UMTS for all
Quality of Service Issues

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Abstract:

How can mobile applications, communications protocols, network topologies and service architecture be specified, designed and implemented so that they compromise robustness, security, fault tolerance with efficient use of the available bandwidth? How can networks be cost-effectively dimensioned and the resources that are available be rationed so that an acceptable Quality of Service (QoS) is available for all users?

These two questions summarise the complexity to determine an objective estimation of an acceptable quality of a particular service. In addition, a typical user is not concerned with how this service is provided, or with any of the aspects of the network's internal design, but only with the resulting end-to-end service quality. The degree of satisfaction is generally expressed by the user in a non-technical language. It may be appropriate to express it in a more fuzzy way and to examine the requirements of applications overall and include the subjective opinions of the user.

The ITU series of recommendations E.750 provide methods for traffic engineering. However, to achieve its objectives, it is necessary to consider the effect of the human factor in real conditions.

This document proposes a methodological approach to determine the user traffic demand and QoS parameters with user perception significance.

Results from objective and subjective analyses are then confronted in order to determine thresholds of acceptability of a service under known conditions.

This methodology is applied here to a case study of video telephony for sign language. The same approach can be re-used for the assessment of other communication services. An initial static phase aims to assess the performance of the compression and the transmission channel. The second phase aims to determine the impact of the transmission channel on the user perception.

For the case study, three compression techniques have been considered: H261, H263 and MPEG4. Channel measurements will be done on a single slot GSM channel via a PSTN and an ISDN line, where the conditions are known. Effective bandwidth can be extrapolated from these measurements to determine the total capacity required (number of slots) for the various compression techniques analysed.

This work is planned within the UMPTIDUPTI project until June 98. At this stage, none of the given values in the results tables and charts have been verified. They are only intended to provide an example of representation and cannot therefore be used as scientific basis.

1. OVERALL UMPTIDUMPTI PROJECT

1.1 Role of UMPTIDUMPTI within ACTS

Part of the *application components HCI* within the ACTS chart, UMPTIDUMPTI aims to verify that the emerging broadband and mobile services and equipment are usable by all, in particular People with special Needs (PSN).

1.2 Objectives

1. proposals for meeting user requirements, usability, non-conventional uses supporting social integration;
2. specify interfaces;
3. develop applications and services;
4. demonstrate applications in a networked environment;
5. validate in user trials;
6. input to standards bodies

1.3 Technical Approach

To achieve these objectives, the workplan is organised around three main activities:

1. Telecommunication networks and interfaces
2. Application and services
3. Trials

Trials aim to demonstrate the optimisation to the mobile environment of existing and new applications for PSN and validate their use for a range of impairments. Three series of trials have been planned (96, 97, 98), with mobile communication infrastructure procured through National Host.

From the networking point of view, innovative use of services and protocols in wireless mobile networks will drive the standardisation of UMTS, focusing on common service specifications and application programming interfaces.

1.4 Key Issues

1.4.1 Multimedia

The provision of applications containing text, audio and video as well as conversion between these media and representations optimised for special needs;

1.4.2 Quality of service

Particularly critical in mobile network, especially when considering interworking with other networks.

1.4.3 Security

The authentication of called and calling parties by means appropriate to special needs;

1.4.4 Interfaces

Service specifications in view of eventual integration to UMTS platform, protocols, especially for data transfer, application programming interface, ergonomics of terminal design;

1.4.5 Value-added services

Special applications, or assistance provided by third parties, to improve quality of life for special needs;

2. BACKGROUND

2.1 Definition of QoS

QoS is defined by the ITU-T **[E.800]** as follows:

> *"The collective effect of service performance which determines the degree of satisfaction of a user of the service".*

A typical user is not concerned with how a particular service is provided, or with any of the aspects of the network's internal design, but only with the resulting end-to-end service quality. The degree of satisfaction is generally expressed by the user in a non-technical language.

2.2 Determinant factors of QoS

The ETSI Technical Report **[ETR003]** gives an overview of the factors that affect the QoS as perceived by the user. For a mobile service, (often slow) *call set up delay*, *probability of blocking* and the *effective bandwidth* are the most relevant factors of QoS.

2.2.1 Call set up delay

The call set up delay can be defined as the time interval from the instant the user initiate a connection request until the complete message indicating call disposition is received by the calling terminal.

The call set up delay comprises the post-selection delay (authentication, transfer of routing number, etc.) **[E.771]** and the synchronisation delays of the interworking elements of the network.

The exchange of *signalling* between the mobile terminal and the infrastructure

In the case of GSM, the post-selection delay is usually less than 5 seconds, but acceptable system synchronisation delays of the interworking elements for data calls via PSTN are difficult to achieve. Solutions with ISDN seem more adequate to the GSM protocol architecture.

2.2.2 Probability of blocking

The lack of network resources at the user plane as well as the control plane can cause unsuccessful call attempts. The probability of end-to-end blocking can occur at the radio link, at the interworking units between the mobile and the fixed networks or at the transit network.

2.2.3 Effective bandwidth

The concept of effective bandwidth has been developed by several authors **[4]** over recent years to provide a measure of resource usage which adequately represents the trade-off between sources of different types, taking account of their varying statistical characteristics and the QoS requirements.

However, there is not yet a generally accepted definition of an effective bandwidth.

The *quality of the radio link* could be improved by the operator in increasing the cell density, although intrinsic system limits (radio spectrum, signalling speed, etc.) increase the planning complexity when the traffic increases dynamically. Moreover, additional operational cost and extension of licence are the main preoccupation of the mobile operators.

3. Methodology for the assesment of the QoS

As shown on the figure below, the methodological approach for the assessment of the QoS consists of objective and subjective analyses for which results are confronted in order to determine thresholds of acceptability of a service under known conditions.

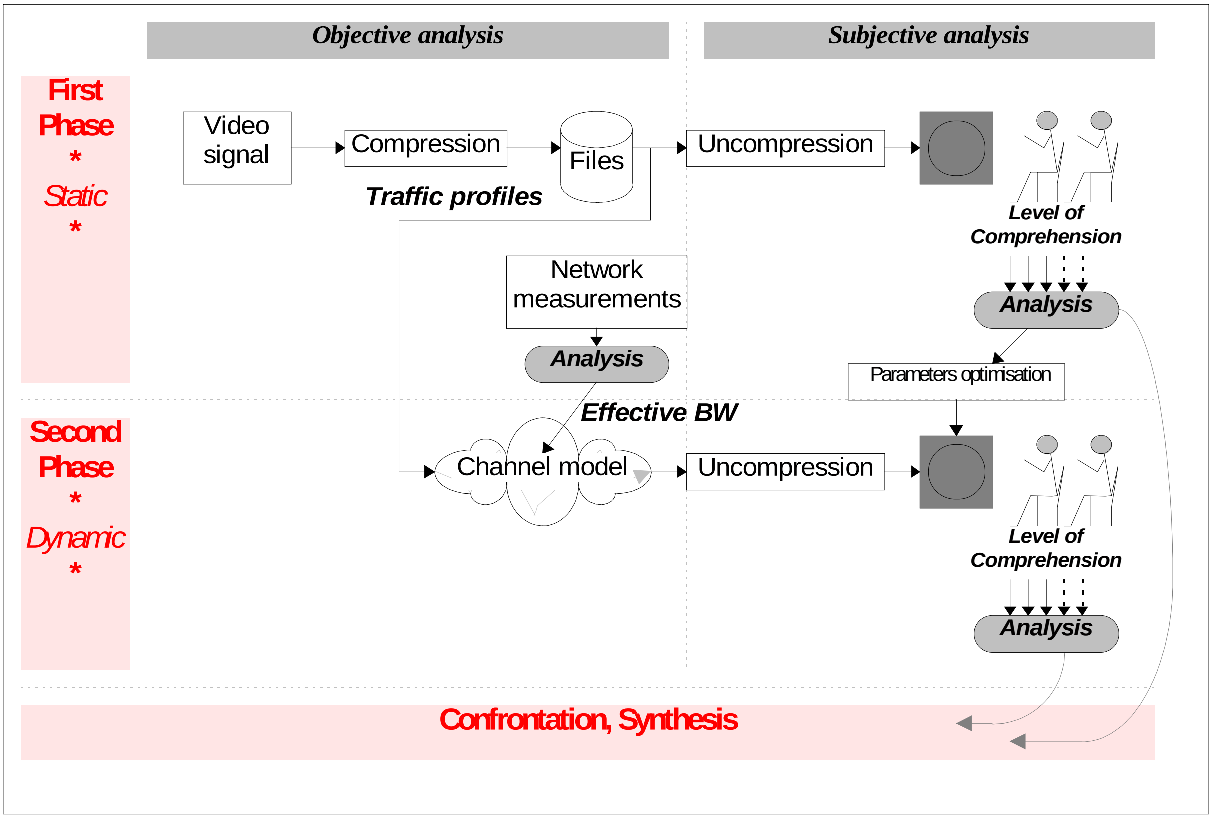
The **objective analysis** is intending to determine *traffic profiles* by evaluating encoding techniques and to determine *effective bandwidth* by evaluating transmission protocols.

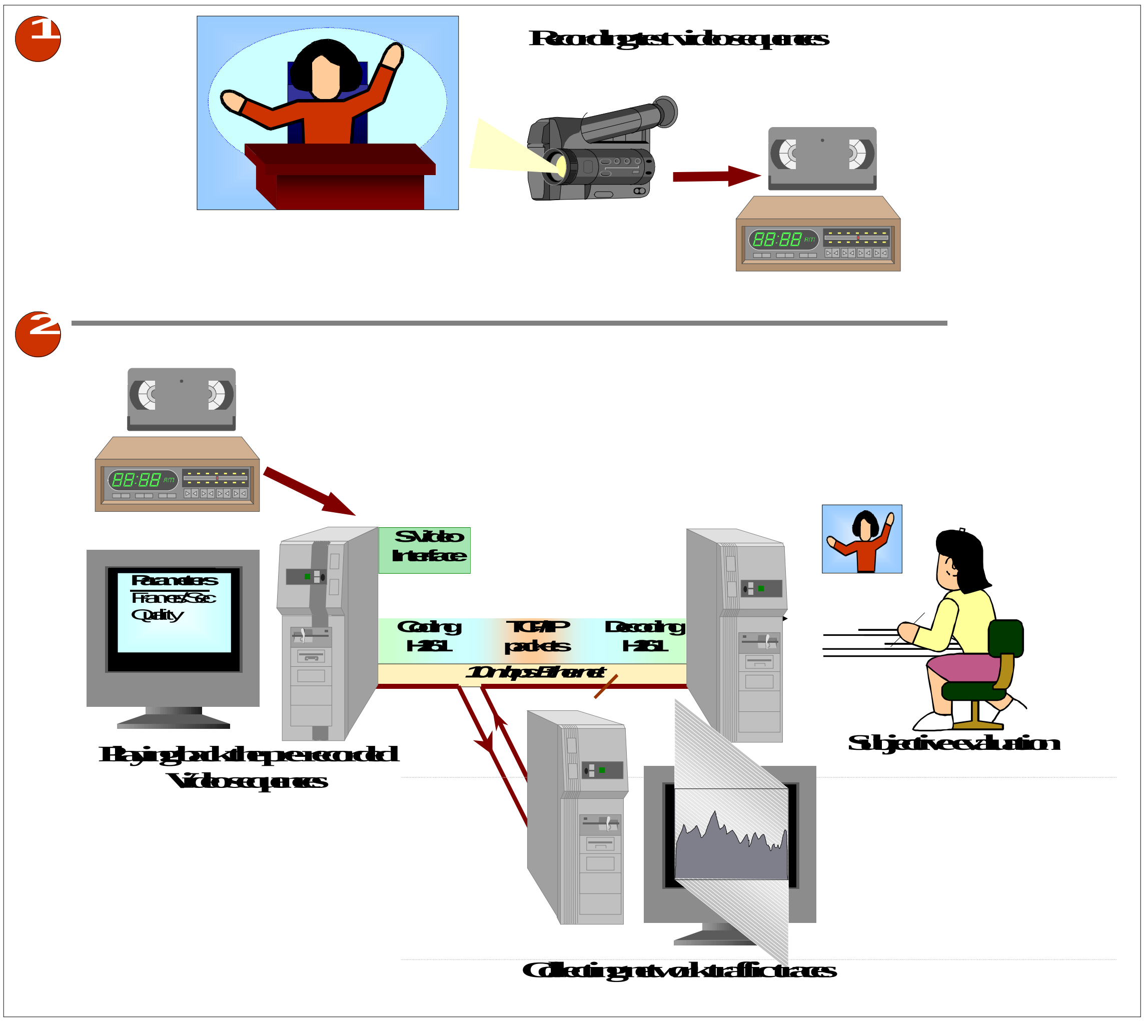
The **subjective analysis** is intending to determine the *level of comprehension* and/or *degree of satisfaction* of the service.

This methodology is applied to a case study: video telephony for sign language. The same approach can be re-used for the assessment of other communication services.

This example is treated in two phases of measurements:

- The **first phase** (static analysis) aims to determine the optimum format of the video picture and the optimal value of the parameters of compression, in order to keep the need of bandwidth as low as possible and facilitate the implementation of the user interface into a mobile terminal, while maintaining an acceptable level of comprehension of the sign language.
- The **second phase** (dynamic analysis) aims to determine the effects of the transmission channel on the quality of the video signal.




1
Recording test video sequences
2
SVideo
Interface
Parameters
Frames/Sec
Quality
Coding
H261
TCP/IP
packets
Decoding
H261
10mbps Ethernet
Playing back the pre-recorded
Video sequences
Subjective evaluation
Collecting network traffic traces

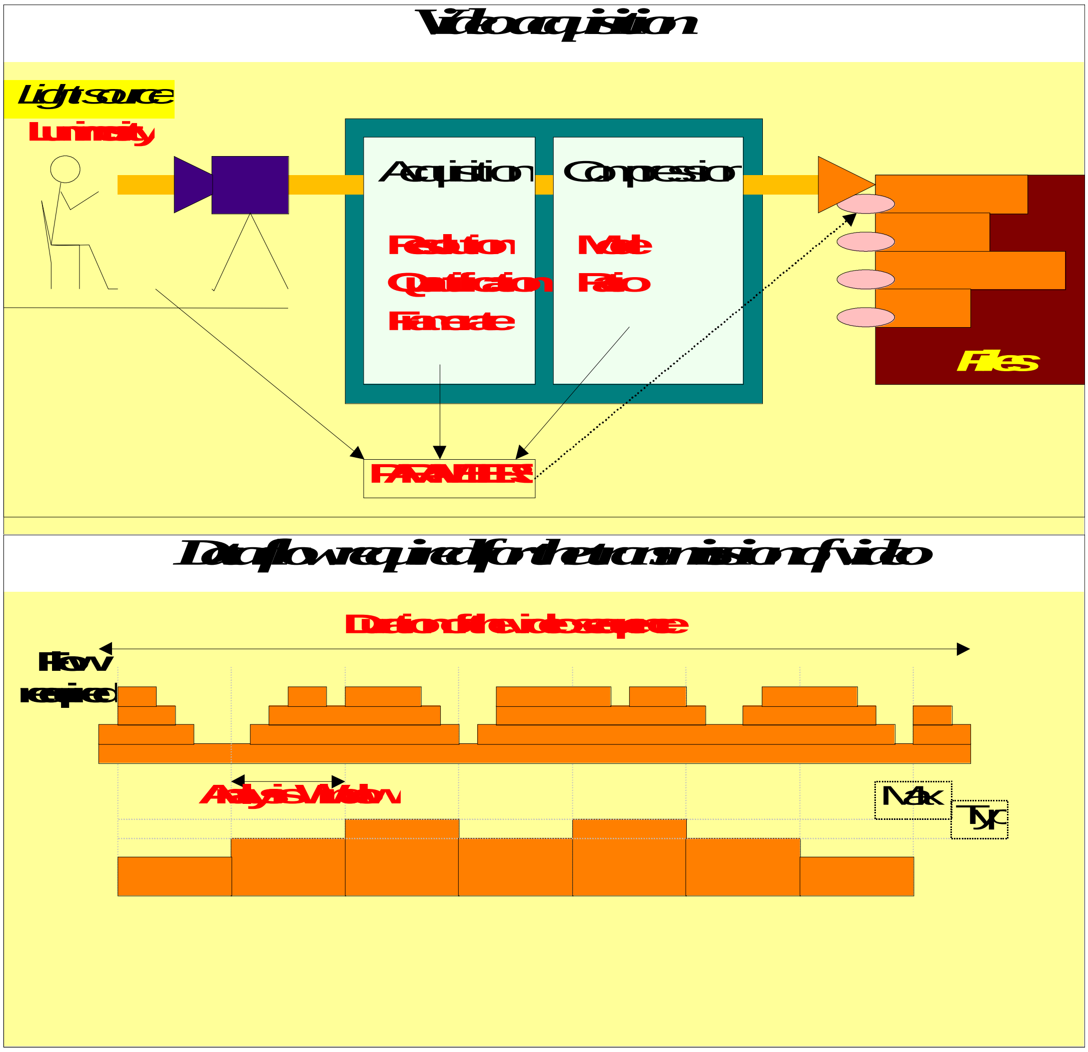
4. TRAFFIC PROFILES

This measurements aim to determine the profile of the encoded user traffic with various parameters settings.

For the case study of video telephony for sign language, these parameters are related to the video format (resolution, quantification, frame rate) and the compression technique (mode, compression ratio).

Several sequences of approximately ten second are recorded and stored into files. A parameter file is associated to each of the video file.

The figure below depict the procedure of acquisition, storage and analysis of these video sequences.



5. EFFECTIVE BANDWITH PERFORMANCE EVALUATION PROCEDURE

5.1 Objective

According to the methodology of the previous section, this section proposes an evaluation procedure to determine the profile of the effective bandwidth at the application level.

5.2 Test bed

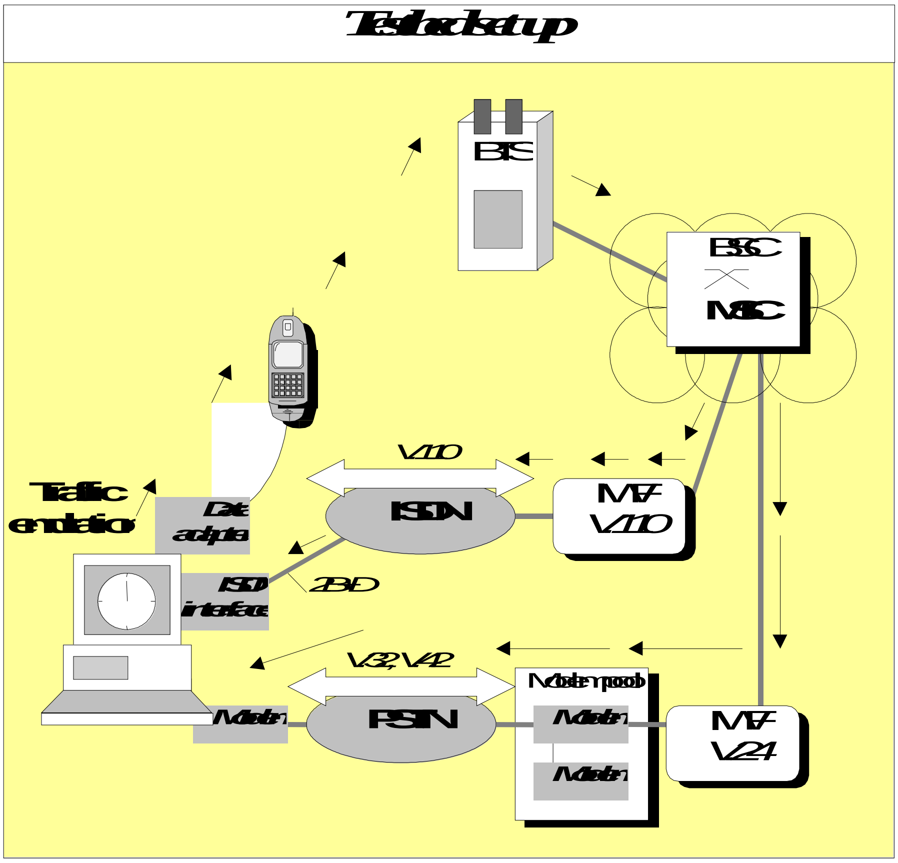
This procedure is tested in a GSM test bed.

As described in **[6]**, GSM specifies two modes of asynchronous bearer services: transparent and non-transparent. The transparent mode of transmission is derived from the ISDN specifications, primarily from V.110. The throughput is constant and the transmission delay is fixed. The non-transparent mode uses a derivative of the HDLC protocol: the RLP protocol which includes error correction mechanism. The throughput is variable as well as transmission delays.

The structure of communication test bed is represented in the figure below.

In these experiments, the fixed end connection is either PSTN or ISDN. The PSTN transmission requires a pair of modems (V.32bis, V.42bis), one controlled by the IWF, the other is directly to the fixed end terminal.

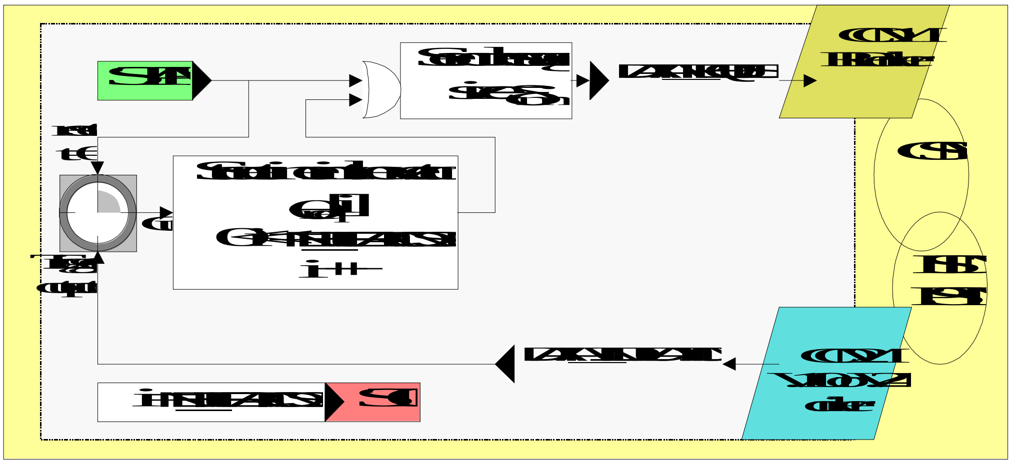
A terminal PC laptop acts as a traffic emulator. Non-transparent transmission mode is selected. Given the very low residual error rate of the RLP (10^{-8}) after correction, no transmission error is assumed during the test sequence.



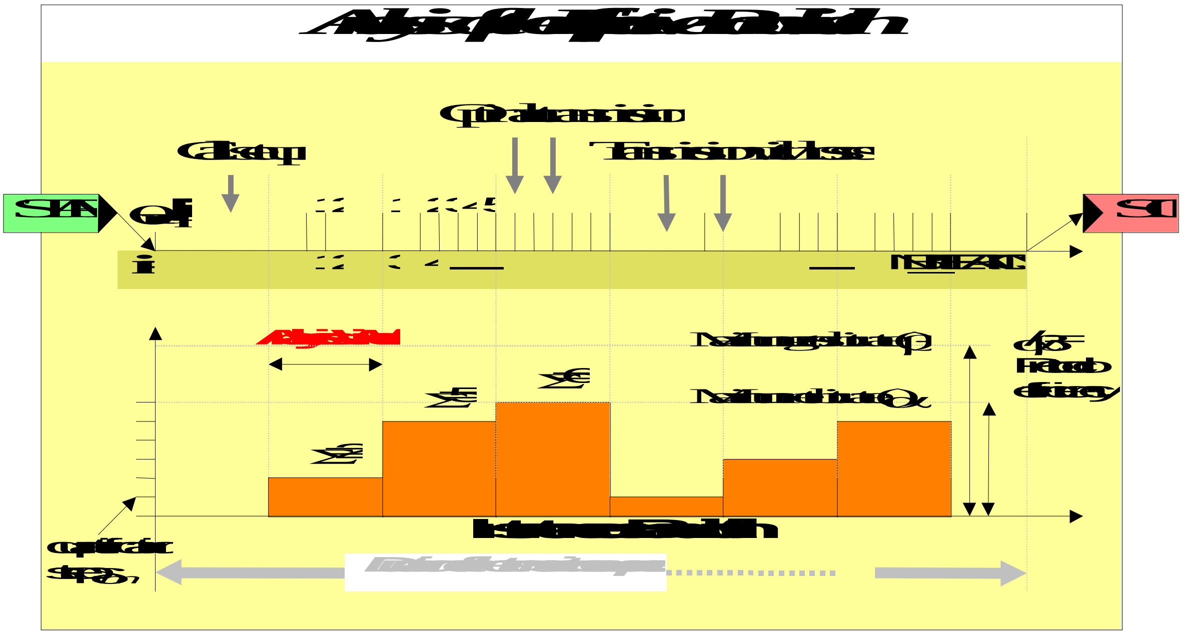
5.3 Traffic emulation

As shown below, a simple traffic generator is implemented into the client terminal. For the present evaluation, `DATA_REQUEST` (messages of constant size δ_m) is triggered at the initialisation and when the signal `DATA_INDICATION` is active.

Each request time is stored in a vector $\theta_{req}[i]$. The transmission stops when the number of iteration requested NB_ITERATION is reached which is also the size of the vector $\theta_{req}[i]$.



The analysis of $\theta_{req}[i]$ will allow to determine the instantaneous effective bandwidth at the application layer. A possible representation of this analysis is shown on the figure below:



6. SUBJECTIVE ANALYSIS

6.1 First phase: Static evaluation

As described in the section *methodology*, this evaluation aims to determine the optimal value of the parameters in order to keep the need of bandwidth, while maintaining an acceptable level of quality.

The results are presented here in fuzzy matrices with three different degree of satisfaction and three different level of comprehension have been chosen arbitrarily:

- BAD,
- MEDIUM,
- GOOD

for the degree of satisfaction

- <75%
- 75-90%
- >905

for the level of comprehension

Two other columns are used to indicate the AVERAGE FLOW and PEAK FLOW of data required.

Each row corresponds to a particular setting of parameters:

- *S*: SCREEN SIZE (cm) 4x4 to 15x15
- *R*: RESOLUTION (pixel per cm) 50 to 200
- *Q*: QUANTIFICATION (bits) 4 - 24 bits
- *FR:* FRAME RATE (per sec) 7 to 15
- *CM:* COMPRESSION MODE MJPEG, H261, H263, MPEG4
- *CR:* COMPRESSION RATIO 1 to 0.01

		Degree of satisfaction			***Level of comprehension***			***Data flow required***	
		BAD	**MED.**	**GOOD**	**<75%**	**75-90%**	**>90%**	**AVERAGE**	**PEAK**
S= variable > R= max Q= max FR= max CM= MJEG CR= max	4x4 6x6 ...	60 % 40 % ...	35 % 50 % ...	5 % 10 % ...	40 % 30 % ...	55 % 65 % ...	5 % 5 % ...	150 kb/s 210 kb/s ...	180 kb/s 250 kb/s ...
S= average **R= variable >** Q= max FR= max CM= MJPEG CR= max	50 100 150 ...	80 % 65 % ...	20 % 33 % ...	0 % 2 % ...	60 % 45 % ...	40 % 53 % ...	0 % 2 % ...	50 kb/s 95 kb/s ...	100 kb/s 150 kb/s ...
S= average R= average **Q= variable >** FR= max CM= MJPEG CR= max	4 8 16 ...								
...	...								

...	...								

6.2 Second phase: Dynamic evaluation

The dynamic evaluation aims to determine the impact of the transmission channel on the user perception. All compression and user interface parameters are set to their average value as determined in the first phase.

Each row indicate a different setting of the effective bandwidth parameters:

- *T*: Average Synchronisation delay (sec) 1 to 30
- *C*: Average Capacity after synchronisation (kb/s) 10 to 200

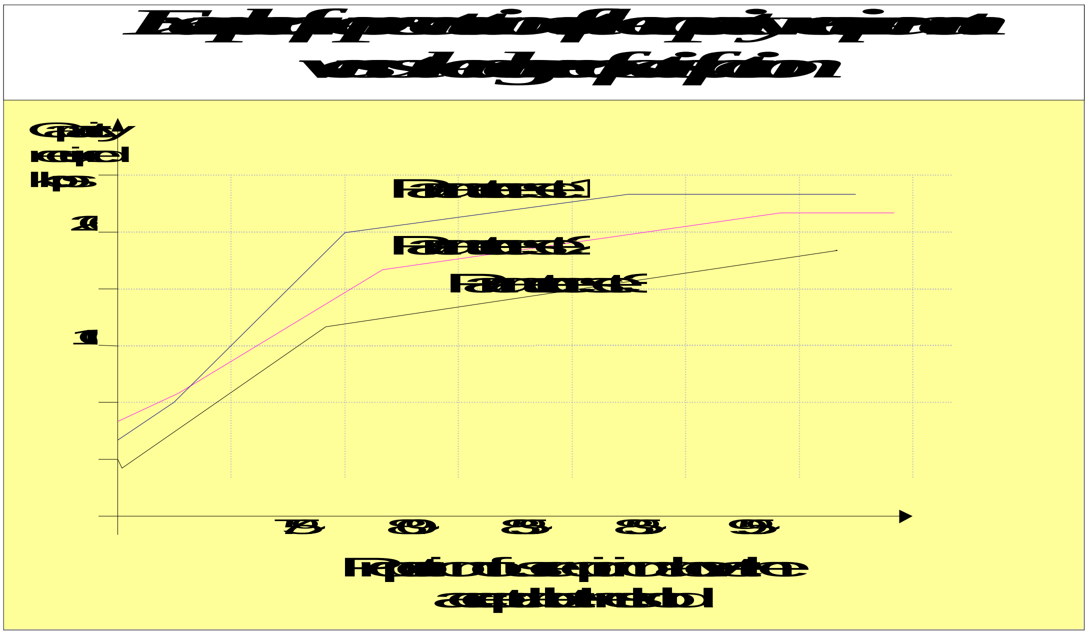
		Degree of satisfaction			***Level of comprehension***			***Difference with static***	
		BAD	**MED.**	**GOOD**	**<75%**	**75-90%**	**>90%**	**Degree of satisfaction**	**Level of compreh.**
T= min **C= variable >** CM= H261	10 50 100 200	60 % 40 % ...	35 % 50 % ...	5 % 10 % ...	...	...	...	50% 2% 0%	
T= max **C= variable >** CM= H261	10 50 100 200	80 % 65 % ...	20 % 33 % ...	0 % 2 % ...	...	...	...	60% 25% 15% ...	
T= average **C= variable >** CM= H261	10 50 100 200								
T= other **C= variable >** CM= H261	...								
...	...								
T= min **C= variable >** CM= **H263**	...								
...	...								
T= min **C= variable >** CM= **MPEG4**	...								
...	...								

7. CONFRONTATION AND SYNTHESIS

The difference of the subjective opinion expressed during the first and the second phase reveal the influence of the channel on the degree of satisfaction.

From these results minimum requirements in terms of channel capacity, call set up delays, can be determined for a given degree of satisfaction and/or level of comprehension.

A possible synthetic representation of it is shown below:



The parameters set can be a mode of compression with a particular set of parameters such as the compression rate.

8. References

8.1 General references

[1] Personnal Communication and Traffic engineering in ITU-T, Davide Grillo, Fondazione Ugo Bordoni, dec. 1996

[2] MPEG-4 Testing and Evaluation Procedures, ISO/IEC N0999, 1995

[3] Measured Performance of data transmission over GSM, Timo Alanko, University of Helsinki, nov. 1994

[4] Stochastic Networks, Theory and applications, F.P Kelly, Oxford Science Publications, 1996

http://www.statslab.cam.ac.uk/~frank/eb.html

[5] L. LIU Performance method for mobility management in cellular networks. ICUPC 96.

[6] UMPTIDUMPTI D07: Mobile communication and Special Needs

8.2 Normative References

ITU E.135	Human factors aspects of public telecommunication terminals for PSN	1995
ITU E.600	Terms and definitions for traffic engineering	1993
ITU E.750	Introduction to the E.750 series of recommendations	1993-96
ITU E.751	Reference connections for traffic engineering of Land mobile networks	1993-96
ITU E.755	Reference connections for UPT traffic performance GoS	1996
ITU E.760	Terminal Mobility traffic modelling	Draft
ITU E.765	Personal Mobility traffic modelling	Planned
ITU E.770	Land mobile and fixed network interconnection traffic GoS concept	1993
ITU E.771	Network GoS parameters and target values for circuit switched public land mobile services	1993-96
ITU E.775	UPT GoS concept	1996
ITU E.776	Network GoS Parameters for UPT	1996
ITU E.780	Traffic engineering methos for land mobile systems	Draft
ITU E.785	Traffic engineering methods for networks supporting UPT	Planned
ITU E.800	Quality of service and dependability vocabulary	1994
ETSI ETR 003	General aspects of Quality of Service (QoS) and Network Performance	1995