generic Adaptation of Scalable Multimedia Contents

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Outline

• Introduction
• Adaptation Decision-Taking
• Multimedia Content Adaptation
• Conclusion
Universal Multimedia Access

• Any content should be available anytime, anywhere

• [Universal Multimedia Experiences :=
  – User should have worthwhile, informative experience anytime, anywhere]
UMA Challenge and Concept

Content Adaptation for Universal Access

Heterogeneous Networks, Dynamic Conditions

Growing mismatch

Rich Multimedia Content

Diverse Set of Terminal Devices, User Preferences

Need for scalable content, descriptions, negotiation, adaptation
Abstract Model for Scalable Bitstreams (1)

- Organization of scalable bitstreams in layers, levels, tiers, parcels \( \Rightarrow \) hypercube
- Encode once, then truncate layers (or bits) for lower quality / resolution ...
- Requires relatively simple operation: remove, update, (insert)


Abstract Model for Scalable Bitstreams (2)

31dB, 4CIF version with only the Y color component (i.e. a grayscale image)
Simplified Adaptation Framework

- Context-related metadata for adaptation decision-taking
- Adaptation Decision-Taking
- Multimedia Content Adaptation
- Content-related metadata for content adaptation
- Scalable Multimedia Content
- Adapted Scalable Multimedia Content
- Context-related metadata

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Context- and Content-related Metadata

• **Context-related metadata**
  - **End user**: preferences (content, presentation, interaction, etc.), disabilities, location, environment, requested perceived QoS (PQoS)
  - **Terminal**: A/V capabilities, codecs, type of terminal, battery status, etc.
  - **Network**: available bandwidth, delay, jitter, packet loss, etc.
  - **Adaptation**: which adaptation operations are supported by devices along the delivery path?

• **Content-related metadata**
  - **Media characteristics**: bit-rate, frame-rate, frame width/height, etc.
  - **DRM information**: which adaptation operations are allowed under which conditions
  - **Adaptation QoS**: relationship between usage environment constraints, feasible adaptation operations satisfying these constraints, and associated utilities (i.e., qualities)

• **Static metadata**: usually constant during the multimedia delivery
• **Dynamic metadata**: frequently varying during the multimedia delivery
Adaptation Decision-Taking

Goal of adaptation decision-taking

- The **optimal selection of parameter settings** for the actual multimedia content adaptation engines that **satisfy constraints** imposed by actors of the content distribution chain (e.g., content/service/network providers, terminals, end users) while **maximizing QoS**

- Known approaches for adaptation decision-taking
  - Static look-up approach
  - **Optimization-based approach**
  - Knowledge-based approach
Optimization-based Adaptation Decision-Taking

- Mathematical approach based on an optimization problem
  - Adaptation parameters and effects modeled as variables $v$ with a given domain
  - Causal dependencies described as functions (e.g., look-up tables, stack functions)
  - Limitation constraints restrict the feasible adaptation parameters
  - Optimization constraint $o$ represents the objective function (optimization goal), e.g., in most cases: maximize quality
  - Adaptation decision-taking: find values for the variables representing adaptation parameters that do not violate the limitation constraints (feasibility) and maximize the optimization constraint (optimality)

$$\min o_i(v) \quad \forall 0 \leq i < k, \forall 0 \leq j < m$$

subject to $l_j(v) \rightarrow true$
Example: Temporal Video Adaptation

- **Variables**
  - frame-rate, bit-rate, psnr

- **Limitation constraint**
  - bitrate <= available bandwidth (e.g., 520kbps)

- **Optimization constraint**
  - maximize psnr

<table>
<thead>
<tr>
<th>frame-rate [fps]</th>
<th>15</th>
<th>20</th>
<th>25</th>
</tr>
</thead>
<tbody>
<tr>
<td>bit-rate [kbps]</td>
<td>400</td>
<td>480</td>
<td>600</td>
</tr>
<tr>
<td>psnr [dB]</td>
<td>35.5</td>
<td>36.8</td>
<td>38.5</td>
</tr>
</tbody>
</table>

| feasible?       | ✓   | ✓   | ✗   |
| optimal?        | ✗   | ✓   | ✓   |
Optimization-based ADTE

- Universal Constraints Description (UCD)
- AdaptationQoS
- Usage Environment Description (UED)
Multimedia Content Adaptation

- **Adaptation by selection**
  - Store several versions of the content on the server
  - cf. choice/selection mechanism in MPEG-21 DID
  - cf. MPEG-7 variation descriptor
  - Waste capacity on the server

- **Adaptation by transcoding**
  - Need much processing power
  - Separate transcoder for each transcoding step
  - Difficult to manage

- **Adaptation by transformation**
  - Make use of scalable formats, i.e., by retrieving parts of the content; possibility to render a degraded version
  - Types of scalability: temporal, spatial, SNR quality, ROI, complexity..
  - Examples: JPEG2000, MPEG-4 audio/visual, MPEG-4 SVC, ...
generic Bitstream Syntax Description

- XML document describing the high-level structure of a bitstream (i.e. in headers, packets or layers, not bit-per-bit)
- Not an alternative format, but additional layer = metadata
- Finer or coarser levels of detail, depending on the application
gBSD-based Multimedia Publishing

traditional Web (XML/ XSLT) publishing

gBSD-based multimedia “publishing”
generic Bitstream Syntax Description

• gBS Schema is conforming to BSDL (standardized within MPEG-21 Digital Item Adaptation)
• Predefined elements: gBSDUnit and Parameter
• Advanced functionalities
  – Format independence
  – Semantically meaningful marking
  – Hierarchies of gBSDUnit elements
  – Flexible addressing scheme
  – Distributed adaptation in terms of multi-step adaptations
Example: gBSD
Conclusion

• **Multimedia Content Adaptation**
  – A tool which serves the aim of UMA
  – **Adaptation decision-taking**: find optimal parameter settings for actual adaptation engines
  – **Coding format-independent multimedia content adaptation**: deploy once, use many times

• **Transcoding**
  – Like a *fix to the current problem* (and the ones to come); *specific solutions needed* for a growing number of instances

• **Scalable coding**
  – Would be a *generalized solution to the interoperability problem*, but only if widely adopted across domains
  – Would facilitate **UMA in a generic way**
Thank you for your attention

... questions, comments, etc. are welcome ...

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