QoE Assessment Method for Video Quality and Pricing in IPTV Services

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Outline

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Motivation

- IPTV services are becoming some of the most promising applications over the next-generation network (NGN).
- To provide users with sufficient quality, IPTV service providers must properly evaluate, design, and manage users' quality of experience (QoE).

QoE factors in IPTV services

- Audio
- Video
- Metadata
- Text
- Graphics
- Pricing
- EPG
- Browser
- Accessibility
Concept of service value assessment

- Methodology for assessing overall QoE is needed.
- We define the overall QoE as “service value.”
  - Service value assessment deals with audiovisual quality and other QoE factors such as usability, functionality, and pricing.
- Service value is formulated by functions evaluating characteristics of each QoE factor.
  - Advantage factor “A” in the E-model is a good example of expressing QoE for convenience.

\[
\text{Service value} = \text{Function} \left( f_1, f_2, f_3, \ldots, f_N \right)
\]

- \( f_i \): QoE evaluation function for i-th factor
- \( N \): Number of QoE factors
Which service is better?

VoD service A
Charge: €20 per month

VoD service B
Charge: €5 per month
Goal of our study

- Establishing service value (overall QoE) evaluation method
  - Our first target of QoE factors: video quality and pricing

- Our Approach:
  - Analyze effects of individual QoE factors
  - Select suitable assessment method for both video quality and pricing
  - Establish service value evaluation model for video quality and pricing
  - Verification of proposed model
Target IPTV service for service value evaluation

- **Target service:**
  - Video on demand service
  - Video quality depends on coding rate.
  - Customers pay a fixed charge every month.

- **QoE factors:**

<table>
<thead>
<tr>
<th>QoE factor</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>MPEG2 video coding rate</td>
<td>2, 3, 4, 6, 10 [Mbit/s]</td>
</tr>
<tr>
<td>Service charge per month</td>
<td>1, 2, 3, 4, 6, 8, 10 [yen]</td>
</tr>
</tbody>
</table>

Note: Service charge is normalized by the minimum of all values.
Subjective QoE assessment for video quality or pricing

- Rating scale: 5-grade rating scale (in Japanese)
  - Video quality: 5: Excellent, 4: Good, 3: Fair, 2: Poor, and 1: Bad
  - Pricing: 5: Very satisfactory, 4: Satisfactory, 3: Fair, 2: Unsatisfactory, and 1: Very unsatisfactory

- Test sequences: 4 video sequences from ITU-R Rec. BT.802-1

- Each subjective QoE was represented as a Mean Opinion Score (MOS) calculated by averaging the scores of 50 subjects.
  - Video quality: MOS\textsubscript{Q}
  - Pricing: MOS\textsubscript{P}
Effects of individual QoE factors

- MOS for video quality
- MOS for pricing

- MOS for video quality
  - MOS (MOS\textsubscript{v})
  - Test sequences: TS-a, TS-b, TS-c, TS-d

- MOS for pricing
  - MOS (MOS\textsubscript{p})
  - Normalized service charge

Averaged MOS
Effects of individual QoE factors (cont’d)

- An interval scale “$I$” is introduced by converting the MOS.

\[
I = \ln \left( \frac{S - S_{\text{min}}}{S_{\text{max}} - S} \right)
\]

- $S$: MOS for video quality or pricing
- $S_{\text{min}}$: Minimum score of category, i.e., 1
- $S_{\text{max}}$: Maximum score of category, i.e., 5
Effects of individual QoE factors (cont’d)

- Sense of video-quality and pricing can be approximately expressed by the logarithmic function of coding-rate and service-charge, respectively.

\[
I_Q \propto \log R
\]

\[
I_P \propto \log P
\]
Assessment method for video quality and pricing

- We adopted two kinds of rating scale that are referred to as the contingent valuation method (CVM). (in Japanese)

- **Scale A:**
  How much would you pay to use the service offered at the video quality?
  - Not pay
  - 1
  - 2
  - 3
  - 4
  - 6
  - 8

- **Scale B:**
  Did you think that you would use the service offered at the video quality and pricing of 3?
  - Yes
  - No

Pricing is changed for each condition.
Comparison of evaluation results

- Relationship between video quality and pricing obtained by each rating scale is different.

![Graph showing the relationship between video quality and normalized service charge for two different rating scales, Scale A and Scale B. The graph illustrates the percentage of subjects willing to pay at different normalized service charges and video quality levels.](image)
Comparison of evaluation results (cont’d)

- We directly compare services of some combinations of coding rate and pricing by using a pair comparison method.
- As a result, QoE can be accurately evaluated using scale B.

<table>
<thead>
<tr>
<th>Coding rate [Mbit/s]</th>
<th>Service pricing</th>
<th>Percentage of subjects willing to pay [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Scale A</td>
</tr>
<tr>
<td>2.0</td>
<td>1.0</td>
<td>72</td>
</tr>
<tr>
<td>6.0</td>
<td>4.0</td>
<td>32</td>
</tr>
<tr>
<td>2.5</td>
<td>1.5</td>
<td>66</td>
</tr>
<tr>
<td>4.0</td>
<td>3.0</td>
<td>50</td>
</tr>
</tbody>
</table>
Rating scale for service value assessment

- We introduce the following rating scale based on a rating scale B. (in Japanese)

How would you rate your satisfaction with the service offered at the video quality and pricing of 3?

15-grade rating scale
Willingness-to-pay price decreases exponentially with decreasing video quality under the condition of the same QoE.
Service value evaluation model

- We propose a service value evaluation model as a linear function of video quality and pricing on a psychological interval scale.

\[ I_V = \alpha I_Q - \beta I_P + \gamma \]

\[ = \alpha' \log R - \beta' \log P + \gamma' \]

- \( I_V \): Estimated overall QoE (service value) on an interval scale
- \( I_Q \): Sense of video quality on an interval scale
- \( I_P \): Sense of pricing in on interval scale
- \( R \): Video coding rate
- \( P \): Pricing
- \( \alpha, \beta, \gamma, \alpha', \beta', \gamma' \): Constants (\( \alpha, \beta, \alpha', \beta' > 0 \))
Estimation accuracy

- Service value can be accurately evaluated from video coding rate and pricing by using the proposed model.

\[
MOS_{Vest} = \frac{1 + 15 \exp I_Y}{1 + \exp I_Y}
\]
Conclusion

- Concept of “service value assessment” is proposed.
- We determined suitable assessment method for both video quality and pricing.
- We found that the willingness-to-pay price decreases exponentially with decreasing video quality under the condition of the same QoE.
- We established a service value evaluation model as a linear function of video quality and pricing on a psychological interval scale.
- Evaluating the effects of other QoE factors on service value is for further study.