generic Adaptation of Scalable Multimedia Contents

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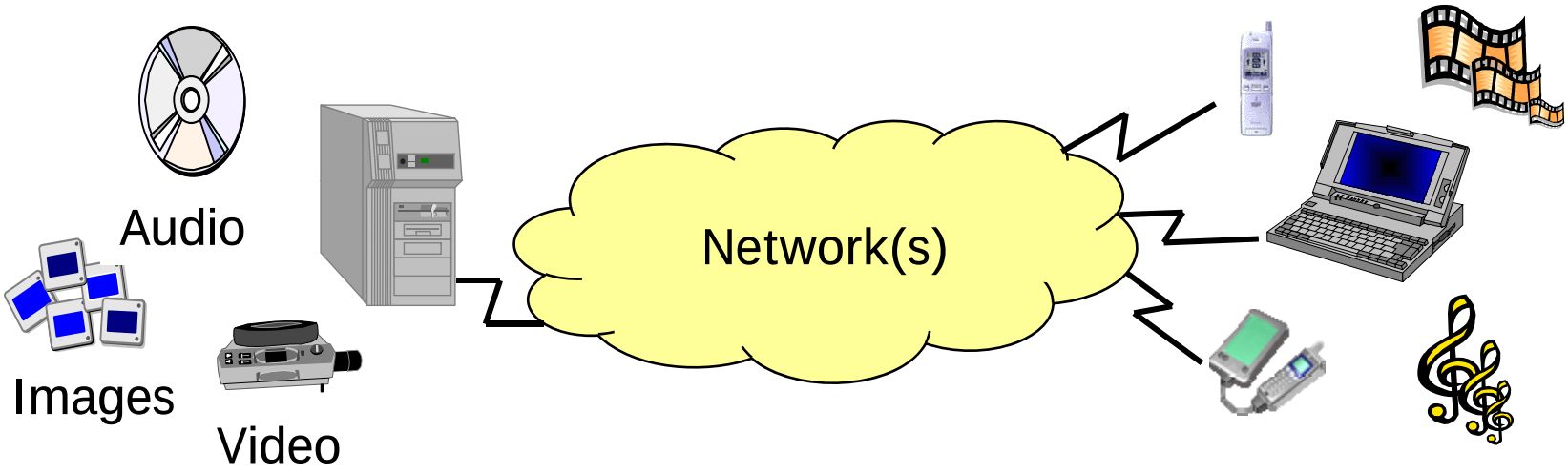
Outline

- 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

Heterogeneous Networks,
Dynamic Conditions

Rich Multimedia
Content

Diverse Set of
Terminal Devices,
User Preferences

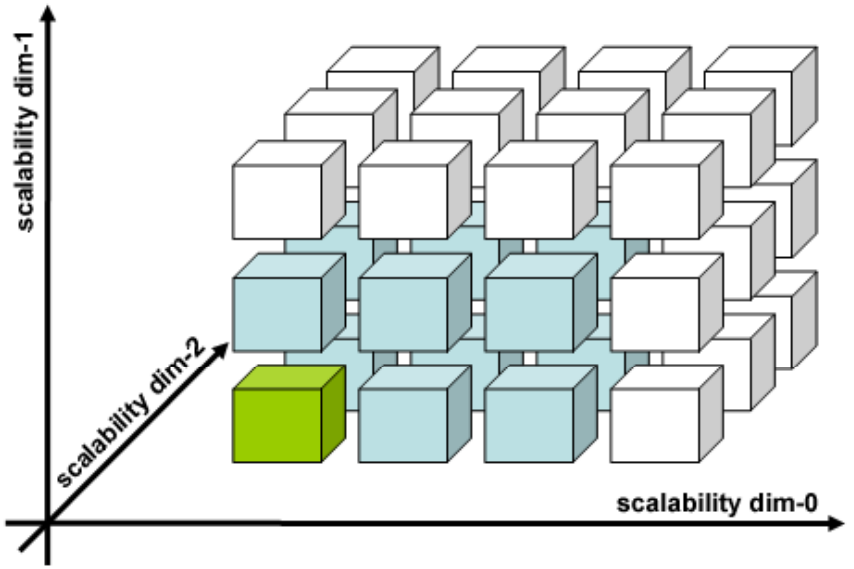
Growing mismatch

⇓

Need for scalable content, descriptions, negotiation, adaptation

Abstract Model for Scalable Bitstreams (1)

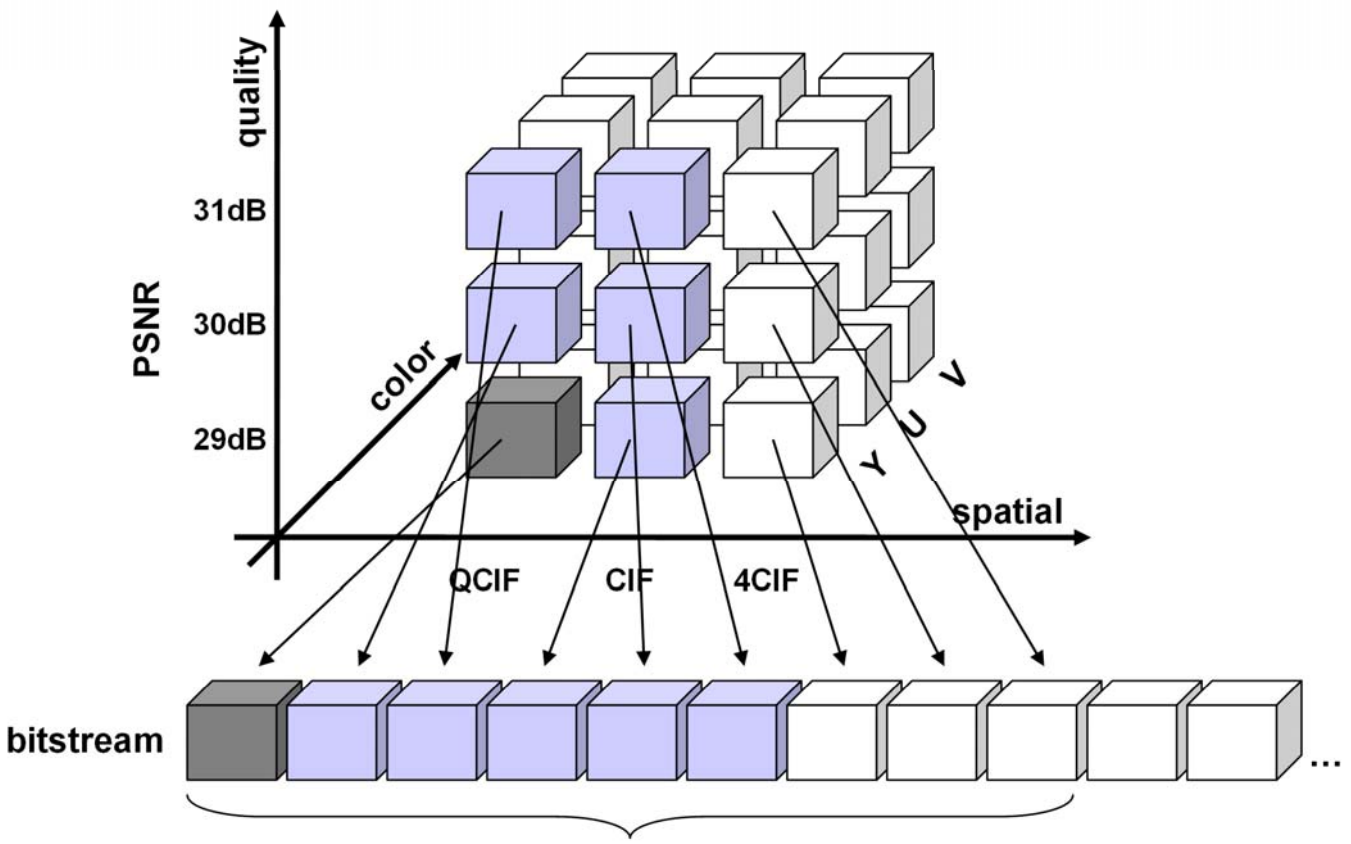
- Organization of scalable bitstreams in layers, levels, tiers, parcels ⇨ hypercube
- Encode once, then truncate layers (or bits) for lower quality / resolution …
- Requires relatively simple operation: remove, update, (insert)



[D. Mukherjee, et.al., **A Framework for Fully Format-Independent Adaptation of Scalable Bit Streams**, *IEEE Trans. on Circuits and Systems for Video Technology*, vol. 15, no. 10, pp 1280-1290, Oct. 2005]

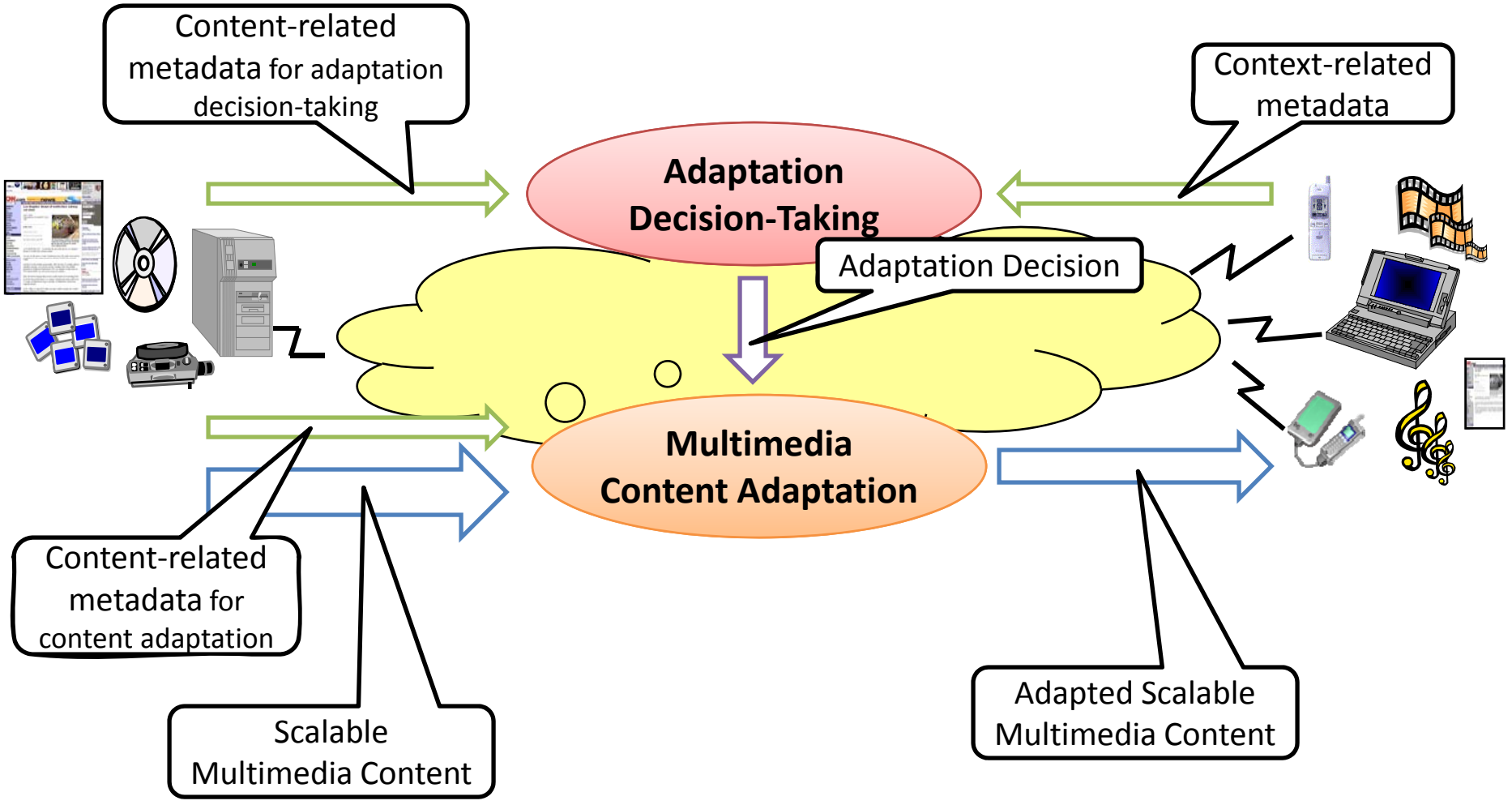
[S. Lerouge, et.al., **Fully Scalable Video Coding in Multicast Applications,** *SPIE Electronic Imaging: Science and Technology 2004*, vol. 5308, pp. 555-564, (San Jose, CA, USA), January 2004.]

Abstract Model for Scalable Bitstreams (2)



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

Simplified Adaptation Framework



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 *l* 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)

$$\min o_i(v) \quad \forall 0 \le i < k, \forall 0 \le j < m$$
$$subject\ to\ l_j(v) \rightarrow true$$

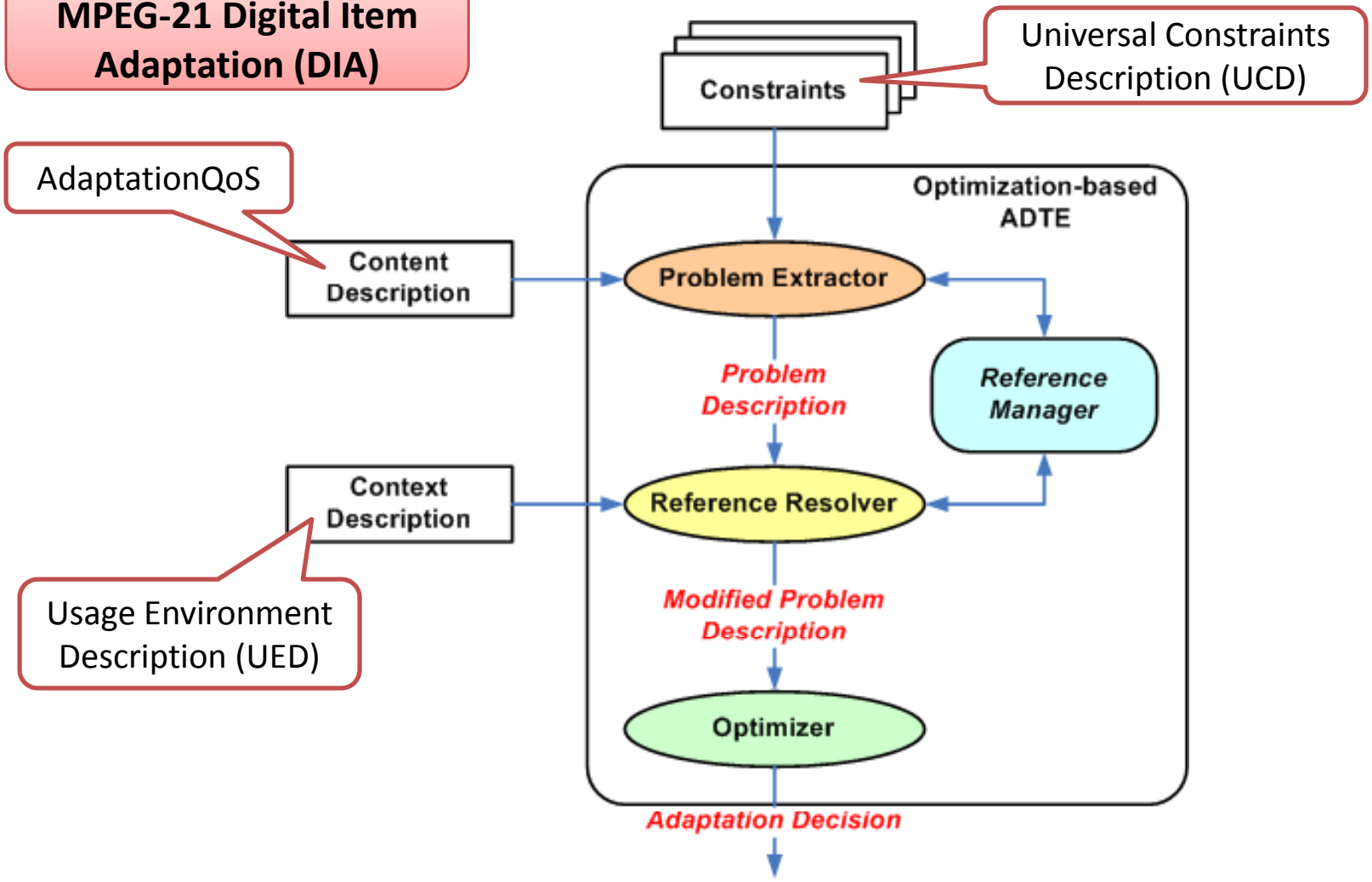
Example: Temporal Video Adaptation

- Variables
  - frame-rate, bit-rate, psnr
- Limitation constraint
  - bitrate <= available bandwidth (e.g., 520kbps)
- Optimization constraint
  - maximize psnr

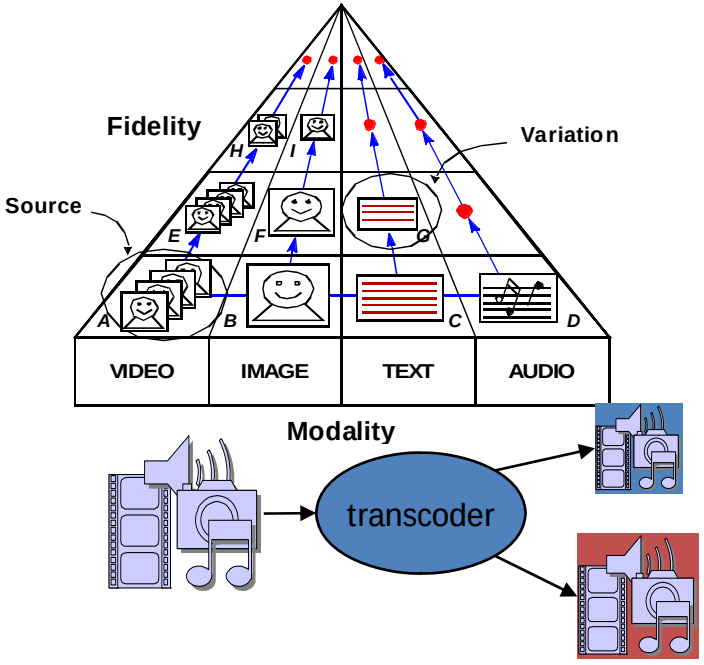
frame-rate [fps]	15	20	25
bit-rate [kbps]	400	480	600
psnr [dB]	35.5	36.8	38.5
feasible?	✓	✓	✗
optimal?	✗	✓	

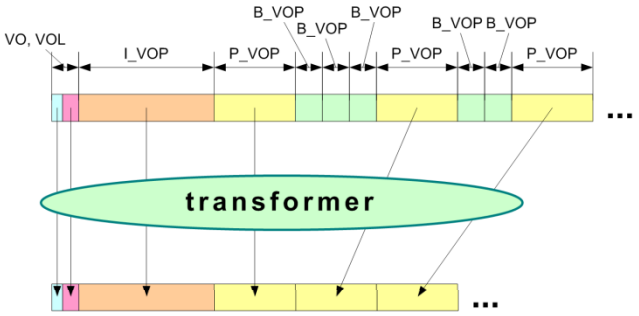
Optimization-based ADTE

Int'l Standard Support:
MPEG-21 Digital Item Adaptation (DIA)



Multimedia Content Adaptation

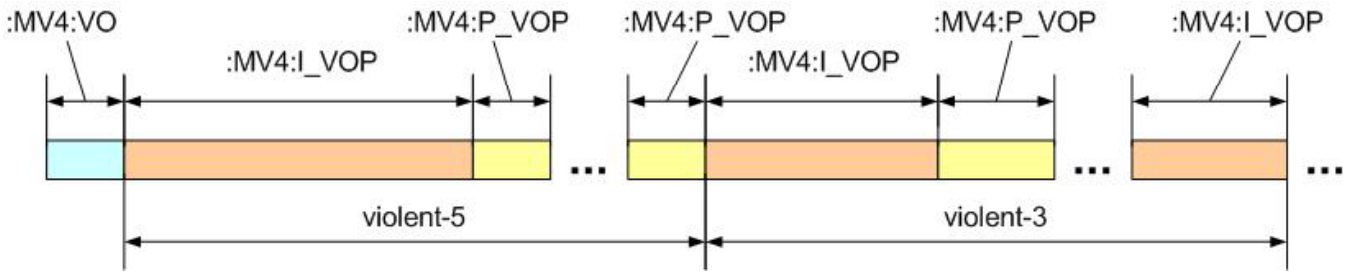




- Adaptation by selection
  - Store several versions of the content on the server
  - cf. choice/selection mechanism in MPEG-21 DID
  - cf. MPEG-7 variation descriptor
  - Waste capacity on the server
- Adaptation by transcoding
  - Need much processing power
  - Separate transcoder for each transcoding 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

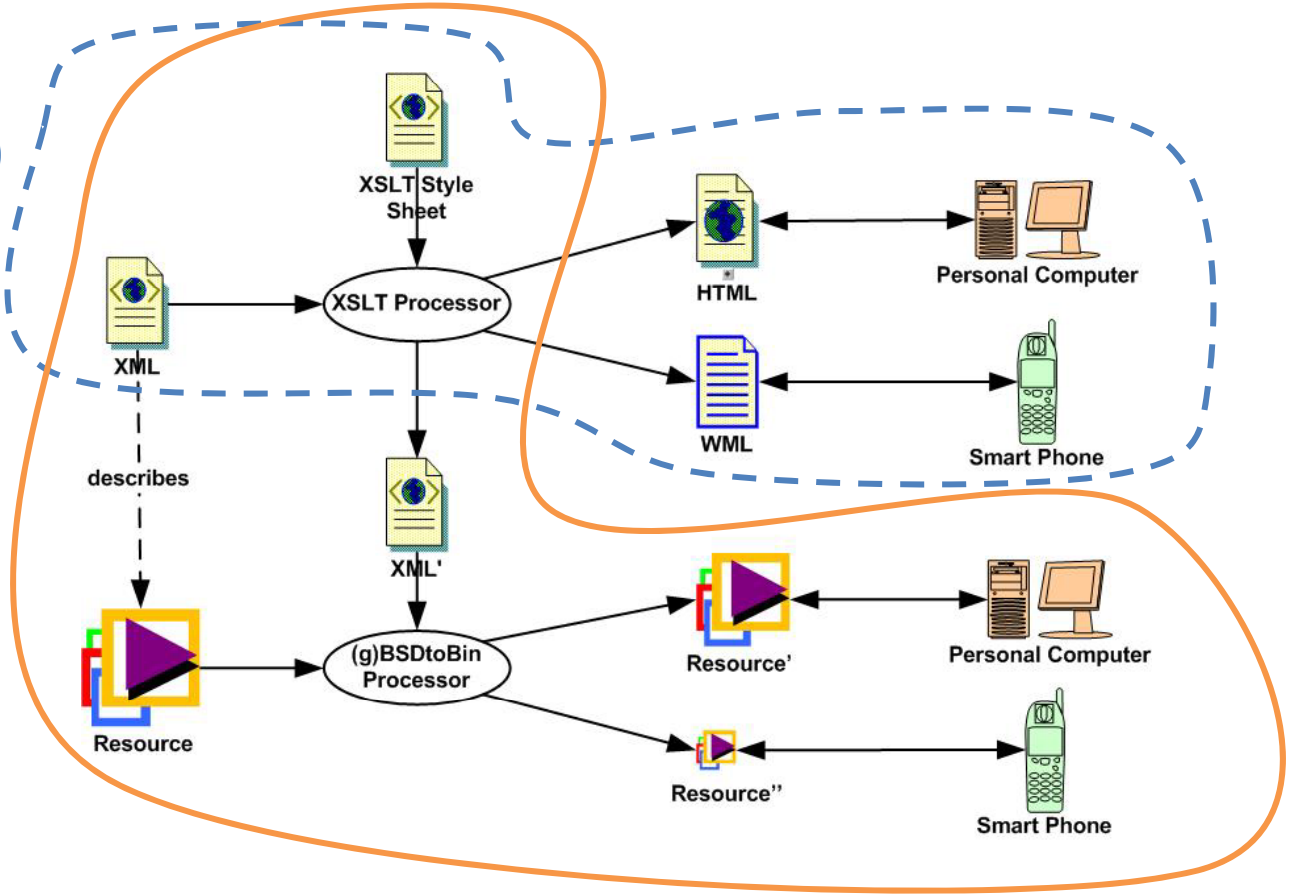
- XML document describing the high-level structure of a bitstream (i.e. in headers, packets or layers, not bit-per-bit)
- Not an alternative format, but additional layer = metadata
- Finer or coarser levels of detail, depending on the application



gBSD-based Multimedia Publishing

traditional Web (XML/XSLT) publishing

gBSD-based multimedia "publishing"

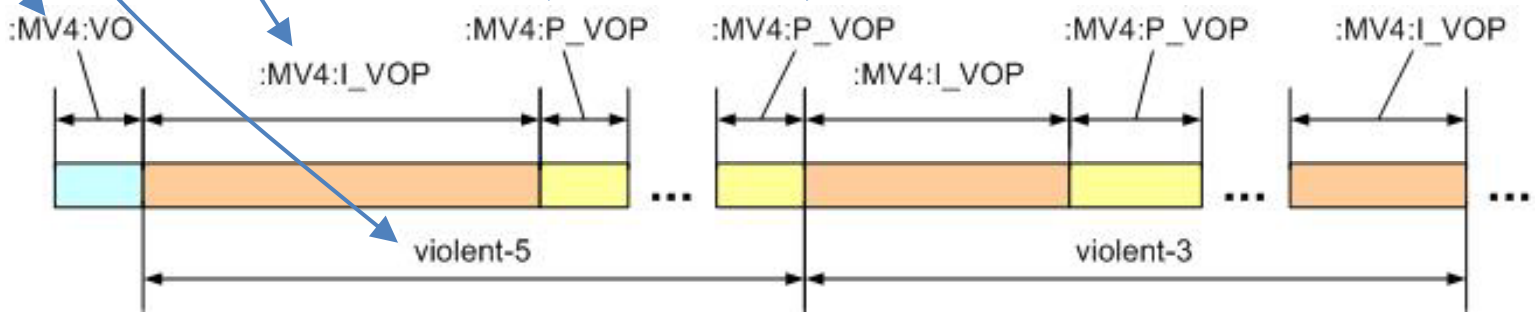


generic Bitstream Syntax Description

- 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

```
<gBSDUnit syntacticalLabel=":MV4:VO" start="0" length="26"/>
<gBSDUnit start="26" length="99983" marker="violent-5">
   <gBSDUnit syntacticalLabel=":MV4:I_VOP" start="26" length="2877"/>
   <gBSDUnit syntacticalLabel=":MV4:P_VOP" start="2903" length="64"/>
   <!-- ... and so on ... -->
   <gBSDUnit syntacticalLabel=":MV4:P_VOP" start="98296" length="1713"/>
</gBSDUnit>
<gBSDUnit start="100009" length="68022" marker="violent-3">
   <gBSDUnit syntacticalLabel=":MV4:I_VOP" start="100009" length="1825"/>
   <gBSDUnit syntacticalLabel=":MV4:P_VOP" start="101834" length="1780"/>
   <!-- ... and so on ... -->
   <gBSDUnit syntacticalLabel=":MV4:I_VOP" start="166802" length="1229"/>
</gBSDUnit>
<!-- ... and so on ... -->
```



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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

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Thank you for your attention

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

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