Instrumental Metrics. Retrieved from http://drops.dagstuhl.de/opus/volltexte/2012/3598/pdf/dagrep_v002_i005_p001_s12181.pdf

Islam, M.S., & Mehdi, S.N. (2011). How Different QoS Mechanisms Affect VoIP QoS Metrics. Retrieved from http://www.diva-portal.org/smash/get/diva2:422202/FULLTEXT01.pdf

Kim, H.J., Cho, K.S., Kim, H.S., & Choi, S.G. (2010). *A Study on a QoS/QoE Correlation Model for QoE Evaluation on IPTV Service.* Retrieved from http://www.icact.org/upload/2010/0395/20100395_Abstract_B.pdf

Leinen, S. (2007). One Way Delay. Retrieved from http://kb.pert.geant.net/PERTKB/OneWayDelay

Levy, J. (2014). PlayStation Now: Sony Unveils Cloud Gaming. *Sony*. Retrieved from http://thebottomline.as.ucsb.edu/2014/01/playstation-now-sony-unveils-cloud-gaming

McGonigal, J. (2011). We spend 3 billion hours a week as a planet playing videogames. Is it worth it? How could it be MORE worth it? *Ted.com*. Retrieved from http://www.ted.com/conversations/44/we_spend_3_billion_hours_a_wee.html

McKendrick, J. (2013). 16 key service quality metrics to boost cloud engagements. *Zdnet.com*. Retrieved from http://www.zdnet.com/article/16-key-service-quality-metrics-to-boost-cloud-engagements/

Menasce, D. (2002). QoS issues in Web services. *IEEE Xplore Abstract.* Retrieved from http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=1067740&url=http%3A%2F%2Fieeexplore.ieee.org%2Fxpls%2Fabs_all.jsp%3Farnumber%3D1067740

Microsoft. (2003). What is QoS?: Quality of Service (QoS). Retrieved from http://technet.microsoft.com/en-us/library/cc757120(v=ws.10).aspx

Mines, C. (2011). 4 reasons why cloud computing is also a green solution. *GreenBiz*. Retrieved from http://www.greenbiz.com/blog/2011/07/27/4-reasons-why-cloud-computing-also-green-solution

O'Callaghan, J. (2011). How does OnLive work? *How it Works Magazine*. Retrieved from http://www.howitworksdaily.com/how-does-onlive-work/

quazoo.com. (2013). *Internet Protocol Suite.* Retrieved from http://www.quazoo.com/q/Internet_protocol_suite

Safdari, F., & Chang, V. (2014). Review and analysis of cloud computing quality of experience. Proceedings of the ESaaSA '14 workshop, Barcelona, Spain.

Serral-Gracia, R. (2010). An Overview of Quality of Experience Measurement Challenges for Video Applications in IP Networks. *Craax.upc.edu*. Retrieved from http://www.craax.upc.edu/papers/2010/WWIC2010-2.pdf

Sevcik. (2010). Bandwidth IS NOT SPEED. *Network World.* Retrieved from http://www.networkworld.com/article/2227224/data-center/bandwidth-is-not-speed.html

Stanford, M. (2011). *QoS Metrics.* Retrieved from http://www.wirevolution.com/category/qos-metrics/

Takahashi, D. (2014). *Cloud Gaming could reach a turning point in 2015, analyst says. GamesBeat.* Retrieved from http://venturebeat.com/2014/11/24/cloud-gaming-could-reach-a-turning-point-in-2015-analyst-says/

Technologies, R. (2014). SteelCentral for Performance Management and Control. *Riverbed.* Retrieved from http://www.riverbed.com/products/performance-management-control/opnet.html

Techsoup. (n. d.). Network Performance Metrics Defined. *TechSoup*. Retrieved from https://www.techsoupforlibraries.org/cookbook-3/networking-and-security/tools/network-performance-metrics-defined

Thompson, P. (2009). *Part 1: Quality of Service and Quality of Experience [YouTube video].* Retrieved from https://www.youtube.com/watch?v=1NxKcVs8WBU&list=UUyuzhbJIrT1PE3aDQ6B1v5A&index=3

Thompson, P. (2009). *Part 1: Quality of Service and Quality of Experience [YouTube video].* Retrieved from https://www.youtube.com/watch?v=1NxKcVs8WBU&list=UUyuzhbJIrT1PE3aDQ6B1v5A&index=3

University of Surrey. (2014). *Quality of Experience - University of Surrey - Guildford.* Retrieved from http://www.surrey.ac.uk/cvssp/research/quality_experience/

Valter. (2013). What is Jitter in Networking? *Howdoesinternetwork.com*. Retrieved from http://howdoesinternetwork.com/2013/jitter

Wijnants, M., Agten, S., Quax, P., & Lamotte, W. (2009). Investigating the Relationship Between QoS and QoE in a Mixed Desktop/Handheld Gaming Setting. *Sigcomm.org*. Retrieved from http://conferences.sigcomm.org/co-next/2009/workshops/student/papers/Wijnants.pdf

Yao, Y., & Chang, V. (2014). Towards trust and trust building in a selected Cloud gaming virtual community. *International Journal of Organizational and Collective Intelligence*, *4*(2), 64–86. doi:10.4018/ijoci.2014040104

Yao, Y., & Chang, V. (2015). Cloud gaming virtual community-a case study in China. *International Journal of Organizational and Collective Intelligence*, *5*(2), 1–19. doi:10.4018/IJOCI.2015040101

Yin-Poole, W. (2012). Microsoft: internet bandwidth issues make cloud gaming a "challenge". *Eurogamer.net.* Retrieved from http://www.eurogamer.net/articles/2012-06-07-microsoft-internet-bandwidth-issues-make-cloud-gaming-a-challenge