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D1-3

The SDMB Service Demonstrator

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Abstract:

The SDMB Service Demonstrator is a simulation of the SMDB service running on a Pocket PC. This document services two purposes.

Firstly, it describes the evaluation of service parameters (bandwidth, delays and interruptions) to deliver an acceptable Quality of Service (QoS) to end-users. Secondly, it outlines an interaction style and interface for the SDMB service. Important conclusions relating to screen size and preferred service types (Live vs Push and Store) are also reported.

Keyword list: SDMB Service Demonstrator

EXECUTIVE SUMMARY

This document contains deliverable **D1-3** of the IST Integrated Project MAESTRO – Mobile Applications & sErvices based on Satellite and Terrestrial inteRwOrking (IST Integrated Project n° 507023).

MAESTRO project aims at studying technical implementations of innovative mobile satellite systems concepts targeting close integration & interworking with 3G and Beyond 3G mobile terrestrial networks.

MAESTRO aims at specifying & validating the most critical services, features, and functions of satellite system architectures, achieving the highest possible degree of integration with terrestrial infrastructures. It aims not only at assessing the satellite systems' technical and economical feasibility, but also at highlighting their competitive assets on the way they complement terrestrial solutions.

This is the first of 3 sub-tasks within Task 1.1 of Work Package WP01 – "SDMB Service Demonstrator Program".

The deliverable **D1-3** – "**The SDMB Service Demonstrator"** - describes the technical and design requirements for the demonstrator. Technical requirements are assessed through studies to identify relevant parameters for the SDMB service. A bandwidth study examines the market acceptance of TV material delivered at a range of bandwidth on two different devices, a 3G phone and an iPAQ PDA. The delay study examines user tolerance to a range of different start up delays and service interruptions to understand the technical constraints on a live streaming service. As part of this study we also assess the relative demand for two different SDMB scenarios, a pure streamed TV service vs. a pure push and store service.

The final section of the document outlines the logic behind the design of the SDMB service and its interaction style.

The task is lead by UCL and is supported actively by BYTL, GFI-C, ASP, E-TFI, BT and SPH as MAESTRO partners.

DOCUMENT HISTORY

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1.1	16th October 2004	Document draft – including bandwidth study details
2.1	27th October 2004	Added demonstrator design details
2.2	18th November 2004	Added delay study details
2.3	22nd November 2004	First document draft for circulation within workgroup W01.
3.1	07th January 2005	Final version for delivery

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1 INTRODUCTION

The SDMB demonstrator serves two complementary purposes. First, the demonstrator is quite literally a demonstration of what the service might look like to end-users. Second, it functions to refine the service requirements as part of a scenario based design process. In other words, by allowing potential users of the service to experience a demonstration of the service first hand we (i) enable users to generate additional requirements that we may not have considered, (ii) refine and validate our assumptions of the service requirements and (iii) gain a greater understanding of the commercial potential of the service. These issues will be addressed as part of D1.5 – the Commercial Service Definition.

However, before creating the demonstrator three key questions needed to be addressed. Specifically, these were

1. What are the relevant parameters for delivering content?
2. What types of interaction need to be considered?
3. What should the user interface look like?

Sections 2-5 describe the evaluation of service parameters through a series of laboratory studies. These studies examine user tolerance to different levels of bandwidth, delay and service interruptions to help refine the quality of service (QOS) requirements of the service. Section 6 describes the range of interactions that need to be considered. Section 7 describes the design of the interface. The identification of promising services was achieved by running a large number of focus groups. The details and findings of the focus groups are described in D1.4 (Service Assessment).

2 EVALUATING SERVICE PARAMETERS

The demonstrator must simulate the transmission and presentation of content using a Satellite Digital Multimedia Broadcast system (SDMB). This section evaluates the particular aspects of transmission that can influence the quality of service (QoS). The evaluation focuses on the three main parameters of an SDMB transport system: (i) available bandwidth, (ii) delay and (iii) data loss.

The values on these parameters are chosen to cover the whole range of “typical” values as well as those that may occur in extreme conditions (e.g., limited coverage, switching of reception between SDMB and terrestrial networks, etc.). Empirical testing of the impact parameter values have on Quality of Service is conducted in the laboratory on two different samples of end-users.

2.1 User Equipment

The QoS evaluations were conducted on two different devices, an iPAQ Personal Digital Assistant (PDA) and a NEC 3G phone. The iPAQ (See Figure 1) was chosen for it’s large screen size (240x320) and large memory capacity (1GB). At start of the trials this exceeded the specifications of the best commercially available phone. [Sony Ericsson P900, screen 208x320, memory, 32MB). The large screen size enabled us to evaluate use reactions with material encoded at CIF resolution (352x288).

Figure 1: iPAQ H2210 used for user trials.

HP2210 iPAQ

Display:

3.5" TFT liquid crystal display with LED backlight, 64K colours 16-bit, 240 x 320 resolution

Memory:

1GB CF storage card.

Media Player:

Windows media player (WMV format).

The NEC e616 was one of the first commercially available 3G phones in UK. With a screen resolution of 176x240 and a memory capacity of 19MB this device was used to evaluate reactions with material encoded at QCIF resolution (176x144) (See Figure 2).

Figure 2:NEC e616 - 3G phone used in user trials

NEC e616 (3G)

Display:

Display: 65,536 colors, TFT, 35 x 43mm (240 x 176 pixels).

Memory:

Total internal memory of 19MB), capable of

Media Player

Decode/play 3GPP

MPEG-4 video.

3 BANDWIDTH REQUIREMENTS STUDY

3.1 Introduction

Within the SDMB service definition there are a number of different scenarios. These range from *Live TV* on the phone, to *Push and Store* services or a combination of the two. Little is known, however, about the demand for different service types or the technical requirements to deliver an acceptable quality of service (QoS). Existing research has tended to focus on Sports as a service [3,4, 5] and - at least within the UK - Sports Highlights have been at the forefront of marketing efforts for 3G TV services. Recent work by [6] however indicates that the demand for sports services is relatively weak. In focus groups people indicated that they preferred to watch live football in a group and preferably on a large screen. Mobile viewing of football content was seen very much as a back-up service rather than a regular activity.

As little is known of the requirements for other types of services we conducted a study to examine these questions in a random sample of 20-30 year olds in the UK. A primary focus of the study was the bitrate requirements for different service types.

3.2 Encoding Bit rate

The encoding bit rate is the predominant factor that influences video and audio quality on the user equipment but for SDMB services it is important to distinguish two different relationships between encoding bit-rate and those available for transmission. With *real-time streaming* of live or pre-recorded material, the encoding bit rate cannot be higher than the available transmission rate. In contrast, with *Push and Store* services the video content can be encoded at higher bit rates than the transmission bit rate as the delay requirements for delivery are relaxed. It is possible therefore that material encoded at 1Mbps could be delivered over a 256kbps link for viewing at some later date. (e.g. the next day).

Different classes of content or services will also have different ranges of bandwidth requirements. As described by [7] the bandwidth requirements for TV are a function of the temporal nature of the data and the importance of the audio and visual channels in understanding the message. Generally, content with a high degree of change, for example, moving background due to camera pans (Highly Temporal Data) requires more bandwidth. Thus highlights from a football match would require significantly more bandwidth that highlights from a snooker match.

3.3 SDMB Bandwidth Study

Three different questions are addressed in the study, (i) the demand for different service types, (ii) the bandwidth requirements for different service types and (iii) people's willingness to pay for these services. Demand and willingness to pay were assessed using a simple questionnaire, bandwidth requirements were assessed by showing users a range of clips encoded at a different bandwidths and asking them to indicate whether they found the service acceptable. At very high bandwidths we can expect everyone to indicate that the service is acceptable, at very low bandwidths we expect everyone to indicate that the service is unacceptable. This measure is reported as the % of the market that find a given service level acceptable.

3.3.1 Participants

We randomly selected a group of twenty 20-30 year olds from a University Subject Pool to take part in the study. The mean age of the participants was 26. Each participant was paid approx €15 for participation.

3.3.2 Demand

To assess demand for different service types we presented users with the simple scenario below. The services were chosen to reflect a range of material that might be of interest to this target group. By recording which of the two services people chose we measured demand for the different service types.

SCENARIO: *Your mobile phone company offers a service to stream video to your mobile phone. The standard package allows you to choose two from the following services:*				
NEWS	**WEATHER**	**MOVIE TRAILERS**	**MUSIC VIDEOS**	**FOOTBALL**

3.3.3 Bandwidth Requirements

As described in the introduction previous studies have assessed bandwidth requirements for Sports services on mobile devices yet relatively little is known about the requirements for other service types. To investigate this we adapt the measure of Acceptability used by [8] coupled with a concept of market % described by [5] to measure *the percentage of the target group that find a given level of service acceptable*. In addition, unlike previous studies we asked users to rate the acceptability of both video and audio channels and examined acceptability on two different devices – an iPAQ a handheld computer (PDA) and an NEC 3G phone. The devices had different resolutions and supported different video codecs. The Windows based iPAQ supports the WMV codec whereas the Symbian based NEC phone supports the 3GPP standard. A summary of the codecs, resolutions and range of bit rates tested are presented in Table 1. Full details of all the video and audio bitrates tested are presented in Appendix A.

			Bit rate Range (kbps)		
Device	**Codec**	**Resolution**	**Total**	**Video**	**Audio**
IPAQ 2210	WMV [REF]	320 x 240	64 – 512kbps	52 – 448kbps	12 – 64kbps
NEC 3G phone	3GPP [REF]	176 x 144	28 – 256kbps	16 – 243kbps	6.7 – 12.2kbps

Table 1: Encoding parameters for the two devices

3.3.4 Willingness to Pay

We assessed users willingness to pay *after* they had experienced the different service on both the iPAQ and 3G phone. The issue was addressed with the following two questions.

Q1 : *Approximately how much are you paying for your current mobile service / month ?*

Q2 : *How much extra would you pay for the TV services you have just seen (assuming the highest quality) ?*

3.3.5 The TV Content

Representative TV content was chosen to correspond to the 5 different services users were given a choice of. Each clip was 15 seconds in length. Details of the content are presented in Table 2.

Service	**Content**
Movie	Kill Bill 2 movie trailer
Music clip	Beastie Boys MTV music video clip
Football	Goal highlights from Manchester Utd vs. Arsenal
News	CBSNews news clip
Weather	BBC UK weather update (T low/-Ahi, V-Hi)

Table 2: TV content clips of the five service types

3.4 Results

3.4.1 Demand

The popularity of different types of services is presented in Table 3. The most popular service by far was News, Music was the second most popular and Football was in fact the least popular.

	News	Music	Weather	Movie	Football
Market % Demanding this Content Type	85	60	20	20	10

Table 3: Demand for different content types compared

3.4.2 Video Bandwidth Requirements

We found very different bandwidth thresholds for different types of services at a resolution of 320 x 240. The most demanding type of content was the football coverage (See Figure 3). Even at 448kbps this service did not achieve 90% market acceptance but plateaued for bit rates of 332kbps and greater at an acceptability of 84%. News and Weather delivered an acceptable service to 90% of people at a video bandwidth of just 112kbps. However, to reach a similar market share the Music and Movie content needs to be coded at twice the former rate (224kbps).

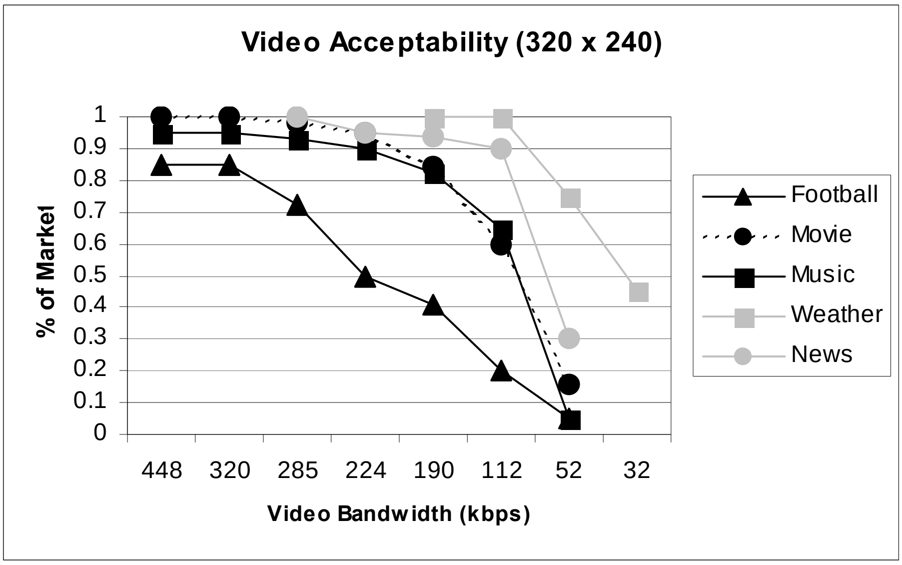


Figure 3 : Video acceptability of content types across bit rates on an IPAQ

A very different pattern of results was produced for content encoded using 3GPP and viewed on the 3G phone at 176 x 144 (See Figure 4). At this resolution Movie content required half as much bit rate (111kbps) as on the IPAQ to be acceptable to 90% of the market whereas Music and News content required a substantial encoding rate of 243kbps, similar to what was needed on the IPAQ. The football coverage reached also about 90% market acceptability at 243kbps, in contrast to its poor acceptability (ca. *60%* interpolated) at a comparable bit rate on the IPAQ. This is quite interesting as it suggests that people would rather watch football encoded at 243kbps on a smaller screen with a smaller resolution.

Weather was again acceptable to almost 100% at 111kbps. This can be explained by the absence of motion in the picture, in this clip the background of the video depicting the weather map is static during the duration of the clip. For all other types of content acceptability drops off sharply as the bandwidth drops below 111kbps.

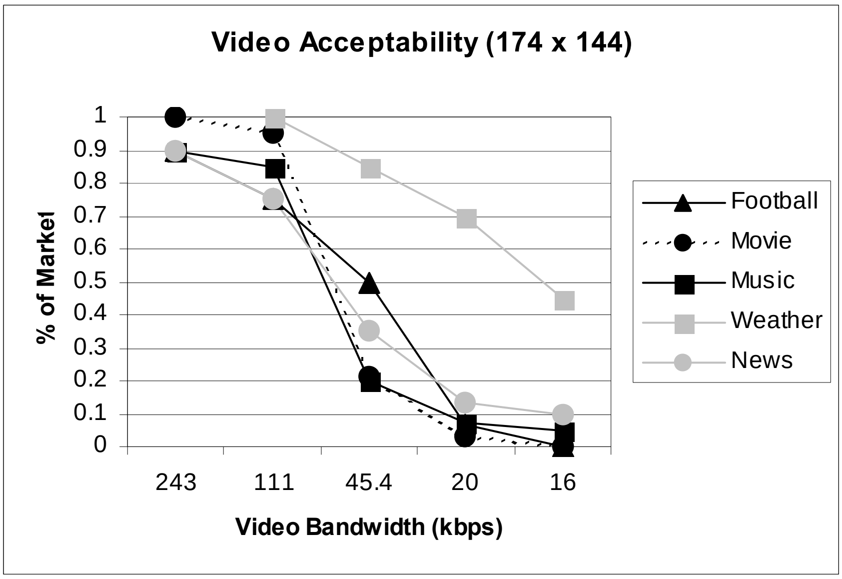


Figure 4 : Video acceptability of content types across bit rates on a 3G phone.

3.4.3 Audio Bandwidth Requirements

The clips encoded using Windows Media Encoder had a range of different audio bandwidths. User rating of audio acceptability at these different levels is illustrated in Figure 3. For 90% acceptability all service types require a bandwidth of at least 32kbps. The acceptability drops off sharply as the bandwidth devoted to audio drops below 32kbps.

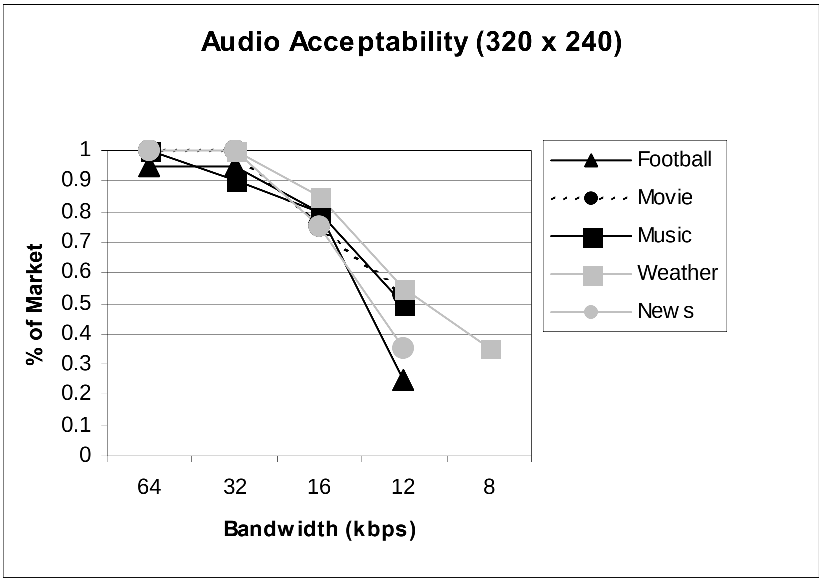


Figure 5 : Audio acceptability of of content types across bit rates on an IPAQ

For clips encoded using 3GPP MPEG-4, only two levels of audio bandwidth were encoded. The acceptability ratings for these are shown in Figure 4. On the phone, only News and Weather services are acceptable at 12.2.kbps. The other three services, Music, Movies and Football require a greater bit rate.

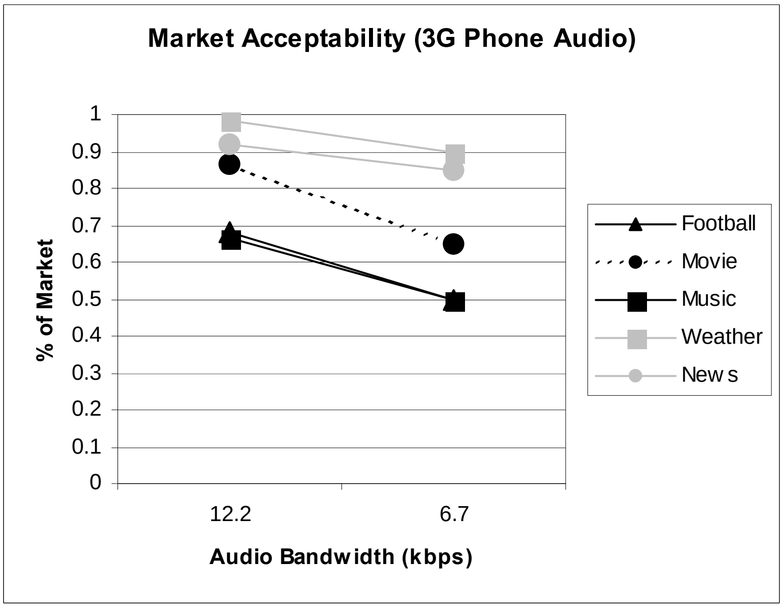


Figure 6: Audio acceptability of content types across bit rates on a 3G phone

3.4.4 Willingness to Pay

There is no correlation between users' existing spending on mobile services and the amount they are willing to pay for TV like services. Existing mobile service costs ranged between 10 and 60 Euros, and the average spend was €30/month. Willingness to pay varied between 1 and 30 Euros with an average value of €11/month. This coincides with other studies that suggest that people are willing to pay as much for mobile TV as for newspapers [9]. However, the value also coincides with current pricing of 3G TV services in the UK so it is possible that this value is more related to *what people think they would have to pay* rather than what they would actually pay.

3.5 Discussion.

The results of our study add to the growing weight of evidence [6,9] that News is the service most demanded by end-users. Further, it illustrates the substantially different bandwidth requirements for different types of service with News being one the most bandwidth efficient. There are a number of other factors that may contribute to users perception of acceptability beyond bandwidth alone. For example, the audio on the 3G phone clips was encoded at a very low bit rate. While this may be adequate for voice calls it is clearly below requirements for most of the content types we tested. It is also possible that although people rated audio and video separately, the low quality audio may have impacted on users rating of video. Other factors include the codec used and the quality and performace of the user equipment.

4 WHAT SIZE SCREEN SIZE?

4.1 CIF, QVGA, VGA….

A major decision for the Maestro service is what size display or screen to code for. The smaller the screen, the smaller the bandwidth and therefore more services or programs can be offered. Conversely, coding for larger screens may well offer users a better experience, even though the range of programs available would be more limited. In the bandwidth study two different screen sizes were evaluated – 320x 240 (QVGA) and 176x144 (QCIF). The larger screen size is representative of high-end phones coming onto the market now (2004). The smaller screen size is much more widely available.

4.2 Mega Pixel Displays in 2008?

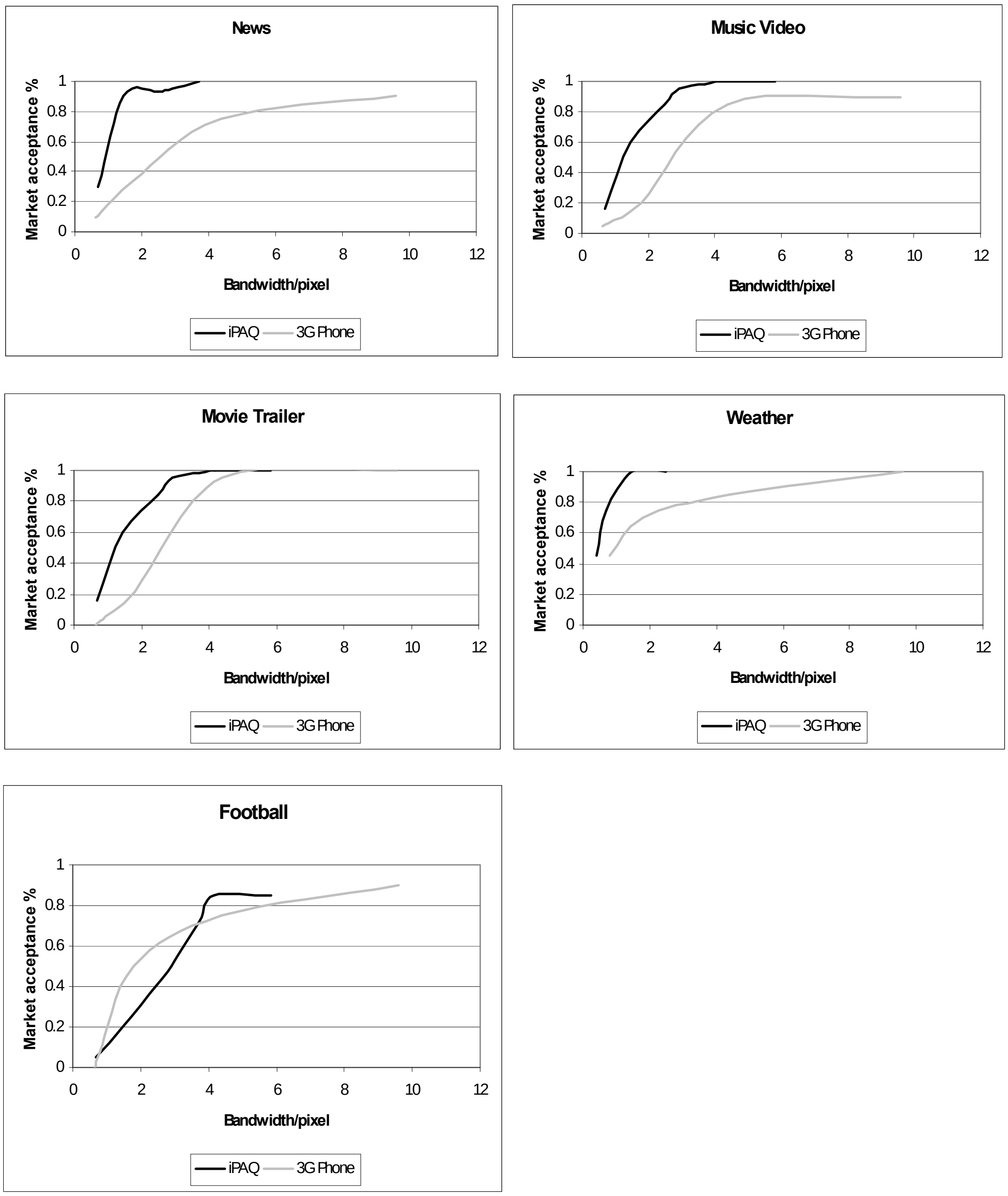
One question we can ask is what will the screen resolutions will be in 2008?

The main factor driving up screen size on mobile phones is the demand for high quality displays for both game and photographic content. Mega pixel cameras on the phone are appearing on the market now (2004) and we are confident they will be a standard feature by 2008. With this is mind it seems inevitable that mega pixel displays will also be fitted on the majority of phones. These considerations would suggest that content should be encoded at a minimum of 320x240.

4.3 Bandwidth Efficiency

A second question we can ask is what is the bandwidth efficiency of different display sizes?

An insight to this can be gleaned by rescaling the data from the bandwidth study for the different screen sizes. This data is shown in Figures X-X for the 5 different services we tested. The figures show market acceptance for different service types



plotted against the bandwidth/pixel used by the service. If we take a 90% market acceptance as the baseline, then for every service, the material viewed on the lar

Figure 7: Bandwidth Efficiency of Different Devices.

ger screen (ie. The iPAQ) requires less bandwidth/pixel than material seen on the 3G phone. This suggests that in terms of market acceptance the large display is more bandwidth efficient. This is another argument to design the service around a larger display size.

One explanation of this effect is that the increased number of pixels may compensate for degradations in image quality as a result of video compression. There are however, other explanations such as a better quality LCD display on the iPAQ so a definitive answer to the question of bandwidth efficiency would require another study comparing different display sizes on the same device.

5 DELAY TOLERANCE STUDY

Another factor influencing quality of service (QoS) are the delays experienced while using the service. In the context of SDMB two different types of delays are considered.

1. With real-time streaming of live or pre-recorded material a delay will be experienced when the user initially connects to the service.
2. With live material content interruptions during signal reception may mean that the content is not 100% received on the user equipment (UE). In the cases of incomplete transmission the user may experience a freezing of the video material for the duration of the missing material.

The aim of the delay tolerance study is to identify acceptability thresholds for different types of delay. In other words, what is that maximum connection or interruption delay that users will tolerate while still viewing the service as acceptable?

5.1.1 Participants

We randomly selected a group of twenty 19-30 year olds from a University Subject Pool to take part in the study. The mean age of the participants was 23. Each participant was paid €7.5 for participation.

5.1.2 Demand

To assess demand for different service types we presented users with the simple scenario below. The services were chosen to reflect a range of material that might be of interest to this target group. By recording which of the two services people chose we measured demand for the different service types.

SCENARIO: *Your mobile phone company offers a service to stream video to your mobile phone. The standard package allows you to choose two from the following services:*				
NEWS	**WEATHER**	**MOVIE TRAILERS**	**MUSIC VIDEOS**	**FOOTBALL**

To expand on this set of services we also asked participants to specify any other services they would like that were not part of this list.

5.2 Delays, Content and Encoding

As it wasn't clear, a priori, whether tolerance of delays and interruptions would interact with different types of content we tested two different groups with different types of content, a weather broadcast and a film trailer. Three short segments were extracted from each of these two source clips to provide content for the six different conditions tested.

Content	Description
Movie Trailer	Movie Trailer for the film "Coffee and Cigarettes"
Weather	BBC UK weather update

Table 4: Video clip description

These clips were encoded for display on the iPAQ PDA in Microsoft WMV format (using the *MS Media Encoder*) at a resolution of 320x240 pixels (maximum iPAQ resolution). Table 5 (below) shows the range of delays and service interruptions tested.

	Start-Up Delay		Service Interruption	
Content	**Total Start Up Delay**	**Service Interruption**	**Total Start Up Delay**	**Service Interruption**
Movie Trailer	5	-	5	0.3
	13	-	5	1
	23	-	5	2
Weather	5	-	5	0.3
	13	-	5	1
	23	-	5	2

Table 5: Start-Up delays and service interruptions

5.3 Description of subjective test

Participants were probed for three different ratings of the video services. These were (i) whether they found the service acceptable (ii) A rating of the overall quality of service and (iii) a rating of their satisfaction with the service.

Each user was given a sheet was given a sheet with the following information:

The project aims to investigate the ffects of delay and interruptio to digital TV based services on hand held mobile devices. We will stream some video for you to view on the mobile device and have altered levels of service ralting to the delay and interruption to TV based services. We would like you to express how satisfied you were with the service for each clip.

5.3.1 Willingness to Pay

We assessed users willingness to pay *after* they had experienced the different service on both the iPAQ and 3G phone. The issue was addressed with the following three questions.

Q1 : *Approximately how much are you paying for your current mobile service / month ?*

Q2 : *How much extra would you pay for the TV services you have just seen (assuming the highest quality) ?*

Q3: *What is MAXIMUM amount you would SERIOUSLY be willing to pay /month for such a service? (Please circle one of the following)*

£1.00/month

£2.50/month

£5.00/month

£7.50/month

£10.00/month

£15:00/month

5.3.2 Service Use

Although very difficult to assess without a live field trial we attempted to get an indication of how often and how long people thought they might use the SDMB service for. This was done via a questionnaire.

5.3.3 Service Preference

We also guaged demand for different service types (*Live* vs *Push and Store*) with the following question:-

Q8 : **Which of the two service scenarios below would you prefer?**

Scenario A

On the Mobile TV service you can watch live TV on your mobile device. The service gives access to 5 live TV channels (.e.g BBC1, ITV1, E4, etc..)

Scenario B

On the mobile TV service you can watch TV clips that have been downloaded and stored on your mobile. You can select the types of clips you want to receive. Your device receives and stores around 4 hours of TV/day. Services like News are automatically updated every hour.

Q9: **Please explain why you chose that scenario?**

5.4 Results

5.4.1 Demand

The popularity of different types of services is presented in Table 5. News Music and Movie trailers were the most popular content. The main change from the results of the bandwidth study was an increased demand for Movie Trailers and a decreased demand for News. We attribute this to the (very humorous) Movie Trailer content used in this study that may have enhanced demand for this type of content. The demand for other content types (e.g. Music, Weather and Football) is at comparable levels to the previous study. Of the other types of service people cited the most popular request was for games, general sports content and soaps.

	News	Music	Movie	Weather	Football
Market % Demanding this Content Type	53	53	53	26	16

Table 6: Demand for different service types.

5.4.2 Video Delay and Interruptions

The participants were very tolerant to different start up delays in the service. There was no significant difference between acceptability of 5, 13 and 23 second delays. Around 90% of the people tested found all three levels of delay acceptable (See Table 7). The average service ratings for these three delays where between Fair and Good and the average satisfaction was between Slightly Satisfied and Satisfied.

The results for service interruptions are presented in Table 8. Participants seem reasonable tolerant to interruptions of up to a second in the service. But between 1 and 2 seconds there is a dramatic drop in acceptability.

		Start-up Delay (secs)		
		5	**13**	**23**
Acceptability		89%	100%	95%
Service Rating	***Excellent***	16%	11%	5%
	Good	47%	47%	47%
	Fair	26%	42%	37%
	Poor	-	-	11%
	Bad	11%	-	-
Satisfaction	***Very Satisfied***	-	5%	5%
	Satisfied	74%	63%	53%
	Slightly Satisfied	16%	32%	37%
	Dissatisfied	5%	-	5%
	Very Dissatisfied	5%	-	

Table 7: Ratings for service start-up delays.

		Service Interruptions (Secs)		
		0.3	**1**	**2**
Acceptability		.89	.84	.47
Service Rating	***Excellent***	5%	5%	-
	Good	32%	26%	11%
	Fair	47%	53%	42%
	Poor	16%	11%	42%
	Bad	-	5%	5%
Satisfaction	***Very Satisfied***	5%	11%	-
	Satisfied	32%	32%	5%
	Slightly Satisfied	47%	42%	58%
	Dissatisfied	11%	16%	37%
	Very Dissatisfied	5%	-	-

Table 8: Ratings for service interruptions.

5.4.3 Willingness to Pay

As before there was no correlation between users existing spending on mobile services and the amount they are willing to pay for TV like services. Existing mobile costs averaged €28. The amount they said they were willing to spend per month was €11.5/month. However, when asked to seriously consider the maximum they would be willing to pay this figure dropped to €10/month.

5.4.4 Service Use

When asked about use of the service most people said they would use it 1-2 times /day for between 5 and 15 minutes each time.

		Duration each time			
		< 5 mins	5-15 mins	15-30 mins	
Frequency	Less than once/day	-	16%	-	-
	1-2 times/day	16%	47%	5%	-
	2-4 times/day	-	16%	-	-
		-	-	-	-

6 INTERACTION PARADIGMS

6.1 Introduction

This section explains the design considerations for the demonstrator which will emulate the service of the Satellite Digital Multimedia Broadcast (SDMB) system.

The SDMB service assumes the use of mobile phones with extensive storage that allows the consumption of previously cached content at opportune times as well as watching live streams and receiving alerts.

The design of the interface of this service has to take into account how people use their mobile phones, how and why they watch regular television, how that differs from interactive television consumption behaviour, the requirements of the different content types, the technical restrictions due to the SDMB design, users and their needs, and last but not least, possible interactions of these factors. We will address these in turn and will then justify our design decisions based on the presented findings.

6.2 Traditional TV Consumption

Television consumption generally takes place at home. Watching television is a generally a *"lean back"* activity where an audience passively consumes broadcast content. Remote controls facilitate hopping through parallel channels of sequential content - an opportunistic search for content to satisfy a viewer's moods and mindsets. When in a group, however, the decision of what to watch is a contentious one. According to a survey, 9 in 10 families say they regularly disagree over what to watch [2].

People watch television for social and psychological reasons. On the social side people value the time they are collocated with friends or family and enjoy a communal experience. At the same time this promotes negotiation of perception and cognition of reality. For example, people reported that *live* content, e.g., a football match is something that they would rather experience in a group than by themselves. Broadcast live content on mobile phones would represent only a back up for conventional viewing [3].

Mood management is one of the major psychological drivers for watching television. If people are bored they choose excitatory or arousing content, if they are stressed they prefer relaxing content [4].

We also see higher commitment viewing with favourite shows, programs that people plan for ahead of time, and shows that viewers have to pay for on a per-use basis. During these shows people are less open to outside interruptions. Low commitment viewing on the other hand exhibits more channel hopping, competes with many other demands and activities within the home, and might be just a background activity.

For the context of our work we consider the following to be the defining characteristics of standard television:

- Instant on – Once you turn on the TV you receive content immediately.
- Continuous - Channels show content continusouly
- Easy switch - The cost of switching to a different channel is low especially with a remote control that overcomes seat inertia
- Seamless switch - The switch to a parallel channel is more or less instantaneous
- Graceful transitions - Due to the way TV is being programmed the transitions from program that has just ended to the next program are smooth as broadcasters try to keep their viewers
- No spatial overlap - Channel navigation does not spatially overlap with the content
- No functional overlap – Television sets are dedicated to their purpose and can be used in parallel with many other appliances.

In a study on digital television Eronen and Vuorimaa found that users who were interested in watching television were not interested in interacting with an EPG or interactive television. The authors emphasized that digital television should maintain the familiar living room TV experience [5].

6.3 Mobile Phones and Mobile TV

The usage of mobile phones evolves around the three general user areas of home, work, and public [6]. The mobile phone has transcended its original role as a means of communication by now serving a multitude of purposes. It has brought about new social norms and behaviours, e.g. emergent phenomena in young adults' socializing patterns. A mobile phone is not only a highly personal tool that many feel dependent on, but also many aspects of being with and being apart from others evolve around it. Its main usage is to stay in touch with friends and family and to be able to synchronize with them across space and time. The perceived threats to this need are the inherent high cost, imperfect coverage, and short battery life [3]. To many, usage of mobile phones does not necessarily imply being on the move but constitutes a means of communication that is ready at hand.

With phones capable of displaying multimedia (AV) content and 3G networks capable of delivery, mobile multimedia consumption has become a reality. With current services videos are usually accessed through *galleries* that include a thumbnail and a title describing the content as depicted in Figure 8. The typical question that arises after a clip has finished playing is: What next? Whereas traditional impromptu television choices are based on the content and the point of entry into the content, the consumption of downloaded or video on demand requires more user interaction and decisions. There is no opportunity for channel hopping as with standard TV and the naming of items in an EPG exerts a strong influence on user choice. Thus, if an item is renamed with certain 'key' words, e.g., forbidden, explicit, illicit, and sex, then frequency of download can be dramatically increased [7].

Figure 8: 3G phone video clip gallery

Being mobile consists of activity spurts that are interleaved with periods of dead or unstructured time. We anticipate low commitment viewing to be the more dominant consumption pattern on a mobile device because of the strong influence of the environment, the fact that attention might compete with other possibly more important needs while being mobile, and last not least the functional overlap with users' means of communication. Previous research has shown that peoples' average [8] usage of mobile TV during these periods is less than ten minutes long. This is similar to our own findings – predicting useage between 5-15 minutes/day. This short use time has ramifications both on the type of content and the way that people will consume it. Longer programs will be more appealing to people that experience extensive dead times for example long commuters [3].

People are worried about being absorbed by multimedia content, which requires their visual attention and is progressing at its own pace continuously. They fear increased risks of accidents or lapses (e.g. missing train stops) [3]. Furthermore, many people are wary about the effect their mobile phone usage, i.e. talking aloud, has on others in public spaces. For these users, multimedia consumption requires the use of headphones, which might further immerse them.

Despite marketing efforts to the contrary, we are convinced that watching TV on a phone will be a serial - solitary activity for the most part. This is not only based on the fact that current screens and their viewing angles are not very conducive to group viewing, as viewers have to move uncomfortably close together [8], but also on the more fundamental fact that the mobile phone is a personal device. Its use is tied into its bearer's needs of staying in touch and being in control which requires exclusive control over the handset.

It is not clear yet how the television brands, i.e. channels like CNN and BBC etc., will carry over to mobile television but current research suggests that a channel centric consumption will prevail for some time over genre or category-centric channels (e.g. the channel of all news programs) [8].

6.4 Evaluation of TV usage

Traditional HCI research involves task-oriented approaches where participants interact with an application in pursuit of a particular goal. We believe that the concepts conceived to measure productive environments are inappropriate for evaluating the pleasure of watching television in a mobile setting, since they do not consider established television watching behaviour, as described in [9], [10], [11], [12], [13].

We believe that measuring affective usability as conducted in [14] would bear more insight into how much people would like following content on the suggested interface.

Effectiveness and efficiency of different video skipping approaches in digital television have been studied in [15]. However, this research addressed full size television screens and devices with a considerable amount of computational power. The tasks were commercial skipping and finding the weather information within a news broadcast.

Not much work has been published on effective browsing methods for consumers of digital television content. The research so far has mainly dealt with the problem on the basis of tasks as, e.g., skimming video [16] and overall gist determination and information seeking [17]. A lot of work on video surrogates in desktop environments addresses browsing and skipping of video content but generally is also task based. Typically these approaches do not assume the video stream to be chunked into content items but rather try to automatically perform this chunking into meaningful parts.

7 THE SDMB INTERFACE DESIGN

We believe that the cost in terms of cognitive overhead and decision-making process in having to choose the next clip in current multimedia interfaces, which is partly due to the payment model, is a major inhibitor of a flow experience of multimedia content - in some respects similar to watching television without a remote control.

We advocate a user interface paradigm for the mobile consumption of TV channels that is based on content items as originally conceived by [18], which make up part of a program. As with traditional TV the programs are serially aligned in channels, which can be accessed through tabs as depicted in Figure 9.

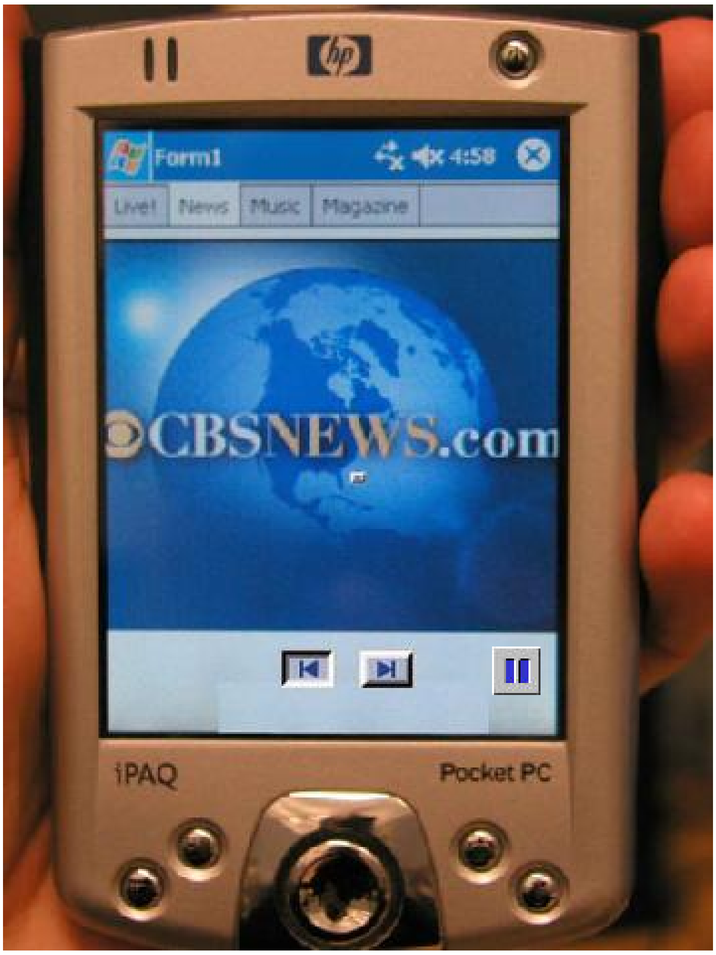


Figure 9: Mobile television demonstrator with channel tabs, pause and skip buttons

7.1 On

We think that a mobile TV should behave like an ordinary TV. When turned on, it starts playing content that may or may not be of interest to the user. If the user does not interact with the mobile TV software it will continue showing content until it has run out of new content and will then loop back to the first program again. The only limitation to continuous playback should be aguarantee that sufficient battery Is left to make calls or perform other functions from the device.

We are not advocating the abolishment of an electronic program guide (EPG), which constitutes a valuable instrument in content navigation [8] and in fact is a tab/channel in our navigational approach. But we are not convinced that an EPG is a good entry point into a mobile TV service. Like some television sets the user interface remembers the channel that was used last. For example when turned on we can automatically resume with the news channel.

7.2 Hop

The envisaged use of mobile television is usually dead or unstructured time. Therefore, we expect users to exhibit low commitment viewing while being in public spaces. If the user is not interested in a channel or program he can switch or hop to a different channel by a single press of a button or by selecting its channel tab on the screen.

If the user wants to engage into more complicated navigational methods on the search for content a separate tab that functions like a menu [8] will give access to the archive, the EPG, and further services.

This interface also allows for more habit formation [19] in contrast to lists displaying video clips, which differ everyday or possibly every time a user browses them.

In terms of interactivity we think that less is more for mobile TV consumption.

7.3 Skip

In other studies users had voiced their desire for indexed programs that would allow them to skip to interesting parts or scenes [8]. We include this functionality. If the user is not interested in a content item but wants to keep watching other items within the same program he can skip to the next content item.

A ‘double-skip’ meaning two fast successive button presses will be interpreted as a skip of the program and the service will continue with the next program within the same channel.

7.4 Stop

Time-shifted viewing as promoted in hard disk based video recorders will be possible by means of a pause button. If for any reason, e.g., to get on a bus the user needs to pause the program at its current position the user can press the pause button. For incoming calls the presentation of the content will be automatically paused and the user confronted with the question whether to accept or reject the call.

7.5 Content

For the majority of users the window of opportunity for mobile TV consumption is short and the interface should allow users to select the content in a TV anytime fashion [8], i.e., from the beginning and neither with major technically induced delays nor a lengthy task of accessing the content.

7.6 Summary

We have presented a design for the SDMB interface, which draws from previous research on television watching behaviour and its psychology, mobile phone usage, and mobile multimedia consumption.

The SDMB interface aims at port many of the standard television characteristics to the mobile phone as long as peoples' communication needs are not compromised especially in terms of battery life. We believe that a television service that starts presenting content immediately on start up, lets users hop channels, skip boring parts and pause the content if necessary is an essential approach to watching audiovisual content while on the move.

APPENDIX A – VIDEO AND AUDIO ENCODING PARAMETERS

Appendix A gives details of the video and audio encoding parameters used in the bandwidth study. The parameters are presented in two tables. Table 1 shows the video and audio encoding for clips shown on the iPAQ. Table 2 shows parameters for clips encoded on the 3G phone.

Name	Bitrate	Audio (WM Audio)	Video (WM Video)
Movie	64 Kbps	12Kbps	52 Kbps, 10fps
music clip	128 Kbps	16 Kbps	112 Kbps, 15fps
	256 Kbps	32 Kbps	224 Kbps, 25 fps
	384 Kbps	64 Kbps	320 Kbps, 25 fps
	512 Kbps	64 Kbps	448 Kbps, 25 fps
music clip	64 Kbps	12Kbps	52 Kbps, 10fps
	128 Kbps	16 Kbps	112 Kbps, 15fps
	256 Kbps	32 Kbps	224 Kbps, 25 fps
	384 Kbps	64 Kbps	320 Kbps, 25 fps
	512 Kbps	64 Kbps	448 Kbps, 25 fps
Football	64 Kbps	12Kbps	52 Kbps, 10fps
	128 Kbps	16 Kbps	112 Kbps, 15fps
	256 Kbps	32 Kbps	224 Kbps, 25 fps
	384 Kbps	64 Kbps	320 Kbps, 25 fps
	512 Kbps	64 Kbps	448 Kbps, 25 fps
News	64Kbps	12 Kbps	52 Kbps, 10 fps
	128Kbps	16 Kbps	112 Kbps, 15 fps
	256Kbps	32 Kbps	224 Kbps, 25 fps
	350Kbps	64 Kbps	285 Kbps, 30 fps
Weather	40 Kbps	8 Kbps	32 Kbps, 6 fps
	64 Kbps	12 Kbps	52 Kbps, 7.5 fps
	128 Kbps	16 Kbps	112 Kbps, 15 fps
	220 Kbps	32 Kbps	190 Kbps, 25 fps

Table 9: Encoding parameters (Microsoft Media for iPAQ)

Table 2 (below) shows the encoding parameters for content evaluated on the NEC 3G phone.

Name	Bitrate	Audio (GSM AMR)	Video (PV MP4)
Movie	28 Kbps	6.7 Kbps	16 Kbps, 6 fps
	64 Kbps	12.2 Kbps	45.4 Kbps, 10 fps
	128 Kbps	12.2 Kbps	111 Kbps, 15 fps
	256 Kbps	12.2 Kbps	243 Kbps, 25 fps
music clip	28 Kbps	6.7 Kbps	16 Kbps, 6 fps
	64 Kbps	12.2 Kbps	45.4 Kbps, 10 fps
	128 Kbps	12.2 Kbps	11 Kbps, 15 fps
	256 Kbps	12.2 Kbps	243 Kbps, 25 fps
Football	28 Kbps	6.7 Kbps	16 Kbps, 6 fps
	64 Kbps	12.2 Kbps	45.4 Kbps, 10 fps
	128 Kbps	12.2 Kbps	11 Kbps, 15 fps
	256 Kbps	12.2 Kbps	243 Kbps, 25 fps
News	28 Kbps	6.7 Kbps	16 Kbps, 6 fps
	64 Kbps	12.2 Kbps	45.4 Kbps, 10 fps
	128 Kbps	12.2 Kbps	11 Kbps, 15 fps
	256 Kbps	12.2 Kbps	243 Kbps, 25 fps
Weather	28 Kbps	6.7 Kbps	16 Kbps, 5 fps
	40 Kbps	12.2 Kbps	20 Kbps, 7.5 fps
	64 Kbps	12.2 Kbps	45.4 Kbps, 12.5 fps
	128 Kbps	12.2 Kbps	110 Kbps, 25 fps

Table 10: Encoding parameters (3GP for iPAQ)