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Nada Adam, Niemah Osman and Is-Haka Mkwawa
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Nada Adam[1], Niemah Osman[1] and Is-Haka Mkwawa[2]
[1]The College of Computer Science and Information Technology, Sudan University of Science and Technology, Khartoum, Sudan
[2]The School of Computing, Electronics and Mathematics, Plymouth University, UK
nedo_dndoon@hotmail.com, niema.osman@gmail.com, Is-Haka.Mkwawa@plymouth.ac.uk

Abstract: *Nowadays, many multimedia communication applications are available in mobile and are fast becoming an essential part of people's lives. Multimedia applications provide services like video call, GPS navigation, mobile learning and teleconferencing. There are several factors that can impact the overall user's perception of these services, for example; service accessibility, service availability, ease of use of the service, session quality, service reliability and the level of security. Quality of protection has become a newly security concept that sets security levels for any service depending on security requirements and customers play a major role in defining these requirements. In this article, we review the quality of protection and quality of experience focusing on multimedia communication in terms of requirements and challenges. The article is concluded by discussions and recommendations on how to co-exist a set of multiple security levels without sacrificing acceptable quality of experience for end users.*

Keywords: *Quality of Experience, Quality of Protection, Multimedia Communication, Security.*

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1. Introduction

Multimedia streaming over mobile devices is one of the most promising communication services that include a huge number of applications. These applications contain various types of media such as video and audio. Multimedia streaming over mobile devices prepares the ground for introducing numerous new high data rate communication services on mobile phones.

Multimedia applications in mobile devices grew in recent years and it is expected that on demand mobile video will grow with a 66% annual increase through to 2019 compared with 57% for data as a whole (Figure 1) [1].

Mobile service providers are facing several challenges to provide good service to customers. For example; video is bandwidth consuming and in order to deliver acceptable service to customers, service providers should keep several issues in mind such as bandwidth, best codec type, send bitrate, video resolution and frame rate.

Users share their experience in specific applications with mobile service providers and application developers that help them to improve the quality of the service.

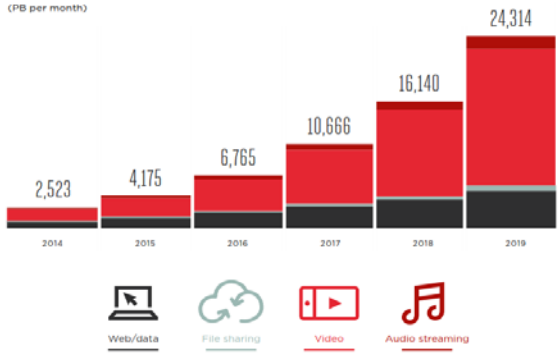

Figure 1. Growth of widely used applications between 2014 and 2019 [1].

Choosing the appropriate level of security is very important for multimedia applications like video calls and customers should be aware about securing such type of communication. However, security is a complex issue, cooperation between application developers should take into account all of these considerations to design a successful application with lowest cost and better user satisfaction.

Ideally, security must be considered as part of the application design and development process. Multimedia application developers are different from each other and may deploy different levels of protection. The performance may be affected negatively if high level of security is applied.

This paper reviews Quality of Experience (QoE) and Quality of Protection (QoP) in terms of requirements and challenges and provides recommendations on how both can co-exist in order to satisfy end users quality of experience when QoP is needed.

This article is organized as follows; Section 2 presents the QoE review. After that, an overview of QoP is provided in Section 3. Section 4 discusses the challenges of QoP and QoE and provides some recommendations on how to co-exist the two concepts in multimedia communication. The conclusions and future work are given in Section 5.

2. Quality of Experience

Quality of Experience (QoE) is a subjective concept that was introduced to measure customers' satisfaction about a particular service. Quality of experience collects all customers experience data and analyses these data to get significant information. At the beginning of the century, telecommunication companies begun to consider QoE in their telecommunication services, for instance, Nokia introduced QoE concept as a perception of end users regarding a service quality and in 2005 stated that "QoE is how a user perceives the usability of a service when in use/how satisfied he or she is with a service" [2].

The Broadband forum in 2006 defined QoE in its technical report TR-126 [3] as" QoE is a measure of end-to-end performance at the service level from the user perspective and an indication of how well the system meets the user's needs".

ITU-T in 2008 defined QoE as "the overall acceptability of an application or service, as perceived subjectively by the end-user" [4]. To evaluate the QoE of a particular service, the user's perceptions, such as ``Good", ``Poor", ``Fair", ``Bad", are often used.

2.1 Quality of Experience Vs Quality of Service

Quality of service (QoS) is closely related to the quality of experience, both of them describe service quality but from different views. Table 1 illustrates the differences between QoE and QoS.

QoS metrics such as packet loss, delay and delay variation (jitter) directly affect QoE [5].

Table 1. Comparison between QoE and QoS

QoS	QoE
Describes service quality from network perspective	Describes service quality from user perspective
Represented by metrics such as packet loss, delay and delay variation (jitter)	Represented by metrics such as Mean Opinion Score
QoS metrics may be difficult to understand by the user and does not represent importance information for them	QoE metrics can clearly reflect users experience and users can understand such information

2.2 Quality of Experience (QoE) assessment methods

QoE assessment methods can be classified into two categories: subjective assessment and objective assessment. Subjective quality assessment (also known as Perception-based) is reality assessment, this test depends on human evaluation of multimedia service and data is gathered from them. Subjective tests are based on the Mean Opinion Score (MOS) and reflect an overall quality from user perspective, test participants assess service level on a scale between 1 and 5, then researchers will do statistical analysis. Note that the cost of subjective testing is high and needs several days to do it, it also needs special facilities and equipment.

Researchers should plan for subjective test correctly, they should prepare test environment, setting up hardware and software that is needed in the test according to the type of multimedia in evaluation, for video streaming, many factors such as room illumination, display brightness and ratio of the luminance of the screen should be considered whether the experiment will be in lab or at home. However, the laboratory environment is convenient for researchers and results are more accurate than the home environment but the home environment may be preferred by the participants because they provide a natural environment.

Prior to the start of test sessions, the participant should know about the assessment procedure and assessment rating categories, test processing and the possible quality weakness like pale of color and brightness. Age, gender, nationality, level of education should be considered in the final result report [6].

The content of the video, source video processing and video compression format directly impact the user experience [6].

Numerous datasets are publicly available for researchers to include in evaluation tests. These datasets are helpful for the development and advancement of video quality metrics especially in

the case that it is impossible to lead subjective tests [7].

Subjective test methods for video include Absolute Category Rating (ACR) which volunteers only watch degraded videos and give the video a score between 1 and 5 as in Table 2. But in Degradation Category Rating (DCR) the volunteers watch both reference and degraded video and decide their opinion in scale as in Table 3.

Table2. ACR rating categories (Sun, 2013, p.139)

Category	Score
Excellent	5
Good	4
Fair	3
Poor	2
Bad	1

Table 3.DCR rating categories (Sun, 2013, p.139)

Category	Score
Imperceptible	5
Perceptible but not annoying	4
Slightly annoying	3
Annoying	2
Very annoying	1

Sometimes, subjective tests are difficult to perform (e.g. in real time streaming), the case in which objective assessment is convenient to asses QoE and give satisfying results. The International Telecommunication Union (ITU) classifies the objective assessment for QoE in 5 categories depend on each model type [8].

(1) Media layer model: this focuses on the content itself and does not need any pervious information about the system under test, media layer model use media signal as input, for example, Full-Reference (FR) Video Quality Assessment and Reduced-Reference (RR) video quality assessment are belong in this type[8].

(2) Parametric packet-layer model: this type depends on packet header information, this type does not require media signal to estimate QoE but face difficulty in evaluating the content dependence of QoE. Parametric packet-layer model used for monitoring audio quality [9] or video quality [10]

(3) Parametric planning model: this type of assessment considers network planning and requires pervious information about the system and has advantage in use in design stage of the service, this type uses mathematical models such as E-model[11],ITU-T published a guide to estimate the impact of typical IP network impairments on the QoE by the end user in multimedia mobile streaming and IPTV [8], this describe parametric planning model, area of the application that can used this model and network factors that used in this model.

(3)Bit-Steam-Layer Model: This model uses packet header and payload as input information and use in terminal embedded operation application, processing capacity should be high because this model includes more computation processes. ITU-T released a guide to researchers about how to use this model [12],this model must be utilized appropriately according to service specification.

(4)Hybrid Model: This model combine some or all of previous models, it extract many information that help to better assessment for QoE. ITU-T J.343 [12] described objective video quality measurement methods which use bitstream as hybrid models, such model helps to improved performance compared to objective video quality models, which use only processed video sequences.

2.3 Quality of Experience in Multimedia Communication

User experience requirements are becoming very important for service providers, network operators and product manufacturers whether the product is software or hardware especially in famous services such as multimedia services.

Multimedia is transported across a communication system (wire or wireless), these media can be discrete media data such as text and graphics or continuous media data such as audio and video.

Multimedia is attractive, easy to understand and is used in many areas in our life like education, health and marketing. However, multimedia needs intensive computation, intensive I/O, continues memory accesses, data locality and may sometimes have the need for real time processing capabilities. For this, communication systems should adapt networks, protocols, services and mechanisms to support multimedia applications.

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QoE is influenced by many factors, in [13] influence factor is defined as follows: "Any characteristic of a user, system, service, application, or context whose actual state or setting may have influence on the

Quality of Experience for the user". Influencing factors can be classified into three categories (c.f., Fig.2)

(1)Human Influencing Factor (HIF) that is concerning of human user characteristic such as human visual system (HVS),gender, age, education, background, and expertise level.

(2)System Influencing Factors (SIF) can be defined as: "System Influence Factors (SIF) refer to properties and characteristics that determine the technically produced quality of an application or service [13]. Bandwidth, security, resolution, delay, jitter, visual interface device and media synchronization are examples of system factors.

(3)Context Influence Factors (CIF) describe the user's environment like location and space, movements, costs and user physiological information level. [14]

Other categories proposed in [15], the QoE is affected by: application, resource, context, and user.

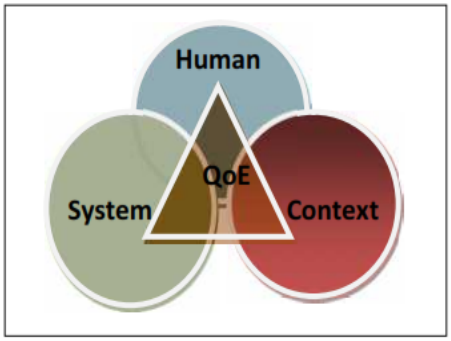

Figure 2. Factors influencing quality of experience [14].

Table 4 shows examples of multimedia types and factors influencing QoE.

3. Quality of Protection (QoP)

Security is one of the biggest problems facing the ICT world. The balance between security and QoE must be done in modern systems and sometimes it becomes a difficult job. Some applications are sensitive and cannot be deployed on public networks. Therefore, an appropriate level of security must be guaranteed and proper balance between the level of security and performance should be made to provide good service to customers. At the same time, service providers must offer and guarantee security services.

Quality of Protection (QoP) concept presents a framework to configure and implement security level for each service. QoP is defined as "a set of security requirements that guarantees to meet a Protection Level Agreement".

Overestimating of system security will cause the system complexity and the performance will be affected from such mechanisms, hence, QoE will be affected.

3.1 Security and Quality of Protection

Cyber security is a critical issue especially with the revolution of communication and networking. It focuses on how to protect information, computers, hardware, software and networks [23].

The security objectives include the following,

Confidentiality: ensuring that only authorized user's access private information or resources.

Integrity: protect information from unauthorized modification.

Availability: information and resources should be available and not denied to authorized users.

Systems are always faced with many risks that can harm user's data or computers and also can damage the overall system. These risks are caused by malicious software, network intruder and vulnerability. Therefore, security engineers should be aware about how to protect the system in an effective manner and eliminate the effect of successful security attacks by planning and implementing suitable security policies.

Security is difficult to manage and security engineers need to have metrics that help them to improve security's efficiency, understand the security requirements of the system and draw overall system security policies.

Security metrics ensure that policies are correct, consistent and they control the behavior of the systems. In order to develop successful security metrics, several information about the system security status needs to be gathered and analyzed and then using a proper designing approach to create the metrics.

Kormos et al. presented in [24] top down approach that help to design effective security metrics. In this approach, metrics were placed in groups according to professional requirement (i.e. reduce vulnerabilities) or user requirements (i.e. reduce impact).

Table 4. A summary of a selected type of multimedia factors that affect QoE.

Author/s	Type of multimedia/ Application	Influencing factor	Communication System	QoE assessment	
				subjective test	objective test
P.Georgopoulos et al[16]	Video Streaming	SIF	Home Network	×	√
S.Shen et al [17]	Video Streaming	SIF	Wireless	×	√
K.. Laghari et al [18]	Video Streaming	HIF,SIF	broadband Network	√	√
L.Karadimce et al[19]	Audio learning/Video learning	HIF,SIF,CIF	Mobile Cloud	√	√
A.Verdejo et al[20]	Mobile Video Game	HIF,SIF,CIF	3G	√	√
T. Daengsi et al [21]	VOIP	HIF,SIF	IP phones	√	√
Z.Song et al [22]	3D Image	SIF	Wireless	√	×

Quality of Protection concern about evaluation of security metrics and determine if the metrics is correct, consistent and leading to required security goals, QoP assure that data flows between levels correctly [25].

The quality of protection set security levels for any service depending in security requirements, these requirements may be defined by customers, developers or from the nature of the service environment.

Ksiezopolski et al. [26] presented QoP methodology to make the balance between performance (quality of signal) and the security level because choosing the appropriate level of security is very important in applications over networks. Security demands vary from one application to another and the performance may be affected negatively if high level of security is applied and as a result the QoE will also be affected.

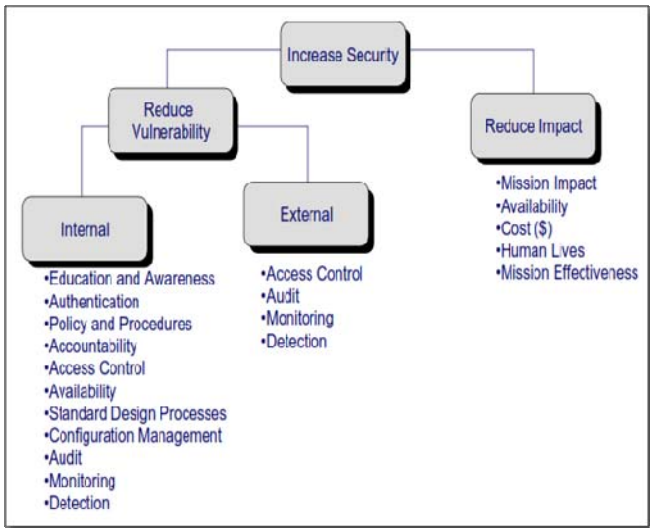

Figure3. Top-Down Tree Diagram(Kormos,p.11,2014)

3.2 Quality of Protection Model

QoP model helps to evaluate the security mechanisms and can then quantify the influence of particular security mechanisms on ensuring security attributes.

QoP models should check that the access privileges to data via authentication, authorization or other access control, ensure the integrity and confidentiality of the data via encryption, watermarking and other security operations at the security points and set proper level of security, the performance must be considered when designing QoP model.

QoP model is designed to be an extension of QoS model and define security operations. Since end users are the best judges of the quality any provided services, the QoP model should take into considerations the QoE parameters.

In [27], Quality of Protection Modeling Language (QoP-ML) has been presented to help design QoP model and improve security management. QoP-ML answers questions about the environmental impact of the security mechanisms and can evaluate energy efficiency and security attributes. Security-Based Data Flow Management in Data Center was taken as a case study.

Agarwal et al. [28] presented quantitative assessment for QoP that maps QoP with QoS in Wireless Local Area Networks to investigating the effect of security mechanisms in network performance, the case study for clarification security features on performance is

Table 5. Research articles that studied QoE and QoP

Authors	Field of study	Main security challenge	Proposed scheme	Present QoE assessment method?	Illustrate the trade-off between protection and performance?
K.Zhan et al [34]	Mobile Healthcare Networks	The sensitivity of medical information that are store in cloud storage should be protected from unauthorized access and malicious behavior	- Privacy preserving health data aggregation - Secure health data processing - Misbehavior detection	no	yes
H.Li et al [35]	Mobile Cloud Networks	Ensure confidentially, integrity and privacy of data that are store in cloud servers.	Search scheme over encrypted data in mobile cloud networks	no	yes
D.Wu et al [36]	Intermittently connected wireless network	malicious node and messages	Trust status aware data forwarding strategy in ICWN	no	yes
M. Mokkas et al [37]	IT services	Availability	3-steps QoE evaluation model for IT services	Objective test	no
W.Wang et al [38]	Sensor equipped smartphones	Guarantee end user privacy from untrusted service providers	Context awareness QoP framework	no	yes

integrating cross layer security protocols in a wireless LAN testbed with IP mobility. However, quantitative assessment of the QoP was presented but some important QoP model characters like energy evaluation and environmental impact were not considered in the model.

Ksiezopolski [29] present QoP methodology to make the balance between performance (quality of signal in real-time systems) and the security level because the choose of appropriate level of security is very important in applications over networks.

Authors [30], presented two models for quality of protection in the cloud, the first model is "provider side model" quality of protection with no guarantee that the quality of protection has been done. The second model called the "user side model" with the possibility of monitoring services to verify that required quality of protection is done. The user sides only monitors the QoP and are not modifying it, users choose what QoP level they need and the provider will provide it. To make sure the QoP on the user side is what has been agreed, the user is given permission to monitor it.

Mechanism based on third-party collaboration. These mechanisms could be used for security policies agreement and security assurance. However, evaluate performance is very important aspect in web services, there is no meaning to give to customers good level of security with poor performance and quality of experience.

QoE for web services is important to evaluate overall performance, for that, effect of QoP and QoE should be considered in such studies.

3.3 Quality of Protection in Multimedia Communication

With the huge amount of media over the Internet, to guarantee security in such communication is a hard task, there are challenges that are facing security mechanism for multimedia communication such as ensuring quality of service, high availability and providing acceptable performance, data encryption and data hiding. Firewall and VPN mechanisms should be adjusted according to multimedia type that is transmitted over the IP network. Common types of attacks like Eavesdropping, man-in-the-middle, call hijacking, denial of services and phishing attacks can adversely affect the quality of experience [31].

In [32], QoP model for mobile multimedia communication has been presented with case study in VoD application that ensures two security service, user authentication and data encryption. This model is aware about QoS and ensures that security architecture balances between security and performance but did not consider environmental impact of the video and audio playback on the quality of service.

Luo et al.[33], provided multi-level security serviced in IP multimedia subsystem (IMS) and described SIP signaling in IMS using Queuing Petri Nets (QPN), these multi-view security policies can be modified according to the application and users' security requirements, so the proposed approach can give better balance between security and performance for the service.

4. Discussion and Recommendations

Multimedia is everywhere nowadays and transferring over communication network that are used to provide multimedia communication services, video, audio and image have special characteristics that make researchers and service providers aware about how to transfer multimedia over different types of network by the best way.

Customers like to receive multimedia in the best way and service providers compete to provide best services to them, but this is a difficult task. High quality images and high video resolution with high quality audio are bandwidth consuming applications, quality of service parameters such as packet loss, delay and latency affect the overall quality of experience. To find out the best media characteristics like number of pixels in image, codec type and send bitrate in video and audio is very important to improve overall quality of experience.

QoP and QoE have not gain a lot of attention so far although they are linked closely. Table 5 presents recent researches that studied QoP and QoE and each of them can be a good beginning for many valuable researches that help to improve the quality of service and make the balance between QoP and QoE.

Since end users are the best judges of the quality of multimedia services consumed by them, this paper recommends the mapping of QoP security levels to QoE by using subjective tests and then propose an objective model. This mapping will server as a reference to researchers in academia and industry in order to provide acceptable QoE whenever QoP is needed in multimedia services.

5. Conclusion and Future Work

This paper reviews two main topics in multimedia communication field, quality of experience which measures a customer's experiences of a multimedia service and quality of protection which evaluates the security policies for multimedia communication. The paper summarizes the difference between QoE and QoS and surveys various subjective and objective assessment methods of QoE. Moreover, how QoP evaluates security metrics and set security level are discussed, furthermore, the paper has provided information on QoP model that are used in evaluation process.

This article also focused on the impact of quality of protection on quality of experience and what are the main issues that should be considered to provide appropriate quality of experience.

More research should be conducted to meet the evolution of multimedia communication in the perspective of the impact of QoP in the overall performance and user quality of experience. This paper has recommended to perform subject evaluations in order to map the QoP security levels to QoE and then propose an objective model for QoP that will include QoE parameters.

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Nada Adam received the BSc. in Computer Science in 2005 from the University of Khartoum in Khartoum, Sudan and MSc. in Computer science in 2012 from University of Khartoum in Khartoum, Sudan. She is currently doing a PhD degree in computer science at the Sudan University of Science and Technology in Khartoum, Sudan. Her research interests include Quality of Protection, Security, Quality of Service, Quality of Experience, Multimedia Communications, Wireless Communication, Computer Networking and Mobile Programming.

Niemah I. Osman received the B.Sc. degree (first-class Hons.) in computer science from Sudan University of Science and Technology, Khartoum, Sudan, in 2002 and the M.Sc. degree (with distinction) in mobile computing from the University of Bradford, U.K., in 2006 and the Ph.D. degree in Communication Networks from the University of Leeds, U.K in 2015. She is currently an Assistant Professor at the Faculty of Computer Science and Information Technology, Sudan University of Science and Technology, Sudan, and was the Head of

Department of Computer Science and member of the university senate in 2007-2008. Her current research interests include performance evaluation of 4G LTE networks and QoE of video services.

Dr. Is-Haka Mkwawa received his PhD in computing from the University of Bradford, UK, in 2004. He is currently with the school of computing, electronics and mathematics at the University of Plymouth. His research interests include QoE control and management, mobility management in mobile and wireless networks, Software Defined Networking, power saving in IoT, overlay networks, performance analysis and evaluation of IMS mobility management, parallel computing, IMS media plane security for next generation of emergency communication and services and collective communication.