Audiovisual Quality Assessment for 3G Networks in Support of E-Healthcare Services

Asiya Khan, Zhuoqun Li, Lingfen Sun, Emmanuel Ifeachor

Centre for Signal Processing and Multimedia Communication
School of Computing, Communications and Electronics
University of Plymouth
Plymouth PL4 8AA, UK.
Email: asiya.khan@plymouth.ac.uk; zhuoqun.li@plymouth.ac.uk; L.Sun@plymouth.ac.uk; E.Ifeachor@plymouth.ac.uk

Keywords: Quality of Service, 3G, Audio Quality, Video Quality, Asterisk®, E-healthcare

Abstract

The third generation UMTS(Universal Mobile Telecommunication Systems) networks has opened up doors to many applications such as real time video calling, video mail, video on demand, interactive video services, etc. and has unfolded new horizons in the provision of e-healthcare because of increased bandwidth. With 3G wireless networks it is possible for healthcare professionals wherever they are to monitor patients anywhere and anytime thus improving the quality of their lives. The purpose of this paper is to present a critical review of the existing literature on audiovisual quality over 3G mobile networks and hence provide an understanding of the key factors that affect audiovisual quality of service and further discuss the existing quality assessment methods for voice and video. We then present results of our preliminary investigation to assess the quality of a video call over live 3G network subjectively. Finally, we discuss the QoS implications in the application of 3G networks in e-healthcare.

1 Introduction

Quality of Service(QoS) as defined by ITU-T is “the collective effect of service performance which determines the degree of satisfaction of a user of that service.” Therefore, successful large-scale deployment of 3G networks and wide applications depend on how good the quality of voice and video is and whether they can meet the end user or a customers’ satisfaction. For both commercial, domestic and time critical healthcare applications it is crucial for equipment providers, network operators and service providers to be able to assess, predict and possibly control the end to end perceptual voice and video quality for 3G wireless networks.

QoS in 3G wireless networks is based on a service classification of four classes: conversational, streaming, interactive and background – each class corresponding to different application requirements. For example, the conversational class has the highest QoS requirements, while the background class has the lowest and can be seen as best-effort traffic class. In the interactive class the bandwidth and delay requirements are lower, but the reliability of the transfer must be high. Streaming class applications include video and audio streaming. The class has high bandwidth requirements but tolerates longer transfer delays[1]. QoS of e-healthcare services as dictated by the medical professional and the patients(end users) will fit in all of the above four traffic classes depending on the required service. For example the QoS requirement for videoconferencing would be both in the interactive and streaming classes. For voice and video communications 3G works on a 64 kb/s circuit switched connection: QoS comes at a cost of bandwidth. This means that a limited amount of data can be sent, making audio and video quality a real challenge.

The current trends in the development of wireless internet applications (IEEE 802.11) and mobile systems indicate that the future internet architecture will need to support various applications with different QoS requirements. More recently the term QoE(Quality of Experience) has been used and defined as the users perceived QoS. It has been proposed in [2,3,4] that a better QoE can be achieved when the QoS is considered both in the network and application layers as a whole. In the application layer QoS is driven by factors such as resolution, frame rate, colour, video codec type, audio codec type, layering strategy, sampling rate, number of channels, etc. The network layer introduces impairment parameters such as jitter, delay, burstiness, latency, packet loss, etc.

The paper is structured as follows. Section 2 summarizes the QoS assessment methods for voice and video outlining subjective and objectives measurements and their tools. In section 3 we give an overview of the audiovisual quality assessment highlighting the factors that affect voice and video QoS. In section 4 we assess the audio/video quality of a video call subjectively and present preliminary test results from our experiment. Section 5 discusses the e-healthcare applications supported by 3G networks and their QoS requirements. Finally, section 6 concludes the paper and highlights areas of further work.

2 QOS Assessment Methods for Voice and Video

QoS for voice and video can be measured both subjectively and objectively. Subjective quality is the users’ perception of service quality(ITU-T P.800) and is measured through subjective quality assessment[5]. The performance of the system under test is rated directly (Absolute Category Rating, ACR) or relative to the subjective quality of a reference system(Degradation Category Rating, DCR). Subjective measurements are based on a number of people giving a score on the quality of the video and audio The most widely used metric is the Mean Opinion Score (MOS). While subjective quality is the most reliable method, it is time consuming, expensive and highly impractical as a method for monitoring or managing quality in real time. Therefore we need an objective method that produces results comparable with those of subjective testing.

Objective testing does not require access to the source. Objective measurements can be performed in an intrusive way or non-intrusive way. Intrusive measurements require a known voice/video file to be sent over a test connection and then compares the original and impaired files. However, non-intrusive methods are based on single side monitoring without generating traffic. Non-intrusive methods use either speech/video signal or network performance metrics. Non-intrusive methods are preferred to intrusive analysis as they do not require a reference signal. Fig. 1[6] gives the framework of non-intrusive monitoring for video quality to estimate and manage QoS for real-time telecommunication services.

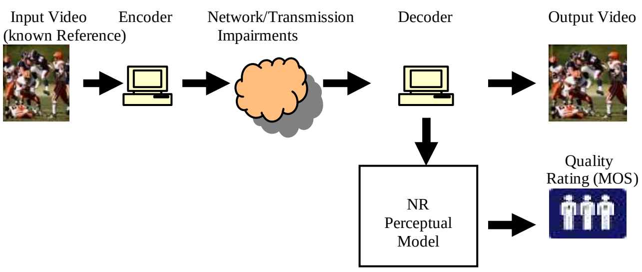

Fig. 1. No-Reference Quality Measurement[6]

2.1 Video Assessment Methods

Mean square error(MSE) and peak signal-to-noise ratio(PSNR) are the most popular objective video quality metrics but they are limited in their capacity to replicate and correlate subjective assessment in terms of mean opinion score. Video quality standards have been developed as full reference, reduced reference and no reference for video quality measurement. Full reference(ITU-T J.144) is based on a comparison of video signals transmitted through a network with respect to original versions of the same signals[7]. Reduced reference(ITU-T J.143) systems operate by extracting low bandwidth features from the source video and transmitting these source features to the destination location, where they are used in conjunction with the destination video stream to perform a perception based quality measurement. Both methods are intrusive. No reference measurement techniques are ones that use measurement of network performance to quantify or predict video quality. It is a non-intrusive measurement method.

Full reference quality metrics for TV applications have been recommended by the ITU-T based on the work of VQEG[8]. V-factor on the other hand is a no reference measurement method developed by QoSmetrics now acquired by Symmetricom[9,10]. V-Factor evaluates the perceptual impact of video quality artifacts introduced by video transmission over a network. The company used the Motion Picture Quality Metrics (MPQM) model to adapt an IP-based video quality scoring method that could be used within V-Factor. Opticom’s Perceptual Evaluation Video Quality(PEVQ) is a full reference, intrusive measurement algorithm for video quality[6]**.** PEVQ provides mean opinion score (MOS) estimates of the video quality degradation occurring through a network, e.g. in video telephony networks.

2.2 Voice Assessment Methods

PESQ (Perceptual Evaluation of Speech Quality), standardized by ITU-T as recommendation P.862, is the test method for measuring end-to-end speech quality over networks. PESQ transforms the original and degraded speech signals into a psychological representation that approximates human perception and calculates their perceptual distance and maps this into an objective MOS score. It is an intrusive measurement method[11].

E-model has been standardized as ITU-T Rec. G.107 and has been established and widely used for speech services including IP telephony. The E-model can estimate the overall communication quality using a combination of quality factors. The E-model takes 21 parameters as inputs that represent terminal, network, and environment quality factors. The output is called the R value which is a psychological scale that is an index of overall quality. The E-model was designed for network planning, but can be used for non-intrusive quality monitoring and measurement.[12]. As E-model relies on many assumptions it therefore, produces an estimate of the overall quality. 3SQM stands for "Single Sided Speech Quality Measure", and is a new algorithm, developed for non-intrusive voice quality testing and is based on speech signal parameter measurement. It includes the effects of both packet level impairments such as loss, jitter and signal related impairments such as noise, clipping and distortions caused by coding processes. It does not require reference speech and performs live network monitoring and testing. It is based on new ITU-T recommendation P.563[13].

3 Audiovisual Quality Assessment and the Factors Affecting Voice and Video QoS

QoS is a crucial part of wireless multimedia design and delivery. Poor QoS results in poor service uptake by users which will result in the potential offered by recent advances in wireless and multimedia technologies not fully utilized. There are many aspects to QoS provisioning. These include Network-layer QoS, Application-layer QoS and ultimately End-user QoS. Network-layer QoS is concerned with the reliable and fast delivery of multimedia data over the wireless technologies. Application-layer QoS on the other hand is concerned with the quality of the multimedia encoding, delivery, adaptation, decoding and play out on the client device. End-user QoS is concerned with the end-user experience in terms of audio and visual quality.

Typically these QoS layers are treated independently and in isolation yet the QoS schemes implemented at each of these layers have an effect on each other. It is essential for network managers, engineers and application developers to have an understanding of the QoS schemes that are in place at the network, application and end-user layer in order to be able to provide a fully end-to-end QoS solution. The ultimate goal of these QoS is to maximize end-user QoS.

3.1 Audiovisual Quality Assessment

In [14,15,16] the authors studied the quality of multimedia content at very low bit rates(24-48kb/s for video and 8-32kb/s for audio). They carried out subjective experiments for assessing audiovisual, audio-only and video-only quality using the ACR(Absolute Category Rating) methodology. The video codec used was MPEG4-AVC(H.264) and for voice they used AAC(Advanced Audio Coding) coding standards.
They found that both Audio Quality(AQ) and Video Quality(VQ) contribute significantly to perceived audiovisual quality. The proposed a model based on the product of AQ and VQ and on the linear combination of AQ and VQ. However, they did not take network errors into account in their model. In [17] it's proposed that the audiovisual quality is a combination of sensorial, emotional and social factors. It's argued that the users' experience and perception of quality is built on the combination of content production (content quality, objective quality, coding), service providing(transmission quality) and handset design and implementation(design, application, interaction, display quality). In [18] they propose a model that sets a framework for the subjective testing of the complete set of user acceptance criteria of mobile TV audiovisual quality experience.
Opinion models have been given in [19] for estimating video quality. Two psychological factors – an aesthetic feeling and a feeling of activity were important metric. Then quality impairments affecting these two psychological factors were analysed. They found that the aesthetic feeling was affected by IP packet loss and video coding bit rate and the feeling of activity depended on delay time, video packet loss, video coding bit rate and video frame rate. They derived an opinion model that estimates the overall audiovisual quality in a point-to-point communication environment of an audiovisual communication service. Similarly in [20] they propose a subjective QoS evaluation model for audiovisual communication system. In their model they take into account the effect of individual audiovisual quality as well as the effect of audiovisual delay and media synchronization. They used the ACR method. The evaluation error of the model they proposed was less than the statistical reliability of the subjective score. In their experiment they controlled the audio/video packet loss rate and the transmission delay of the audio/video IP Packet. In [21] three metrics of network performance in judging the quality of videoconferencing is highlighted as bandwidth, latency and packet loss. They concluded that the packet loss affects communication – both the aesthetics of video quality and speech quality. For example one effect of packet loss was to freeze the video and silence the audio and hence the conversation was temporarily lost. Also unlike a fixed latency, packet loss arrives randomly and thus is unpredictable. In [22] they investigate the perceptual impact of repeated and dropped video frames on perceived quality. They conducted a psychophysical experiment to study the impact of jerkiness and jitter on perceived video quality. Their findings indicate that firstly MOS decreases logarithmically with the frame rate when jerkiness is the main source of degradation, secondly, perceptual impact of jitter is highly content dependent and finally, viewers preferred a scenario in which a single but long freeze event occurs to a scenario in which frequent short freezes occur. Also they found that a drastic increase of the encoding bit rate in order to reduce coding distortions did not necessarily lead to a higher MOS if temporal distortions(e.g. jitter) appeared. This indicates that potential temporal degradations introduced by network transmission errors have a dramatic impact on the perceived quality obtained by an increase of the transmission bandwidth. Therefore they concluded that a simple individual measure of frame rate, bit rate, jitter or loss ratio is not sufficient to measure perceptual quality. Artificial Neural Networks is proposed in [23] for video quality prediction over 3G networks. In [24] they propose an audiovisual quality metric for low bit rate videos based on audio quality, video quality and sequence character factors. They did not take network errors into account.
In [25] they found that subjective QoS of mobile videophones (using the QCIF picture format) is between satisfactory and fair at 32kbps, but additional capacity (i.e. 64kbps) brings clear improvements in QoS (between fair and good). Eventually higher bit rates such as 128 or 384kbps can provide the possibility to use larger picture sizes (e.g. CIF) for the transmission of video. Their opinion model takes into account both network layer parameters and application layer parameters.
Different research efforts in audiovisual quality assessment have led to various findings depending on network parameters, application parameters or both. Opinion models have been proposed to predict audiovisual quality of service taking into account the application layer parameters only and more recently taking the network layer parameters as well. A number of applications of 3G wireless networks in e-healthcare are emerging. These applications, however, are strictly dictated by the QoS parameters perceived by the end user(in this case a medical professional/the patient) and the availability and reliability of the 3G network itself. However, a better understanding of how the perceived audiovisual quality is affected by both voice and video quality is needed to focus effort in improving the QoS of multimedia applications over 3G networks.

3.2 Factors Affecting Voice and Video QoS

End-to-end perceived audiovisual quality is affected by network based parameters and application based parameters.
Consider video transmission over 3G network as shown in Fig 2.

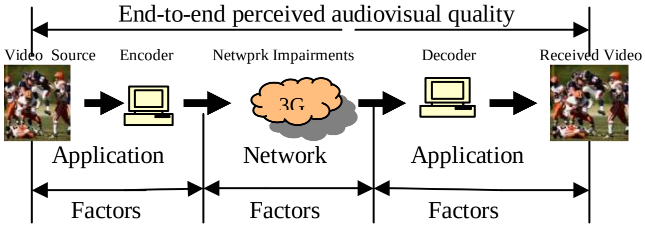

Fig. 2. Video Transmission over 3G Network

Application related factors –

Coding distortions, delay, buffer loss, frame rate, visual quality, bandwidth, loudness, echo, etc.

Network related factors –

Packet loss, network delay, jitter, throughput, etc...

The QoS parameters and their inter-relationship i.e. between the application layer and network layer is summarized in Fig. 3[3].

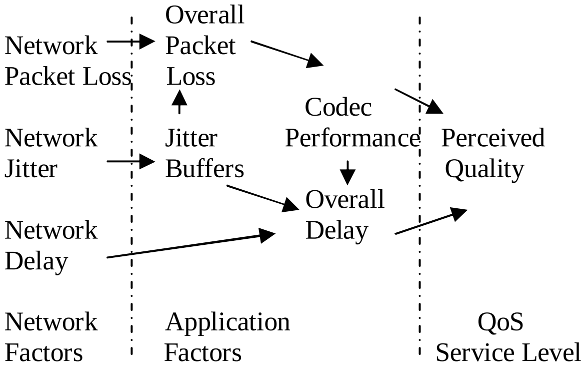

Fig. 3. Inter-relationships between the QoS Parameters[3]

4 Voice and Video Quality Measurement for Video calls over 3G Network

A video call test bed based on the Asterisk® server is set up to assess the quality of voice/video call over 3G network. Asterisk® is an open source telephone system run on a number of operating systems[26]. For our experimental set up we ran Asterisk® under a Linux operating system. Our test bed enables us to initiate live 3G video calls and hence collect live data. The set up is shown in Fig. 4. We initiated a video call using two different 3G handsets to the Asterisk® server via an ISDN link as shown in Fig. 4 below.

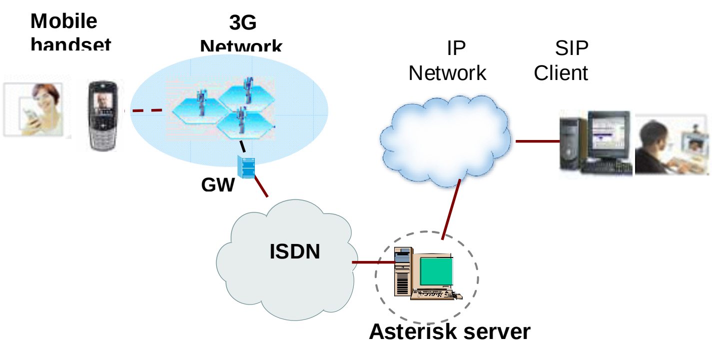

Fig. 4. Experimental Set-up for the Video Call

The Asterisk® server loops back the call. Asterisk® server also serves as a gateway to support a mobile call to the SIP client. At the same time, we dumped the trace at the server for each call. The trace data includes audio/video payload length, I-frames lost and the CRC errors. We analyse the trace data to assess the voice/video quality of the video call over 3G network by the users looking at the video quality subjectively. The video codecs used for the experiment were H.263(baseline level 10) and MPEG4(simple profile @ level 0) for video and AMR for audio as they are the mandatory codecs for 3G. We used two mobile phones of QCIF screen resolution 176X144 pixels with a progressive display.
We dumped the trace data for a 2-min. video call over live 3G network for 3 different scenarios – slight hand movement of the handset, gentle walking with the handset and rapid hand movement of the handset. The parameters are recorded in Table 1.

H/S No	Codec Type	Slight Movement		Gentle Walking		Rapid Movement	
		I - Frames Lost	CRC Errors	I - Frames Lost	CRC Errors	I - Frames Lost	CRC Errors
1	MPEG4	1	26	2	28	2	29
1	H.263	2	23	2	26	2	21
2	MPEG4	1	25	2	25	2	28
2	H.263	2	25	2	24	2	24

Table 1: Trace data from a video call over 3G Network

From Table 1 we observe that the video quality of handset 1 was judged to be much better with H.263 than with MPEG4. However, with handset 2 there was little difference in the video quality for the first two scenarios. But with the third scenario (rapid handset movement) video quality on handset 2 was visually very poor for MPEG4 codec compared to H.263. Preliminary results indicated that the block artefacts are due to the codec type. The experimental results are based on preliminary work on our test bed. Future work will concentrate on collecting MPEG4 header information based on the group of pictures(I/P/B/etc) and objective assessment of end-to-end voice/video quality using tools such as PESQ and PEVQ in addition to subjective methods and better analysis of the errors in estimating the audiovisual quality over 3G network.

5 3G Wireless Networks in Support of E-healthcare Services and their QoS Requirements

Presently £11 billion a year is spent in long-term healthcare for the elderly alone. This figure will rise over the next 20 years as the number of people aged over 65 increases by 40%[27]. Keeping a patient in a hospital bed costs over £800 a week whereas caring for them at home costs £120 a week. The UK government has recently allocated £100million for schemes that eliminate bed blocking in NHS trust hospitals. Some of these schemes use e-health technology that enables patients to recover from operations in their own home rather than a hospital bed. With increased bandwidth and

availability of 3G wireless networks the application in healthcare is growing be it to provide better access to healthcare professional on the move or in a hospital especially when an emergency has occurred in an area where fixed line communication network is not present.
University of Plymouth in conjunction with seven other participants is working on the two year EU funded project CAALYX(Complete Ambient Assisted Living Experience) under the Sixth Framework Programme[28]. CAALYX's main objective is to develop a wearable light device/garment able to measure specific vital signs of the healthy older person, to detect falls and to communicate automatically in real time with his/her carer in case of an emergency, irrespective of where they are. The service is designed to increase the autonomy and self confidence of the elderly. This is particularly important in an ageing society where the number of healthcare professionals are continually shrinking.
In [29,30] a mobile telemedicine system is presented over 3G wireless networks. Some of the scenarios of a telemedicine system are a teletrauma system that provides continuous realtime voice, video and medical data input between an ambulance and a level 1 trauma centre; a mobile remote telemonitoring system that can enable a physician to continuously monitor a patient's physiological data regardless of the patient's location; a wireless telemetry system used in disaster or mass casualty scenarios and can support, control and monitor patients in a relatively large areas by delivering patient's vital signs and medical information to remote facilities[31,32]. In [33] the authors have presented a model for intelligent diabetes management based on 3G network oriented mobile agents. In [34] they proposed the concept of using mobile Business-to-Employee (B2E) approach to support the hospital rota in healthcare using PDAs.
Mobihealth project[35,36,37,38] was funded by the European commission with 14 partners from 5 different countries in May 2002 and was completed in February 2004. The project was the development and trial of new services and applications in the area of mobile health over 2.5G (GPRS) and 3G wireless networks and developed innovative value added mobile health services with the integration of sensors to a wireless Body Area Network(BAN). BAN enabled monitoring, storage and transmission of vital-sign data coming from the patient. Some of the QoS requirements of the mobihealth project were bandwidth, delay, jitter, handover, cost, clock drift, battery life of handset and IP address allocation.

5.1 E-healthcare Application Scenario

Consider a situation in a roadside emergency/patient being monitored at home/high risk patient wearing wireless sensor that takes place in an environment where fixed computing/communication infrastructure is not available.

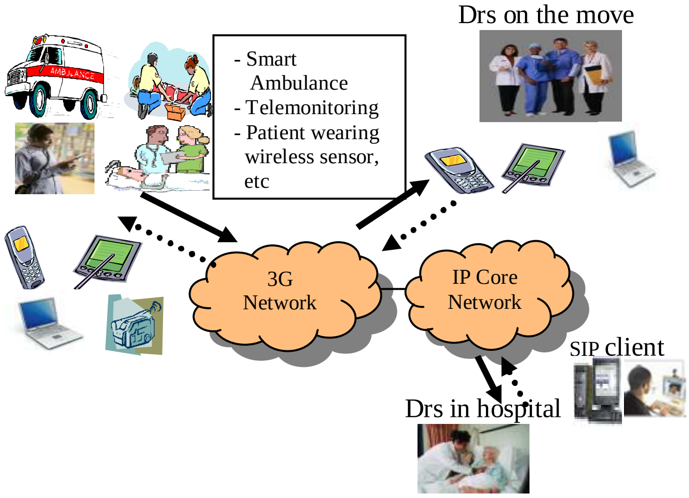

Fig. 5. Various scenarios utilizing 3G wireless network

Fig. 5 outlines a number of scenarios of 3G wireless network applications. Consider a situation where a roadside accident has occurred. Emergency staff in the ambulance would contact via videoconferencing to the hospital from the ambulance, hence delivering healthcare instantly. It may also be that the condition of a high risk patient who wears a wireless sensor has worsened. The wireless sensor that patient is wearing will transmit patient's vital signs to the hospital/ to a doctor on the move. In either case the 3G network is used to establish communication link between the incident site and the health professionals whether on the move or in the hospital via the IP core network. Transmission of data, medical images and live video of the patient can enormously help the junior doctor on site to help improve the condition of the patient. A number of devices e.g. a mobile phone, PDA or a laptop can be used to initiate the mobile voice/video communication.

5.2 QoS Requirements

High quality medical images such a single chest radiograph may require from 40 to 50 Mbytes[39]. With a circuit switched 64Kb/s the restricted bandwidth compression techniques would be crucial and a compromise will be needed with the lossy compression techniques currently available. Similarly, video packet loss/frame loss etc. causes video artefacts such as blockiness, blurriness etc. resulting in loss of some data rendering it impossible for the medical professional to successfully interpret the results.
Security and privacy of medical data is also of concern[40]. Procedures should be put in place to ensure that only authorized personnel have access to the data with encryption etc. A virtual private network was established for security of data in [41] to transmit patient's data from emergency site to the hospital. They ran a trial that tested a teleconsultation system on a moving ambulance that established videoconference links to the hospital to enable the ambulance staff to give emergency treatment to the patient. The trial gave good results. Above all the communication medium

itself has to be reliable i.e. an availability of 3G network with backward compatibility to 2.5G(GPRS) where necessary.
Future trends dictate that mobile handsets would be dual mode – in hotspots utilize the wireless networks IEEE 802.11-WLAN instead of 3G networks. IEEE 802.11- WLAN offers high bandwidth connections at low cost but in limited range compared to 3G network that has an increased area of coverage[42]. Some of the QoS parameters related to voice, video, image and network quality for e-healthcare applications that can affect the communication link are summarized in Fig. 6[3].

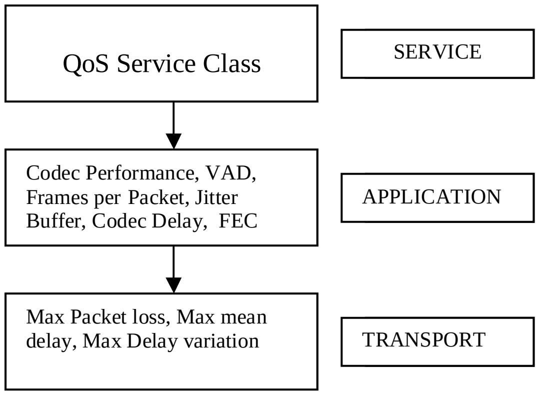

Fig. 6. QoS Parameters[3]

In Fig. 6. services covers videoconferencing, broadcast video etc. for healthcare applications defining voice, video and data service classes. Application factors are codec type, jitter buffer, etc. defining voice, video and data application factors and transport is the bearer classes defining packet loss, delay, jitter, etc.
The most important factor that would affect the voice and video quality would be the network packet loss. Further, video quality is affected by frame rate – how smoothly the motion flows in the video. If the frame rate is too low, the video will look jerky. Similarly, if the visual quality comes out too low, the video will look fuzzy. Standard frame rate for full motion video for 3G networks is 24 to 30 fps. In addition, bandwidth affects a video clips visual clarity. For example, a video with relatively stationary subjects ("talking heads") will have better visual quality than a video with rapid scene changes and a lot of movement.
Voice quality is affected by factors such as loudness, delay, echo, coding distortion and delay, network delay factors, etc. to name a few. The effect of network packet loss is that the speech would sound 'choppy'.

5.3 Applications in E-healthcare

Some of the applications of 3G networks in e-healthcare are given below[27]:

- Asthma and Diabetes management – via videocall/videoconferencing, video streaming, 3G network oriented mobile agents.
- To round up Ecoli bacteria - the wireless chip could have applications in biotechnology and biomedical engineering, including use in miniaturized medical diagnostic kits and bioanalysis.
- Stress relief service – via videocall/videoconferencing, video multimedia messaging – to provide answers to questions instantly.
- Telesurgery - Image-guided surgical robot to assist with brain surgery - the neuroarm operates in conjunction with real-time MR imaging. It is controlled by a surgeon from a computer workstation, it, provides surgeons unprecedented detail in enabling them to manipulate tools at a microscopic scale.
- E-prescriptions to reduce the workload of pharmacist.
- Telemedicine in Teletrauma - exchange of voice, video, medical data between the ambulance and trauma centre/hospital e.g. stroke patients could benefit.
- Telemedicine in Telemonitoring – remotely continuously monitor the patients physiological data
- Telemedicine in Telemetry systems – in disaster and mass casualty situation patients vital signs and medical information can be transmitted to remote facilities.
- Telepsychiatry – in the area of mental health
- Teledentistry – in the area of dental health
- Wireless Body Area Networks(BANs) – to integrate wireless sensors to a body area for monitoring, storage and transmission of vital sign data in high risk patients(e.g. high risk pregnancies).
- Workflow in outpatient clinics – can be improved via short messaging and multimedia messaging service(SMS, MMS).
- Hospital rotas – for more efficient hospital rotas using PDAs.

The main goals of e-healthcare is to increase the accessibility of healthcare professionals, increase the quality of care and continuity to patients, focus on preventive medicine through early intervention to name a few and hence reduce the overall cost of healthcare and enhance the quality of care.

6 Conclusions

With the advent of 3G networks and real time applications like e-healthcare new requirements are imposed on the Quality of Service(QoS). Audiovisual QoS is affected both by network parameters such as bandwidth, latency, packet loss, packet delay variation(jitter) and application parameters such as video packet loss, video frame loss, coding delay, etc.
In addition, it is also dependant on the content type e.g. different QoS for music applications as compared to sport, type of handset design etc. i.e. different quality of service classes dependant on the application. Subjective QoS tests gives a benchmark for objective testing. Non-intrusive methods are favoured as they do not interfere with the system under test. However, they are not very accurate at the moment in their quality prediction.

From the trace data collected we found that video quality is affected by the codec type as well as the handset type e.g. for handset 1 H.263 outperformed MPEG4 whereas, for handset 2 there was little difference seen overall. Preliminary results indicated that the block artefacts are codec dependant.
The users QoS requirement will be the driving force for e-health services to take off. The healthcare application will dictate the accuracy of data e.g. for high emergency situation where human lives are at risk QoS is vital whereas for low-medium situations that are not real-time sensitive a certain amount of compromise in the QoS is acceptable. The requirements for the performance of service (such as delay, jitter), expected security level, acceptable price, etc. will be dictated by the healthcare professionals. The exchange of information over 3G network will allow healthcare professionals to have quick access to patient information such as x-rays and CAT scans, as well as notify doctors (both in the hospital and on the move) immediately in case of an emergency – at home as in the mobihealth project[35,36,37] by sending signals via a body area network wore by the patient or outside the home in a remote location. Workflow in outpatient clinics can be improved via short messaging and multimedia messaging service. Even the healthcare professional's rota system can be improved with the use of 3G wireless network[34]. In summary, the information exchange could be a video call, video streaming, web browsing, video conference, short messaging service, mulitimedia messaging service, etc to name a few dictated by the situation.
Future mobile handsets will be dual mode – in hotspots they will be able to use the IEEE 802.11 wireless LAN instead of 3G networks. Also the future 3G networks i.e. 4G and beyond will be completely packet based and hence opening the bandwidth restriction from 64kb/s (currently for circuit switched video call) to 2Mb/s and beyond.
Therefore, the overall QoS will depend on the objective and subjective testing of both the application(i.e. voice & video) and transmission (network) errors. The most important QoS performance metrics for e-healthcare applications can be summarized as delay, jitter, throughput(bandwidth) and packet loss.
Future work will concentrate on measuring the audiovisual quality in addition to the voice and video quality for video calls over 3G network to assess how voice and video quality affect the overall audiovisual quality and the significance of errors introduced by network parameters. Further to explore the affects of video quality impairments on voice quality and vice versa. Tests will be conducted both subjectively (MOS) and objectively using a tool such as PEVQ.

Acknowledgements

We acknowledge the financial support of the European Commission (The BIOPATTERN Project, Contract No. 508803) for part of this work. We would also like to thank Motorola for their ongoing support for our test bed.

References

[1] M. Hannikainen, T. D. Hamalainen, M. Niemi, J. Saarinen, "Trends in personal wireless data communications", Computer Communications, Vol. 25, Isuue 1, 1, January 2002, Pages 84-89.
[2] M. Siller and J. Woods, "Improving quality of experience for multimedia services by QoS arbitration on a QoE framework" in Proc. of the 13th Packed Video Workshop 2003- polytech.univ-nantes.fr.
[3] J. Monfort, "Basic requirement to quality of service(IP centric)", Workshop on standardization in E-health Geneva, 23-25 May 2003.
[4] T. Hayashi, M. Masuda, T. Tominaga and K. Yamagishi "Non-intrusive QoS monitoring method for realtime telecommunication services", Vol.4 No.4 Apr. 2006.
[5] ITU-T. Rec P.800, Methods for subjective determination of transmission quality, 1996.
[6] Q. Huynh-Thu, Psytechnics Ltd, quan.huynh-thy@psytechnics.com "Recent developments in objective voice and video quality assessment models" ITU-T Workshop on "End-to-End QoE/QoS" Geneva, 14-16 June 2006.
[7] ITU-T Recommendation J.144 "Objective perceptual video quality measurement techniques for digital cable TV in the presence of full reference", ITU, Geneva, Switzerland, 2004.
[8] Video quality experts group, multimedia group test plan, Dec 2005, Draft version 1.8, www.vqeq.org.
[9] Y. Cognet, QoSmetrics, Marcoussis, "QoE versus QoS" 30th March 2006, ITEA Project March 2006- Yves Cognet.
[10] http://qoe.symmetricom.com/products/NetWarrior.asp
[11] ITU-T Recommendation P.862 Perceptual evaluation of speech quality(PESQ) an objective method for end-to-end speech quality assessment of narrowband telephone networks and speech codecs, Feb 2001.
[12] ITU-T Recommendation G.107, The E-model a computation model for use in transmission planning.
[13] ITU-T Recommendation 563 single-ended method for objective speech quality assessment in narrowband telephony applications, May 2004.
[14] S. Winkler and C. Faller "Perceived audiovisual quality of low-bitrate multimedia content" IEEE Trans. Multimedia VOL. 8, Issue 5, Oct. 2006.
[15] S. Winkler and C. Faller "Audiovisual quality evaluation of low-bitrate video" Proc.SPIE/IS&T Human Vision and Electronic Imaging, p. 139--48, 2005.
[16] S. Winkler and F. Dufaux "Video quality evaluation for mobile applications" SPIE proc. Visual Communication and Image Processing, Vol.5150, Lugano Switzerland, July 2003.
[17] F. Pereira, "Sensations, perceptions and emotions: towards quality of experience evaluation for consumer electronics video adaptations, VPQM05 Proceedings, Phoenix, AZ, Jan. 2005.
[18] S. Jumisko-Pyykko, K. Vaananen-Vainio-Mattila {@tut.fi} "The role of audiovisual quality in mobile television", VPQM06 Proceedings, Scottsdale, AZ, Jan. 2006.
[19] K. Yamagishi and T Hayashi, members, "Opinion model using psychological factors for interactive multimodal services" IEICE Trans Commun Vol.E89-B, No.22 February 2006.
[20] T. Hayashi, K. Yamagishi and H. Yoshino, NTT Japan "Perceptual QoS Evaluation Model for Audiovisual Communication Services" World Telecommunications Congress 2006 30 April-3 May 2006, Budapest, Hungary.
[21] G. W. Cermak Verizon Laboratories "Packet loss, bandwidth and latency affect judged quality of videoconferencing", VPQM05 Proceedings, Phoenix, AZ, Jan. 2005.
[22] Q. Huynh-Thu and M. Ghanbari "Impact of jitter and jerkiness on perceived video quality", VPQM06 Proceedings, Scottsdale, AZ, Jan. 2006.
[23] M. Ries, J. Kubanek and M. Rupp, "Video quality estimation for mobile streaming applications with neuronal networks" Proceedings of MESAQIN'06 conference, 5-6 June 2006, Prague, Czech Republic.
[24] M. Ries, R. Puglia, T. Tebaldi, O. Nemethova, Markus Rupp "Audiovisual quality estimation for mobile streaming services" IEEE Proceedings of the 2nd International Symposium on Wireless Communication Systems 2005, 5-7 September 2005, Siena, Italy.
[25] K. Yamagishi and T. Hayashi, "Opinion model for estimating video quality of videophone services" IEEE Globecom 2006 proceedings.
[26] http://www.asterisk.org/

[27] http://www.wirelesshealthcare.co.uk
[28] http://caalyx.eu/
[29] Y. Chu and A. Ganz, "Mobile Telemedicine Systems using 3G wireless networks", Business briefing: US healthcare strategies 2005.
[30] K. A. Banitsas, K. Perakis, D. Koutsouris, G. Konis, S. Tachakra, "Ambulance 3G", 27th Annual International Conference of the Engineering in Medicine and Biology Society, 2005. IEEE-EMBS 2005Volume , Issue , 01-04 Sept. 2005 Page(s): 371 – 374.
[31] Y Chu and A Ganz, "A mobile teletrauma system using 3G networks", IEEE transactions on Information Technology in Biomedicine, Vol. 8, No. 4, December 2004.
[32] K. Perakis, K. Banitsas, G. Konnis, D. Koustsouris, "3G networks in emergency telemedicine – an in-depth evaluation & analysis", 27th Annual International Conference of the Engineering in Medicine and Biology Society, 2005.
[33] M. Li and R. S. H. Istepanian "3G network oriented mobile agents for intelligent diabetes management: a conceptual model", Proc. Of the 4th annual IEEE Conf. on Information Technology Applications in Biomedice, UK.
[34] A. Aneiba, S. Hanlon, H. Shah, "An architecture for mobile web business systems: applied to the healthcare sector", Proceedings of the Third International Conference on Mobile Business, M-Business 2004.
[35] K. Wac, R. Bults, D. Konstantos, A. V. Halteren, V. Jones, I. Widya, R. Herzog, "Mobile healthcare over 3G networks: the mobihealth pilot system and service", Proc. Of 2004 Global Mobile Congress, Shangai, Oct. 11th-13th 2004, pp. 71 – 76, ISSN 1557-0622.
[36] V. Jones, A. V. Halteren, R. Bults, D. Konstantas, I. Widya, R. Herzog, "MobiHealth: Mobile Healthcare" http://www.mobihealth.org, IST – 2001 – 36006.
[37] E. Jovanov, "Wireless technology and system integration in body area networks for m-health applications", Proceedings of the 27th Annual International Conference of the IEEE Engineering in Medicine and Biology Society, Shanghai, China, September 2005.
[38] R. Bults, K. Wac, A. V. Halteren, V. Nicola, D. konstantas, "Goodput analysis of 3G wireless networks supporting m-health services", Proceedings of the 8th International Conference on Telecommuincations, 2005(ConTel 2005).
[39] C.S. Pattichis, E. Kyriacou, S. Voskarides, M.S. Pattichis, R. Istepanian, C. N. Schizas, "Wireless telemedicine systems: an overview", IEEE Antennas & Propogation Magazine, Vol. 44, No.2, pp 143-153, 2002.
[40] Z. Li, L. Sun and E. Ifeachor, "Challenges of mobile ad-hoc grids and their applications in e-healthcare", Proceedings of Second International Conference on Computational Intelligence in Medicine and Healthcare (CIMED' 2005), July 2005, Lisbon, Portugal.
[41] K. A. Banitsas, K. Perakis, S. Tachakra, D. Koutsouris, "Using 3G links to develop a teleconsultation system between a moving ambulance and an A & E basestation", International Journal of Telemedicine and Telecare, Vol. 12, pp 23-25, Royal society of Medicine press, 2006.
[42] Y. E.. Tan, N. Philip, R. S. H. Istepanian, "Fragility issues of medical video streaming over 802.11e-WLAN m-health environment", Proceedings of the 28th IEEE EMBS Annual International Conference, New York City, USA, Aug 30 – Sept 3, 2006.