QOS MAPPING FOR VIDEO SERVICES IN HETEROGENEOUS NETWORKS

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ABSTRACT

This paper presents the design and implementation of a QoS parameter mapping emulator. The emulator is used in selecting the appropriate network parameters in such a way as to provide optimum quality for transmitted multimedia between EDGE and UMTS networks.

1. INTRODUCTION

Future communications systems are intended to support a wide range of applications that require different levels of Quality of Service (QoS). Compared to the current single service network, future multimedia applications require multiple service operation in integrated network environments. The research activities of VISNET [1] aim at developing intelligent audiovisual media processing and transmission techniques that are capable of creating fully networked virtual and augmented reality environments with high levels of interactivity and immersion. Thus inter-network audiovisual communications play an important part in VISNET activities.

The beyond 3G communication network concept involves the coexistence of all the different network technologies. Thus, heterogeneity will play a major role in future networks and operating system environments. Highly differentiated access technologies allow a user terminal to exploit a number of platforms to access heterogeneous services. Application data transmitted over heterogeneous networks will therefore experience systems with limited and varying capacity. under this condition, QoS mapping becomes important as different networks provide different QoS. When multimedia is transmitted from a network with poor performance to a network with good performance, it will bring serious problems will arise, in guaranteeing required quality by the end user.

In order to investigate the performance of novel audiovisual services and applications over future heterogeneous system, an appropriate heterogeneous system emulator model should be designed and implemented. The main objective of this paper is to present such an emulator design for a communication system, which consists of EDGE and UMTS networks.

EDGE and UMTS are the most widely accepted third generation radio access technologies. UMTS is based on Wideband CDMA technology. EDGE is based on TDMA technology and uses the same air interface as the successful second-generation mobile system GSM. Even though EDGE and UMTS are based on two different multiple access technologies, both systems share the same core network. GPRS (EDGE) networks have been developed for several years and have become the main mobile communication system of many regions in the world. This will be updated to EDGE system. UMTS networks will gradually replace the 2G system in the near future. However, they may coexist for several years. The study of QoS mapping between EDGE and UMTS networks will help service providers to offer better multimedia services for users.

This paper presents the design of a QoS mapping emulator for multimedia transmission between EDGE and UMTS systems. Using the developed emulator, the effect of network parameters mapping on the performance of real-time video communications is investigated. The performance investigation is carried out for the transmission of fully error resilience enabled MPEG-4 coded video over a simulated EDGE-to-UMTS system. Based on the experimental results, an optimal QoS parameter mapping for video applications over EDGE-to-UMTS is derived for varying propagation environments.

2 QOS MAPPING EMULATION SYSTEM DESIGN

Figure 1 shows the role of the QoS mapping in a practical operating environment. It resides in the core network and maps network and radio resource parameters from one network to the other.

The emulation system consists of five components: a transmitting mobile terminal, EDGE Emulator, QoS Mapping Emulator, UMTS Emulator and a receiving mobile terminal as shown in Figure 2. The terminal emulator emulates the mobile terminal and is capable of transmitting and receiving multimedia data. An MPEG-4 data transmitter and decoder is integrated into the terminal emulator. The received data is decoded in real time and is display on the terminal emulator.

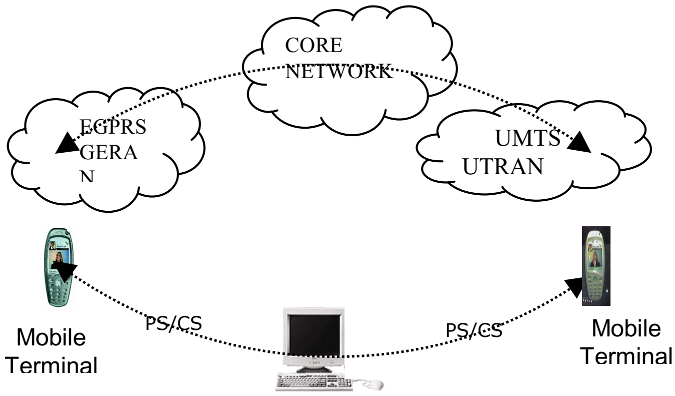

Figure 1: EDGE/UMTS parameter mapping emulator.

The EDGE emulator consists of two parts: GERAN data flow model and EGPRS physical link layer model. The physical link layer model simulates the physical layer characteristics of the channel between EDGE mobile terminal and a base station. The model includes forward error correction, modulation, transmission over fading channels, equalization and reception and detection of correctable and uncorrectable errors. The transmitted signal is subjected to a multipath fast fading environment. The simulator model was built using the COSSAP stream simulation environment and it closely follows the standard specification [2]. The EGPRS data flow simulator is implemented in order to carry out detailed examinations of the effect of channel errors upon applications. The model was implemented in C++. The layers implemented include RTP/UDP/IP transport layers and GPRS SNDC, LLC, RLC/MAC layer protocols. It must be emphasized that only the data flow properties of the protocols have been implemented in this model. This means that only the resulting effect on header sizes, packet and stream segmentation procedures and flow control effects have been implemented.

Similar to the EDGE emulator, a UMTS emulator, which consists of the UTRAN data flow model and WCDMA physical layer, is implemented. The WCDMA physical layer model was developed in a generic manner that enables easy configuration of UTRAN link level parameters such as channel structures, channel coding/decoding, spreading/de-spreading, modulation, transmission modelling, propagation environments and their corresponding data rates according to the 3GPP specifications [3]. The multipath-induced inter symbol interference is implicit in the developed chip level simulator. By adjusting the model parameters, the bit error and block error characteristics can be determined for a range of signal-to-noise ratios (or carrier-to-interference ratio) and for different physical layer configurations. A UMTS radio interface protocol model, which represents the data flow across the UTRAN protocol layers, is implemented in Visual C++. It is integrated with the physical link-layer model to emulate the actual radio interface as experienced by users. This allows for the interactive testing of the effects of different parameter settings of the UTRAN upon the received multimedia quality. Also, this provides information on channel utilization and system complexity for the given connection.

The QoS Mapping Emulator written in Visual C++ 6.0 is a relay program between the EDGE Emulator and the UMTS Emulator. To some extent, the QoS Mapping Emulator can be regarded as the combination of the E/GPRS Emulator and UMTS Emulator. It receives the data sent by the EDGE Emulator, changes the data in UMTS format, and sends them to the UMTS Emulator, and vice versa. If necessary, a trans-coding function can be added to the parameter-mapping program.

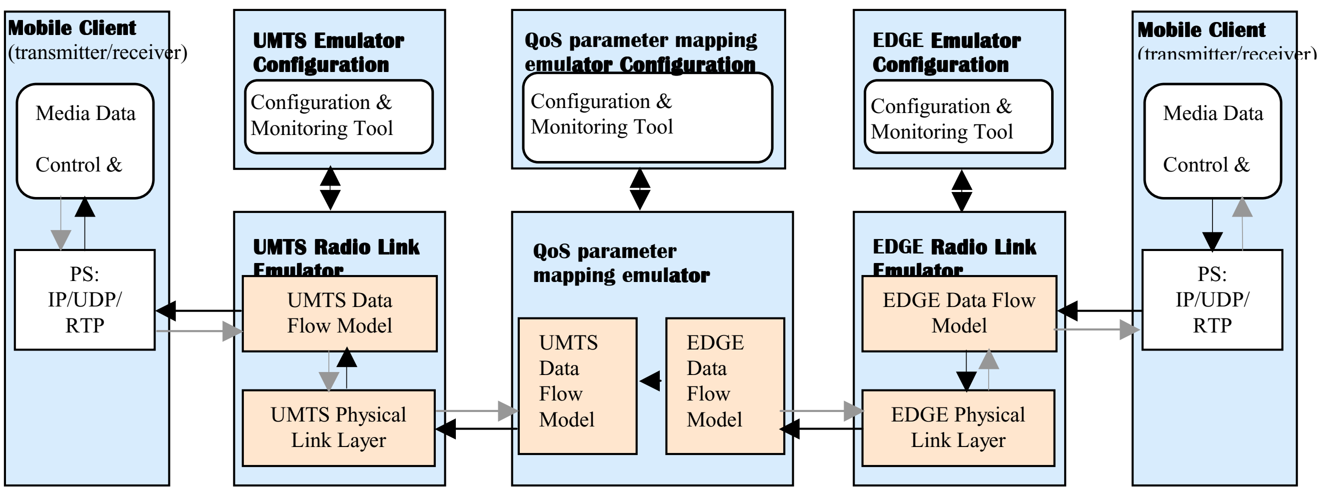

Figure 2: QoS Mapping Emulation System architecture

3 EMULATION RESULTS ANALYSIS

A MPEG-4 encoder and decoder pair are implemented in real-time at the mobile terminals. The connection setup is based on IP/UDP/RTP transport protocols [4]. Video frames are segmented if the video frame size exceeds the specified Maximum Transfer Unit (MTU) size, before they are encapsulated into IP packets for transmission. At the receiving end, if IP/UDP/RTP headers are detected to be corrupted, data encapsulated within that packet is dropped at the network layer.

The propose of the QoS Mapping Emulation system is to obtain the optimal bearer configurations for the EGPRS network and the UMTS network. Experiments are carried out to investigate the influences of different bearer configurations on an EDGE-to-UMTS system. Firstly, video transmission is emulated in both EDGE and UMTS systems separately. Secondly, encoded video is transmitted over the joint EDGE-to-UMTS system. The transmission is emulated over EDGE system. Then, the output data from EDGE Emulator is forwarded to QoS Mapping Emulator, where the appropriate radio resources are allocated for transmission over the UMTS system. After transmission over UMTS system received data is forwarded to the receiving terminal emulator for decode and display.

Full error-resilience enabled MPEG-4 coded video transmission is considered in the experiments discussed. In addition, the TM5 rate control algorithm together with an adaptive intra refresh algorithm [5], are used to stop temporal error propagation and to achieve a smoother output bit rate. ITU test sequences "Suzie", "Foreman" and "Carphone" are used as the source signals. QCIF (176 by 144 pixels) sequences are coded at 10 fps. The received video quality is measured in terms of average frame Peak Signal to Noise Ratio (PSNR).

Test for the EDGE system

The throughput allocation per timeslot at the application level (as seen by the video codec) in the EDGE system is shown in Table 1 for different Modulation Coding Schemes.

Table 1:EDGE Multislotting capacity for video (kbit/s)

Scheme	TS1	3 TS	6 TS	7 TS	8 TS
MCS-1	7.5	22.5	45	52.5	60
MCS-3	12.6	37.8	75.6	88.2	100.8
MCS-5	19	57	114	133	152
MCS-6	25.2	75.6	151.2	176.4	201.6
MCS-9	50.3	150.9	301.8	352.1	384

Simulations are carried out for different propagation environments and the results for the Typical Urban (TU) environment are shown in Figure 3. Ideal frequency hopping is assumed for 3km/h mobile speed. It is seen that MCS-1 gives better performance than MCS-2 at all C/I values up to around 20 dB. At this value however, MCS-5 begins to provide a superior video quality than either of the two schemes. MCS-6 does not match this performance until at least a C/I value of 30dB.

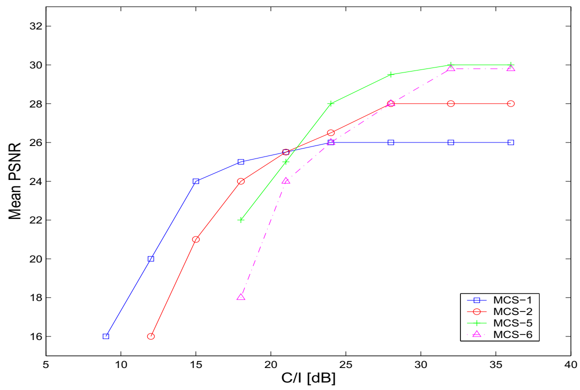

Figure 3: Video Quality at TU1.5 IFH 1800MHz.

Test for the UMTS system

The actual information data rate in a UMTS system is a function of Spreading Factor (SF), rate-matching ratio, channel coding scheme, CRC attachment, operation modes and Transport Block (TB) size. The calculated information data rates according to the different simulation parameter settings are shown in Table 2.

Table 2: Source throughput [kbps] capacity in UMTS

SF- Spreading Factor, CC- Covolutional Code , TC- Turbo Code.

SF	CC 1/2	CC 1/3	TC 1/3	None
64	39.5	26.10	26.7	80.6
32	97	64.5	65.5	197.1
16	206.1	137.4	139.55	419.1
8	442.8	295.1	299.3	899.1
4	915.75	610	619.2	1859.1

The received video quality for different spreading factor realisations are depicted in Figure 6. Video sequences are coded at the appropriate rates listed in Table 2. As expected, allocation of SF 32 provides slightly better performance than others in poor channel conditions due to the better channel protection capability of higher spreading factors. In better channel conditions, allocation of SF 16 provides superior video quality compared to others. SF 8 considerably under-performs all other schemes, even in good conditions. This is due to the inter-symbol-interference experienced in multi-path channels. The channel coding algorithm trends to mitigate the inter-symbol-interference effect. But, significant performance degradation is still visible for low spreading factors (such as 8). Results are shown only for convolutional coding, as similar performances are achieved with turbo coding.

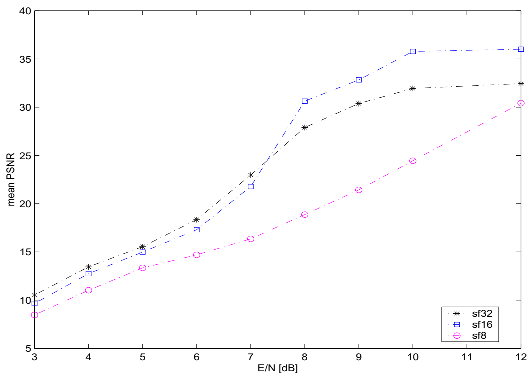

Figure 4: Effect of Spreading Factor.

Tests for the EDGE-to-UMTS system

MCS-1 is selected as the channel coding scheme to be used in the EDGE system, while 1/3 CC is chosen for the UMTS system The spreading factor is set to 32 in the UMTS system. The performance results are compared to those over a single network connection in Figure 6. for the results shown in Figure 6, C/I of the EDGE channel is set to 18dB (good channel), while the channel condition for the UMTS link is varied from Eb/No= 6 dB to 10 dB. When channels on both connections are in good condition, video performance gets better. However, the video quality is always less than that over the single UMTS network. This is due to the QoS parameter mismatch in the two networks.

Figure 7 shows the video performance when the channel condition on EDGE link changes from a good to a poor channel condition. Here, C/I over EDGE is 12 dB. The results are 5-7 dB lower than the quality received over single UMTS network. This is because when the received quality over the first link is poor it is impossible to achieve better quality even the second link is in good condition. This illustrates that it is necessary to perform joint QoS optimization over heterogeneous networks for efficient resource utilization and improved end user quality.

4 CONCLUSION

QoS parameter mapping for video transmission over EDGE-to-UMTS system is investigated by means of system emulation. The experiment has shown that the video quality in an EDGE-to-UMTS network transmission is lower than the one within either an EDGE or a UMTS network. If the QoS of the video transmission in a single network is poor, the network parameters on the second connection should be carefully selected to avoid further quality degradation. Otherwise, the received quality will be unacceptable to the end user. The optimal selection of network parameters for the end-to-end transmission can be obtained through simulation using a parameter mapping emulator, which is described in this paper.

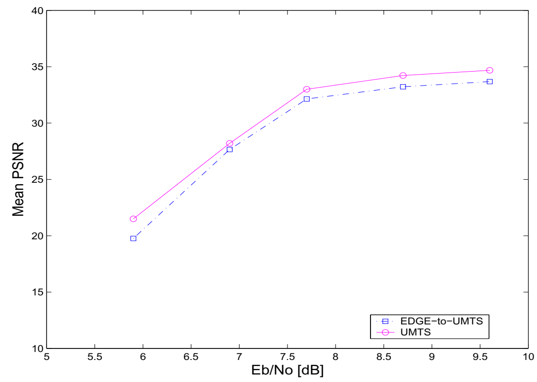

Figure 6: video performance in EDGE-to-UMTS system. EDGE MCS-1 C/I = 18 dB, UMTS 1/3 CC

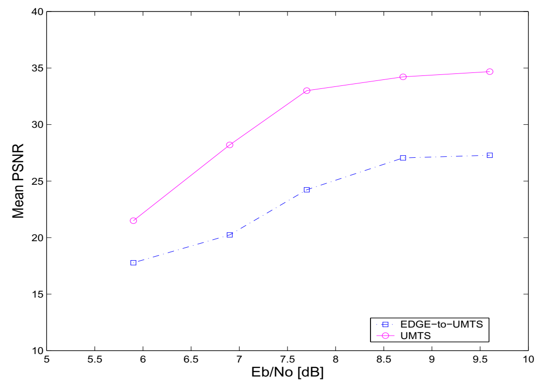

Figure 7: video performance in EDGE-to-UMTS system. EDGE MCS-1 C/I = 12 dB, UMTS 1/3 CC

ACKNOWLEDGMENT

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5. REFERENCES

[1] http://www.visnet-noe.org

[2] "3GPP: GERAN; GSM/EDGE Radio Access Network (GERAN); Overall Description - Stage 2; (Release 5)", 3GPP TS 43.051 V5.0.0 January 2001

[3] "3GPP: Physical channels and mapping of transport channel on to physical channel (FDD) (Release 4)", 3GPP TS 25.211 v4.6.0. (2002-09).

[4] Y. Kikuchi, T. Normura, S. Fukunaga, Y. Matsui, H. Kimata, "RFC 3016: RTP payload format for MPEG-4 Audio/Visual streams".

[5] ISO/IEC JTC 1/SC 29/WG 11. "Information technology - generic coding of audio-visual objects - part 2: Visual", *ISO/IEC 14496-2*: 2001,July 2001.