Unified model for the mapping between the Quality of Service and Experience for multimedia applications

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Outline

- Introduction and motivation;
- Applications:
  - Gaming;
  - Video;
  - Web-browsing;
  - Audio.
- Project Demonstrator;
- Conclusions.
Introduction and motivation

Nowadays operators success does not only depend on how good the Quality of Service (QoS) is, but whether it meets the end user expectations or Quality of Experience (QoE);

QoS is generally defined in terms of the network delivery capacity and resources, not in terms of user’s satisfaction;

Subjective quality assessment is the most accurate way to evaluate QoE, since there is no better indicator of personal quality than the one given by a human being;

Therefore, it is essential to map QoS metrics onto targets for QoE assessment.
Unified model for the mapping between the Quality of Service and Experience in multimedia applications

We propose a unified model that characterizes the relation between QoS parameters and the corresponding QoE, providing network and service providers a framework to evaluate user’s satisfaction;

Key parameters impacting the users experience defined by ITU-T:
- Delay;
- Delay variation;
- Information loss;
- Ping or round-trip time (gaming);
- Encoding bitrate (video).

Four types of applications are considered:
- Gaming;
- Video;
- Web-browsing;
- Audio.
The mapping between QoS and QoE is based on MOS experimental results obtained in the context of the Muse G-Model;

The fitting between the MOS results and QoE leads to a sixth degree polynomial equation:

\[
MOS = 4.16031 + 0.0349952 \times p - 0.104905 \times j - 0.267622 \times \rho \\
- 0.00315486 \times p^2 + 0.011092 \times j^2 + 0.119224 \times \rho^2 + 7.84 \\
\times 10^{-5} \times p^3 - 0.00048113 \times j^3 - 0.0135847 \times \rho^3 - 8.48647 \\
\times 10^{-7} \times p^4 + 9.07 \times 10^{-6} \times j^4 + 0.000412947 \times \rho^4 + 3.92 \times 10^{-9} \\
\times p^5 - 7.51346 \times 10^{-8} \times j^5 + 3.90407 \times 10^{-6} \times \rho^5 - 6.0582 \\
\times 10^{-12} \times p^6 + 2.16813 \times 10^{-10} \times j^6 - 1.87 \times 10^{-7} \times \rho^6
\]

Where \( p \) is the ping, \( j \) is the jitter and \( \rho \) is the percentage of loss;

The goodness of this fit is guaranteed by \( R=0.969 \), \( R^2=0.939 \) and the MSE=0.067.
Video applications
Video applications

For video applications we considered MOS results available in the literature;

$$\text{MOS} = 3.2147 - 0.00266916 \times b_{\text{rate}} - 10.4811 \times d - 20.9894 \times \rho$$

$$- 5.8875 \times 10^{-6} \times b_{\text{rate}}^2 + 40.3305 \times d^2 + 166.121 \times \rho^2$$

$$+ 1.449 \times 10^{-8} \times b_{\text{rate}}^3 - 42.493 \times d^3 - 730.016 \times \rho^3$$

$$- 4.2939 \times 10^{-12} \times b_{\text{rate}}^4 + 18.3884 \times d^4 + 1764.47 \times \rho^4$$

$$- 2.29851 \times 10^{-15} \times b_{\text{rate}}^5 - 3.48213 \times d^5 - 2069.09 \times \rho^5$$

$$+ 8.08679 \times 10^{-19} \times b_{\text{rate}}^6 + 0.237418 \times d^6 + 903.102 \times \rho^6$$

where $b_{\text{rate}}$ is the encoding bitrate, in kbps, $d$ is delay in ms, and $\rho$ is the percentage of loss;

$R=0.915$, $R^2=0.838$ and the MSE=0.197.
Web-browsing
Web-browsing

- We used the data available by the ITU-T G.1030 recommendation;
- The fittings from the MOS experiments results available in this recommendation have a correlation, $R$, superior to 0.90.

\[
\text{MOS} = 4.79 - 1.03 \times \ln\left(1.76 \times \frac{\text{data}}{b_{\text{rate}}}\right)
\]
Audio applications
Audio applications

We considered the ITU-T E-Model from the G.107 recommendation;

\[ \text{MOS} = 3.657 - 0.1345 \times \rho - 0.003303 \times d - 0.004012 \times \rho^2 - 3.275 \times 10^{-5} \times d^2 - 4.564 \times 10^{-5} \times \rho^3 + 4.414 \times 10^{-8} \times d^3 \]

where \( d \) is the delay in ms, and \( \rho \) is the percentage of loss;

\( R=0.992, \ R^2=0.984 \) and the MSE=0.000963.
Unified Model

The unified model is obtained by mathematically integrating the fitness obtained for each application:

\[
\text{QoE} = a_0 + A_1(0.035p - 0.105j - 0.003p^2 + 0.011j^2 + 7.84 \times 10^{-5}p^3 - 48.113 \times 10^{-5}j^3 - 8.486 \times 10^{-7}p^4 + 9.07 \times 10^{-6}j^4 + 3.92 \times 10^{-9}p^5 - 7.513 \times 10^{-8}j^5 - 6.058 \times 10^{-12}p^6 + 2.168 \times 10^{-10}j^6) + A_2(-26.6916 \times 10^{-4}brate - 5.888 \times 10^{-6}brate^2 + 1.449 \times 10^{-8}brate^3 - 4.294 \times 10^{-12}brate^4 - 2.299 \times 10^{-15}brate^5 + 8.087 \times 10^{-19}brate^6)
+ A_3\left(4.79 - 1.03 \ln\left(1.76 \times \frac{data}{brate}\right)\right) + A_4(a_1 \rho + a_2 \rho^2 + a_3 \rho^3 + a_4 \rho^4 + a_5 \rho^5 + a_6 \rho^6)
+ A_5(a_7d + a_8d^2 + a_9d^3 + a_{10}d^4 + a_{11}d^5 + a_{12}d^6)
\]

\(A_1, A_2, A_3, A_4\) and \(A_5\) are Boolean variables used to select the QoS parameters impacting the QoE.
Boolean variables used to select the QoS parameters

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<th>Gaming</th>
<th>Video</th>
<th>Web</th>
<th>Audio</th>
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Heterogeneous scenario of mesh networks

[Diagram showing a heterogeneous mesh network with various nodes and connections, including WiMAX BSs, SSs, 3G/4G Base Stations, Gateway Switch/Routers, and Wi-Fi APs, along with client devices like Smart Phone, Cell Phone, Laptop, and PDA.]
Conclusions

- We have proposed strategies to assess and map the user perception and expectations with measurable technical (QoS) parameters;
- Due to the scarce number of MOS results available in the literature, we have considered the ITU-T recommendations for web-browsing and audio applications;
- We have validated our fittings by means of regression analysis by computing the $R$, $R^2$ and the MSE;
- The values for the coefficient of correlation are higher than $R = 0.9$ for gaming, audio and video.
Conclusions (II)

- By means of mathematical manipulation we have integrated every obtained fitting into a single unified model;
- This equation contains Boolean variables used to select the QoS parameters impacting the QoE and additional variables to be replaced, according to the selected application, to compute the expected QoE;
Thank You!