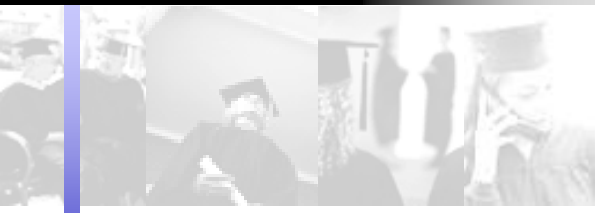

MPEG Standards Enabling Universal Multimedia Access

MPEG-21 Digital Item Adaptation

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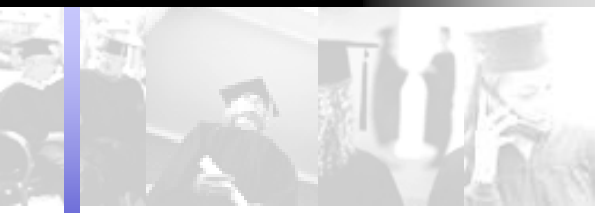
1st Int'l. Conf. on
Automated Production of Cross Media Content for Multi-channel Distribution
~AXMEDIS 2005~
December 1, 2005

Acknowledgement:
Anthony Vetro



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  - usage environment description
  - universal constraints description
- **tools enabling coding format independence**
  - (generic) Bitstream Syntax Description
  - AdaptationQoS, universal constraints description tools
  - BSDLink
- **miscellaneous**
  - metadata adaptation
  - session mobility
  - DIA configuration
- **amd.1: conversions and permissions**
- **amd.2: dynamic and distributed adaptation**
- **conclusion**

intro – concept, key components, goal

enable transparent access to (distributed) advanced multimedia content

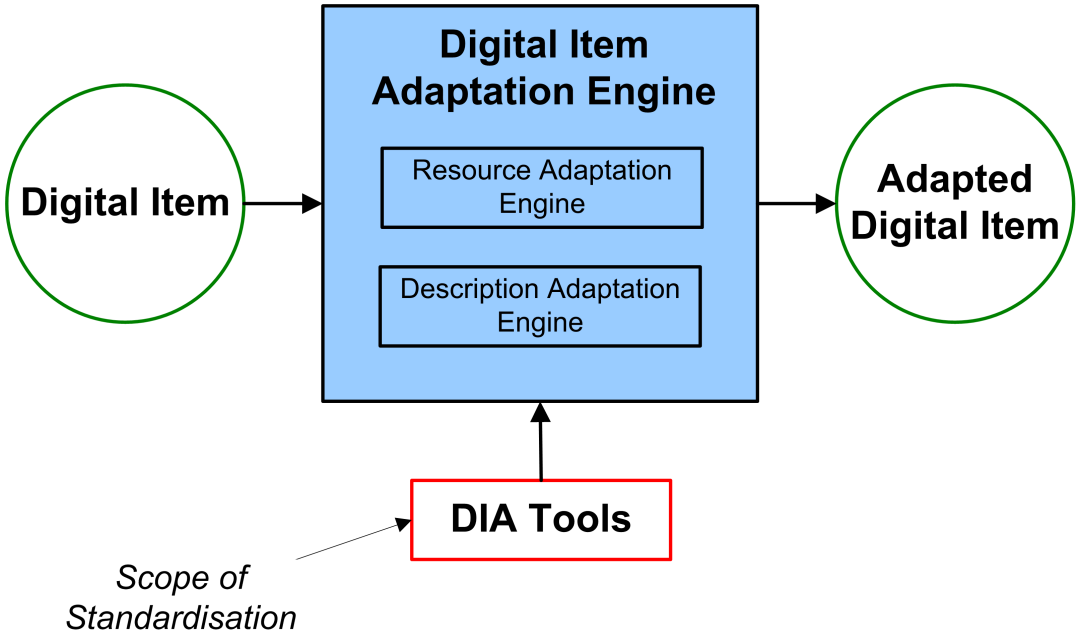
by shielding users from network and terminal installation issues

- **concept**
  - many devices, networks, coding formats, user preferences
  - need for "adaptive delivery" and "re-purposing" of content
  - consistent with the MPEG-21 vision for Terminals and Networks
  - device and coding format independence

key components

- multimedia compression (MPEG-1/-2/-4, H.26x, etc.)
- description of multimedia (MPEG-7)
- description of usage environment including terminal, network, etc.
- negotiation between content, network and devices
- adaptation of Digital Items according to usage environment

intro – overview and scope



- … specifies the **syntax** and **semantics** of tools … **assist the adaptation** of Digital Items
- … used to satisfy **transmission**, **storage** and **consumption** constraints as well as **Quality of Service management**

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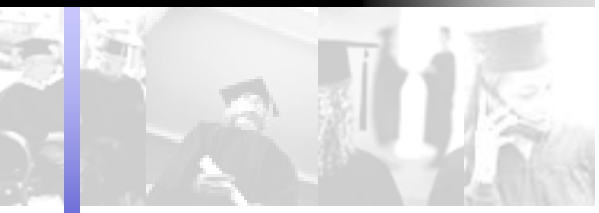
intro – overview of tools



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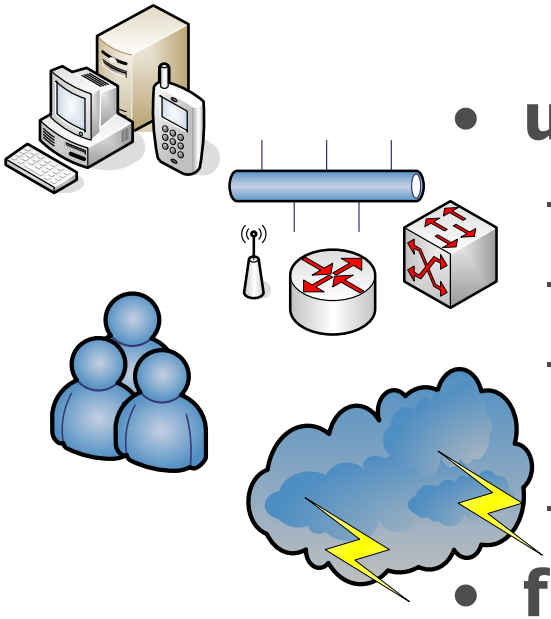
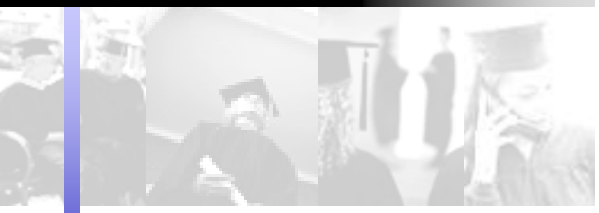
"device" independence



- **usage environment description (UED)**
  - terminal capabilities
  - network characteristics
  - characteristics of a User (in the context of MPEG-21)
  - characteristics of the natural environment
- **fundamental input to any adaptation engine**



terminal capabilities

- **codec capabilities**
  - specify both encoding and decoding formats (profiles and levels)
    - image, video, audio, system, graphics formats
    - MPEG-7 has specified Classification Schemes (CS's) to indicate coding formats
    - for alignment between content and terminal, the same CS's are referenced by MPEG-21 DIA to describe the terminal side
  - specify specific parameters related to the modality, e.g., max bit-rates
- **input-output characteristics**
  - display capabilities, e.g., resolution, rendering format, bits/pixel, color capable
  - audio output capabilities, e.g., frequency ranges, output power, SNR
- **device properties**
  - user interaction support, e.g., mouse/pen properties, other types of input devices
  - power, e.g., average ampere consumption, battery time remaining
  - storage, e.g., size, transfer rate, if it is writable or not
  - device class, e.g., PC, PDA, Set-top-box
  - data IO, e.g., bus width and speed

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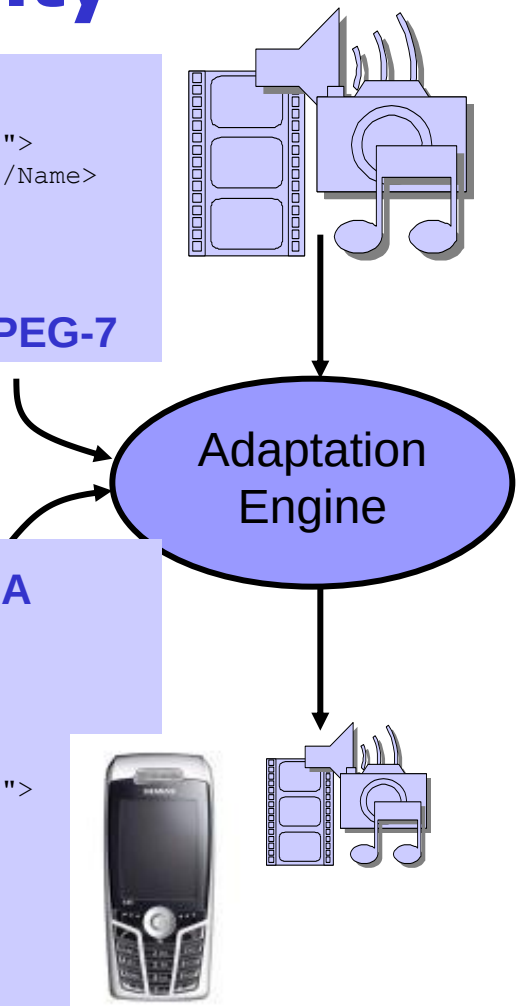
use case: format compatibility

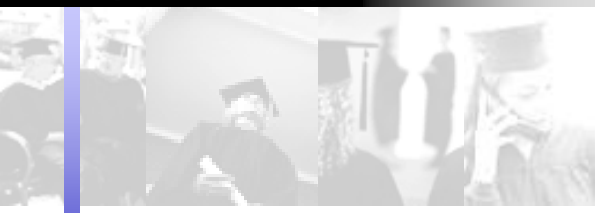
```
<MediaFormat>
    <VisualCoding>
        <Format href="urn:mpeg:mpeg7:cs:VisualCodingFormatCS:2001:2.2.2">
            <Name xml:lang="en">MPEG-2 Video Main Profile @ Main Level</Name>
        </Format>
        <Frame height="720" width="480" rate="30"/>
       <BitRate>5000000</BitRate>
    </VisualCoding>
</MediaFormat>
```

MPEG-7

```
<TerminalCapability xsi:type="CodecCapabilitiesType">
    <Decoding xsi:type="ImageCapabilitiesType">
        <Format href="urn:mpeg:mpeg7:cs:VisualCodingFormatCS:2001:4">
            <mpeg7:Name xml:lang="en">JPEG</mpeg7:Name>
        </Format>
    </Decoding>
    <Decoding xsi:type="VideoCapabilitiesType">
        <Format href="urn:mpeg:mpeg7:cs:VisualCodingFormatCS:2001:3.1.2">
            <mpeg7:Name xml:lang="en">
                MPEG-4 Visual Simple Profile @ Level 1
            </mpeg7:Name>
        </Format>
    </Decoding>
</TerminalCapability>
```

DIA





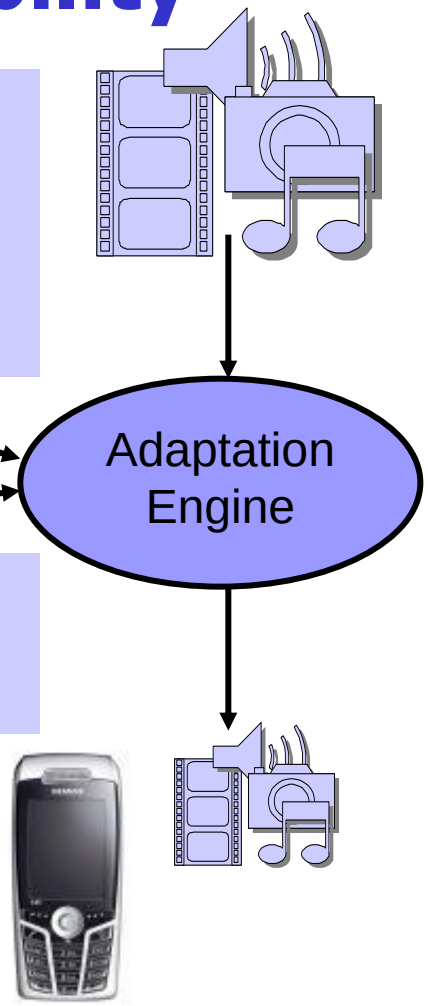
network capabilities

- **static: network capabilities**
  - capacity of a given channel
  - minimum guaranteed bandwidth
  - in-sequence delivery, i.e., are the order of packets guaranteed
  - error delivery, i.e., how does the network deliver erroneous packets
- **dynamic: network conditions**
  - error, e.g., packet loss rate, bit error rate
  - delay, e.g., one-way delay, round-trip delay, delay variation
  - available Bandwidth, e.g., max, min, average
  - timing stamp information also specified, i.e., start time and duration of measurements for condition attributes

use case: bandwidth compatibility

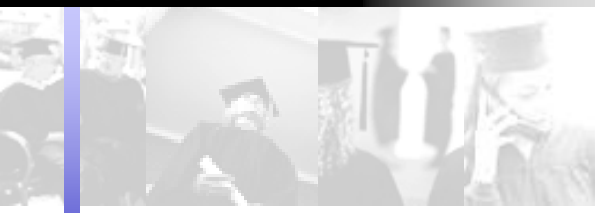
```
<MediaFormat>
 <VisualCoding>
  <Format href="urn:mpeg:mpeg7:cs:VisualCodingFormatCS:2001:3.3.1">
   <Name xml:lang="en">MPEG-4 Visual Advanced Simple Profile @ Level 0</Name>
  </Format>
  <Frame height="704" width="576" rate="30"/>
  <BitRate>96000</BitRate>
 </VisualCoding>
</MediaFormat>
```

MPEG-7




```
<DIA> .....
  <Description xsi:type="UsageEnvironmentType">
    <UsageEnvironment xsi:type="NetworkCharacteristicsType">
      <NetworkCharacteristics xsi:type="NetworkCapabilityType"
        maxCapacity="64000" minGuaranteed="9600"/>
      <NetworkCharacteristics xsi:type="NetworkConditionType">
        <AvailableBandwidth maximum="56000" average="16000"
          interval="300"/>
        <Delay packetTwoWay="200" delayVariation="40"/>
        <Error packetLossRate="0.05"/>
      </NetworkCharacteristics>
    </UsageEnvironment>
  </Description>
</DIA>
```

DIA



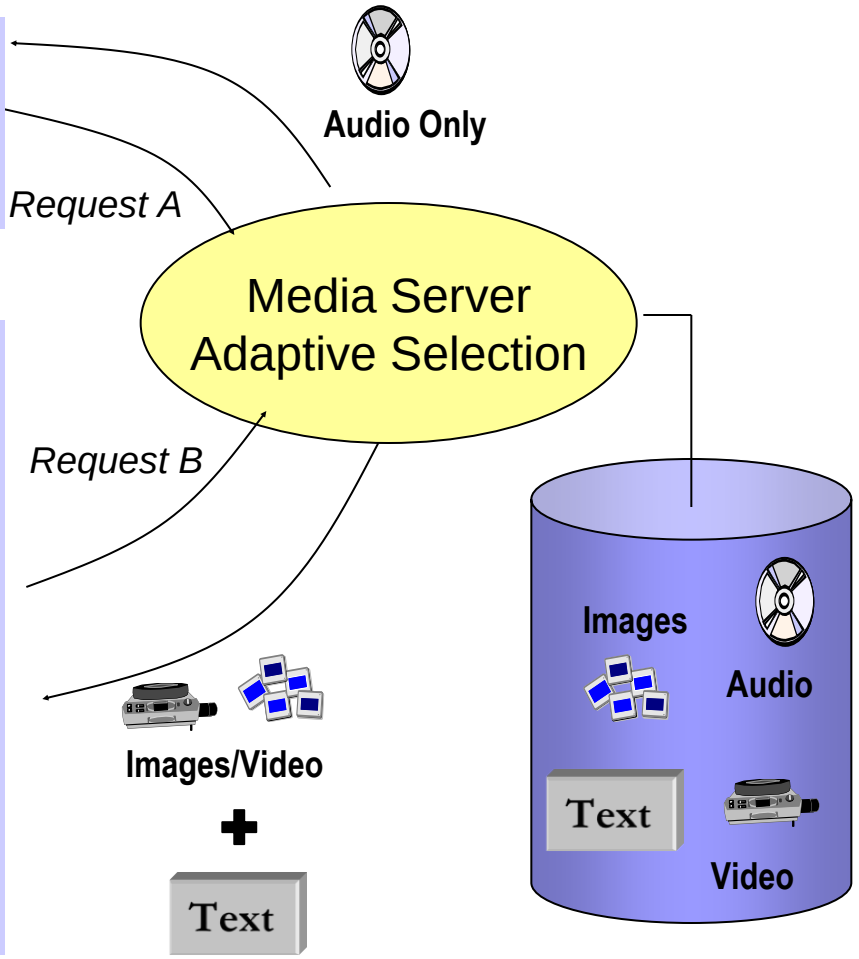
user characteristics

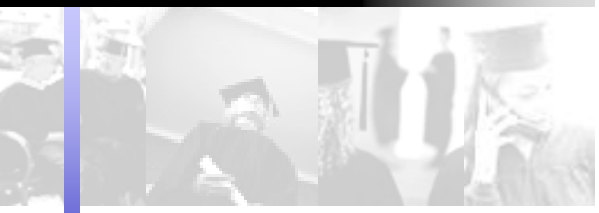
- **user info**
  - reference MPEG-7 Agent DS to specify, e.g., name, contact info
- **content preferences**
  - reference MPEG-7 User Preference and Usage History DS's
- **presentation preferences**
  - audio-related preferences, e.g., equalizer settings, frequency, volume
  - display preferences, e.g., color temperature settings, contrast, brightness
- **accessibility**
  - auditory impairments, e.g., characterize hearing loss in right/left ear
  - visual impairments, e.g., blindness, color-vision and low-vision deficiencies
- **location**
  - describes mobility and destination of Users for location-aware services
  - mobility description enable classifications of users, e.g., highway, pedestrian

use case: adaptive selection of resources

```
...
<User id="User_A">
    <UserCharacteristic xsi:type="VisualImpairmentType">
        <Blindness eyeSide="both"/>
    </UserCharacteristic>
</User>
...
```

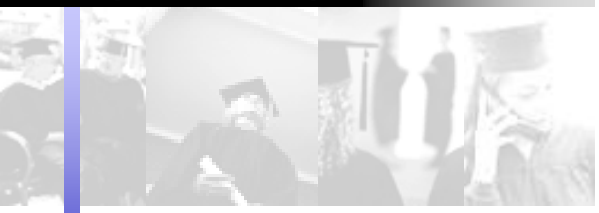
```
<User id="User_B">
    <UserCharacteristic xsi:type="AuditoryImpairmentType">
        <RightEar>
            <Freq250Hz>0.0</Freq250Hz>
            <Freq500Hz>5.5</Freq500Hz>
            <Freq1000Hz>-0.2</Freq1000Hz>
            <Freq2000Hz>-2.0</Freq2000Hz>
            <Freq4000Hz>1.5</Freq4000Hz>
            <Freq8000Hz>5.5</Freq8000Hz>
        </RightEar>
        <LeftEar>
            <Freq250Hz>9.0</Freq250Hz>
            <Freq500Hz>-1.5</Freq500Hz>
            <Freq1000Hz>9.0</Freq1000Hz>
            <Freq2000Hz>9.0</Freq2000Hz>
            <Freq4000Hz>9.0</Freq4000Hz>
            <Freq8000Hz>10.0</Freq8000Hz>
        </LeftEar>
    </UserCharacteristic>
</User>
```





natural environment characteristics

- **location & time**
  - reference MPEG-7 Place DS and Time DS, respectively
- **audio-visual (A/V)**
  - audio noise levels and noise frequency spectrum
  - illumination properties affecting a display



use case: adaptation to A/V environment

- **determine "shift ratio"**
  - difference in illumination under the current condition to that of a reference
- **map colors of an image**
  - based on shift ratio, colors are mapped so that image is perceived under the reference illumination condition

```
...
<NaturalEnvironmentCharacteristic
    xsi:type="IlluminationCharacteristicsType">
    <TypeOfIllumination>
        <ColorTemperature>159</ColorTemperature>
    </TypeOfIllumination>
    <Illuminance>500</Illuminance>
</NaturalEnvironmentCharacteristic>
...
```

```
...
<NaturalEnvironmentCharacteristic
    xsi:type="AudioEnvironmentType">
    <NoiseLevel>20</NoiseLevel>
        <NoiseFrequencySpectrum>
            40 30 20 10 10 10 10 10 10 10
            10 40 40 40 30 30 30 20 20 20
            10 10 10 10 10 10 10 10 10 10
            10 10 10
        </NoiseFrequencySpectrum>
</NaturalEnvironmentCharacteristic>
...
```

- **based on audio noise characteristics, enhancement of the perceived quality could be achieved by masking or attenuating selected frequencies during adaptation**

universal constraints description

- **allows to further constraining the *usage* and *usage environment* of a Digital Item**
- **types of constraints**
  - limitation constraints
  - optimization constraints
- **formulated using the stack function syntax**

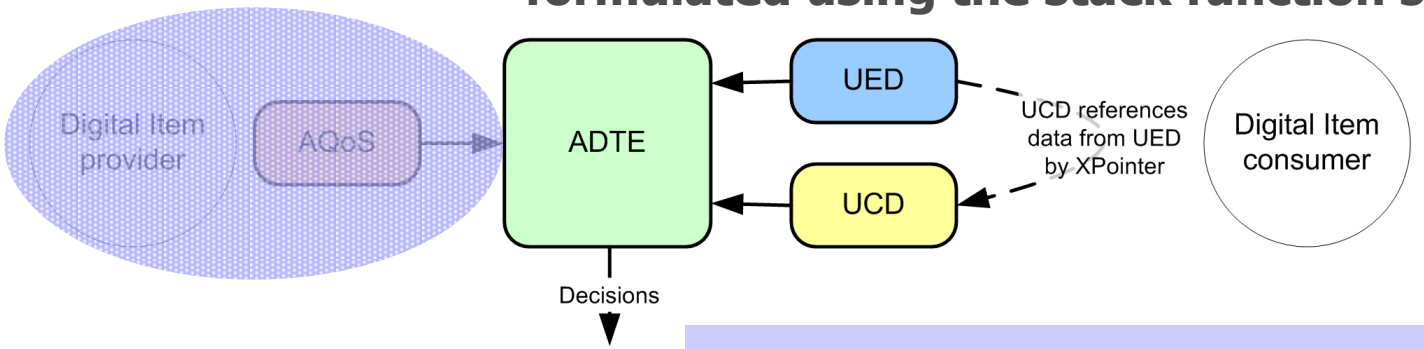
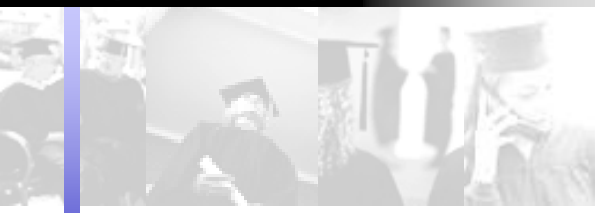


image resolution < 75% of display resolution

max. according to the available network bandwidth



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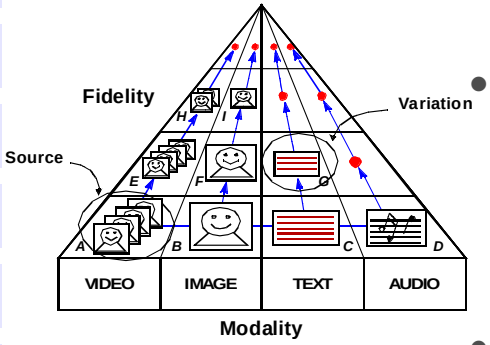
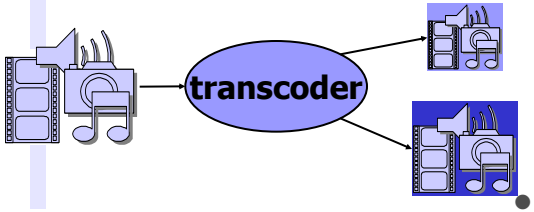
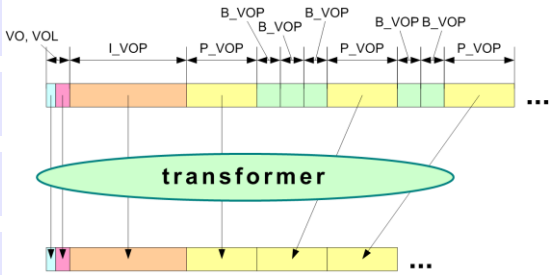
"coding format" independence



- **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

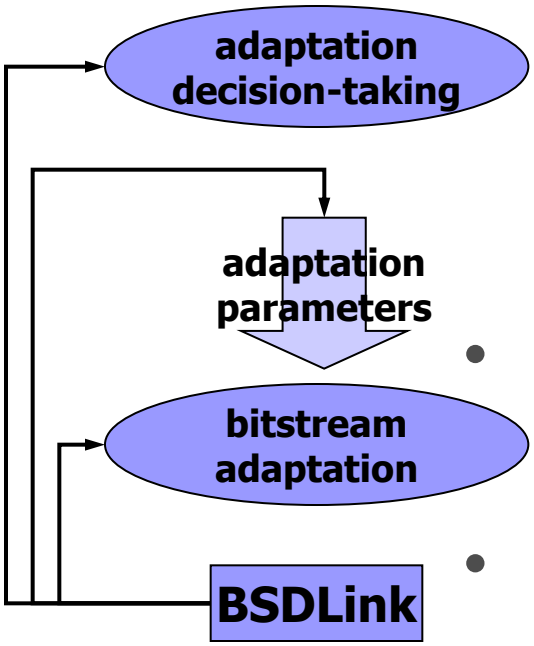


- **adaptation by transcoding**
  - need much processing power
  - separate transcoder for each transcoding step
  - difficult to manage



- **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-21 SVC, …

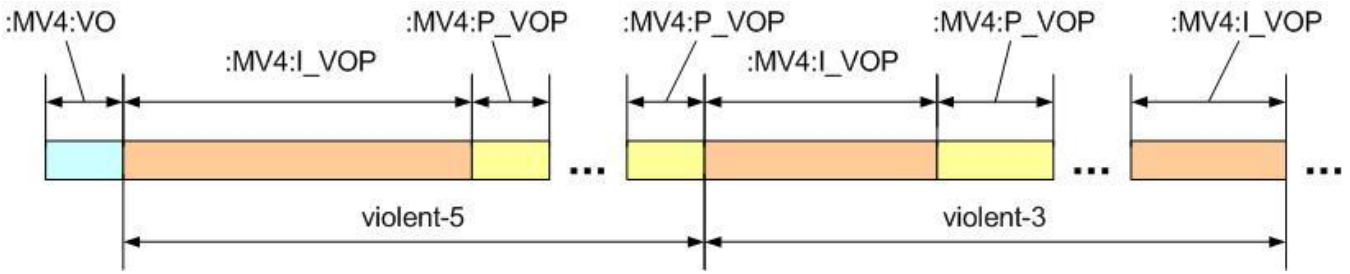
coding format independence (cont'd)



- **adaptation decision-taking**
  - providing the optimal adaptation parameters
  - taking into account usage environment constraints and resulting utilities (quality)
  - ⇨ AdaptationQoS (AQoS), Universal Constraints Description (UCD)
- **(scalable) bitstream adaptation**
  - describing the high-level structure of a bitstream
  - ⇨ Bitstream Syntax Description (BSD)
- **decision-taking and bitstream adaptation**
  - ⇨ BSDLink

BSD – introduction

- **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



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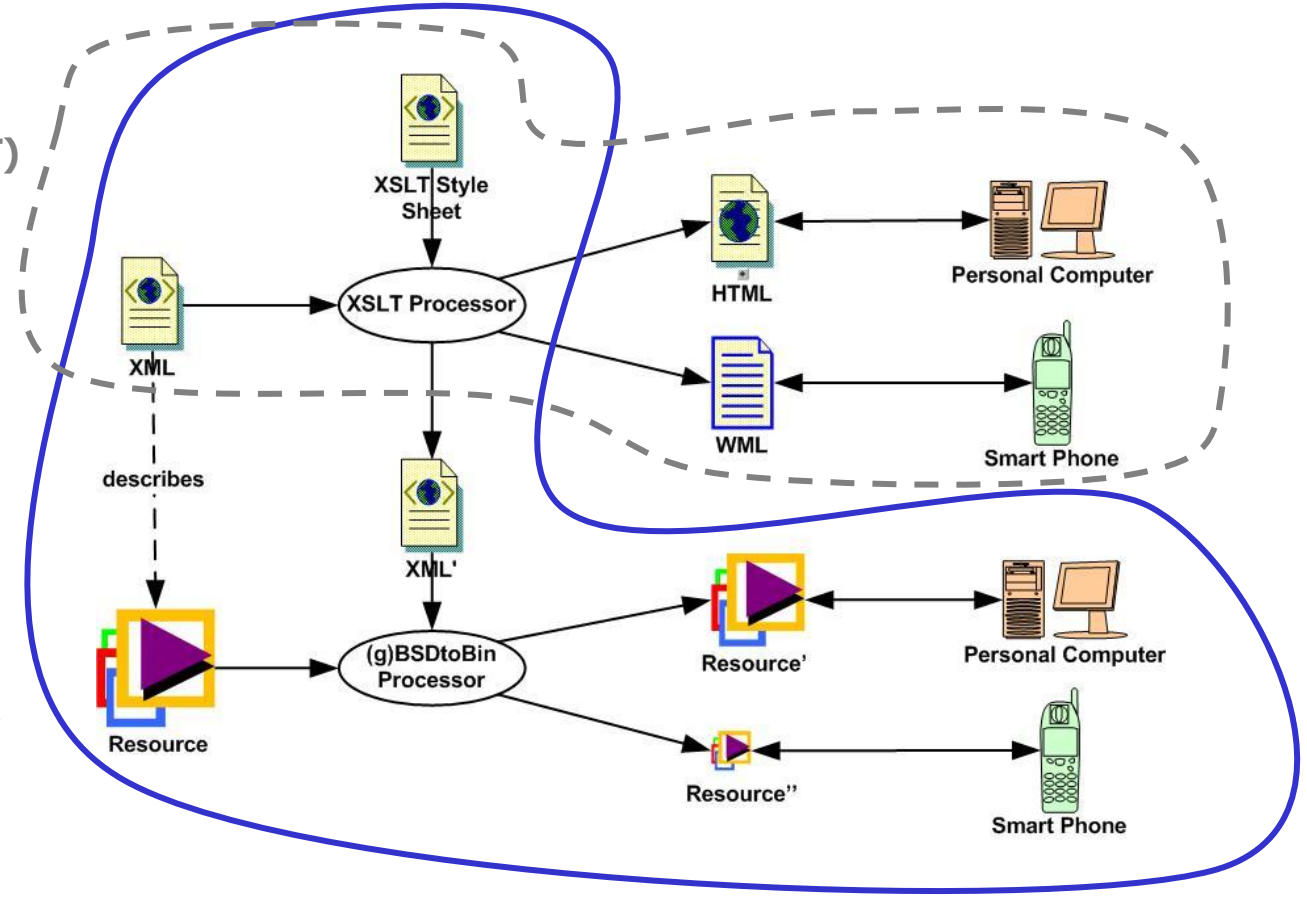
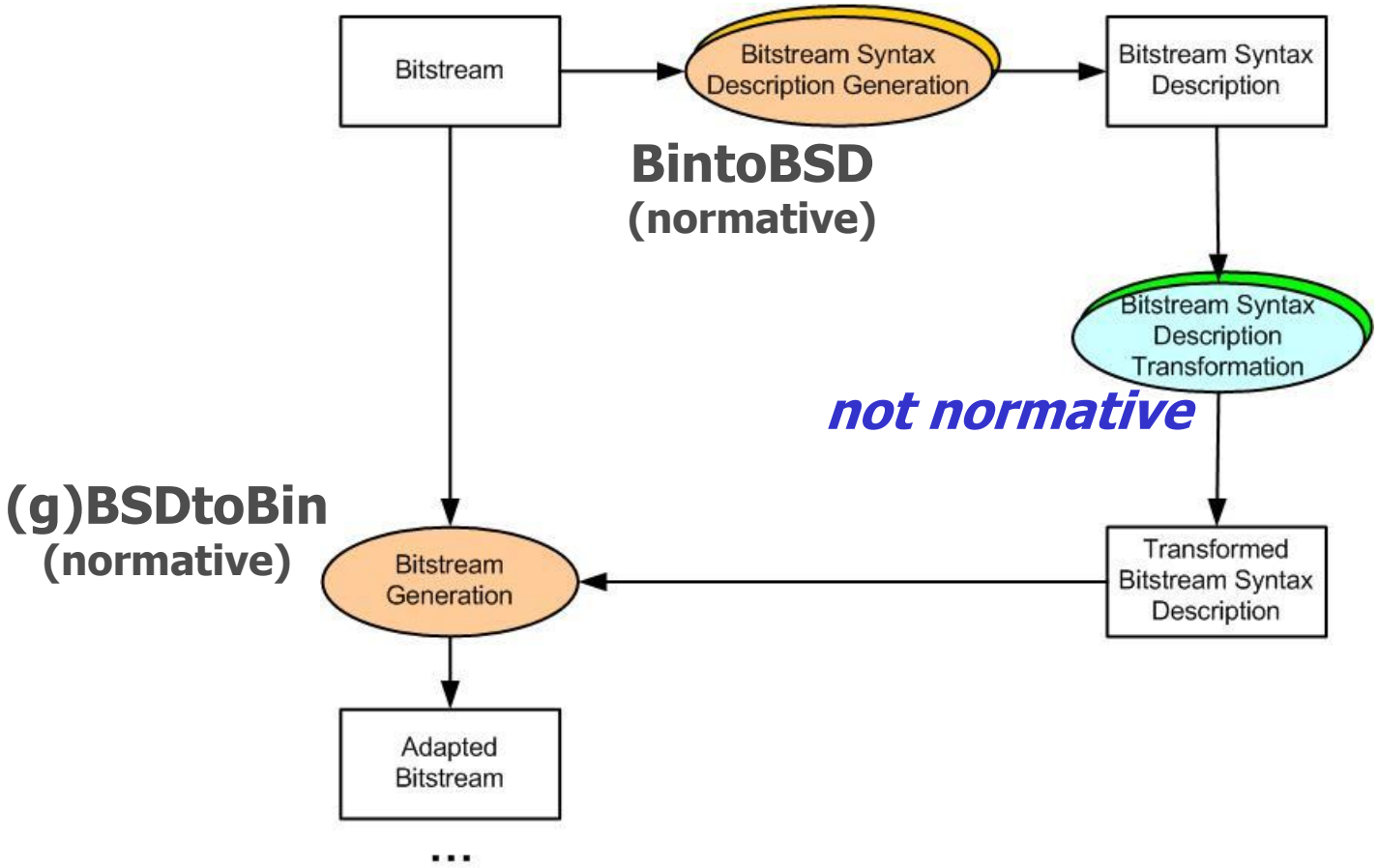
BSD – introduction (cont'd)

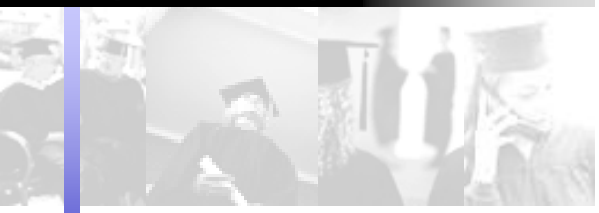
traditional Web (XML/XSLT) publishing

BSD-based multimedia "publishing"



BSD – introduction (cont'd)

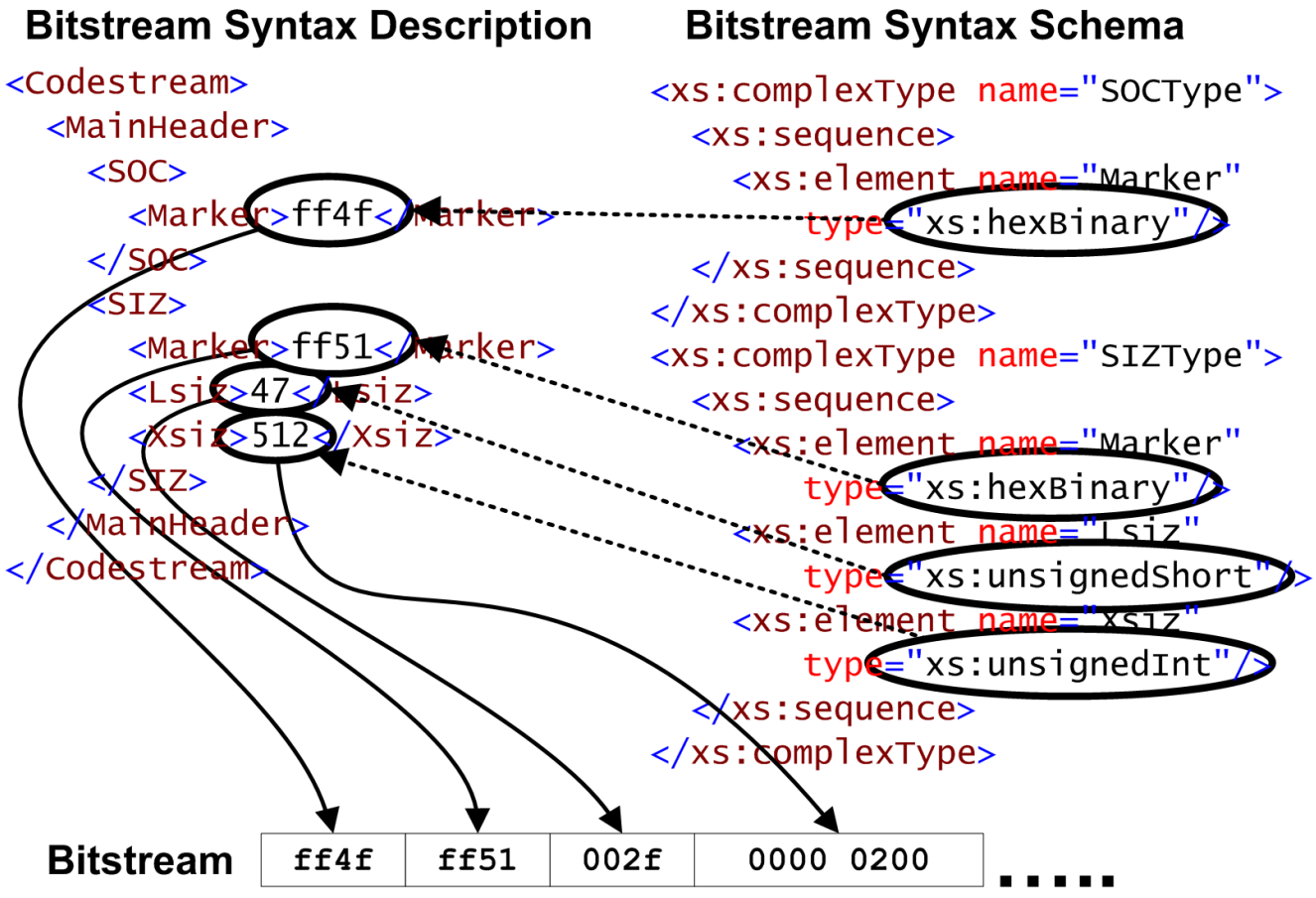


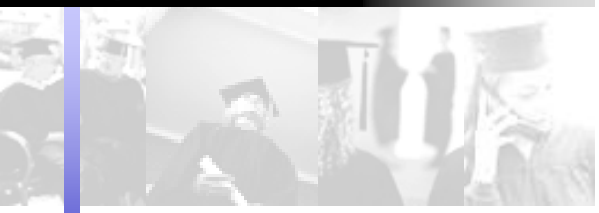


BSD – Bitstream Syntax Description Language

- **new language based on W3C XML Schema**
  - restrictions and extensions wrt. multimedia
- **enables the design of BS Schemas**
  - defines constraints on XML documents in terms of structures and data types
- **functionality**
  - validate (in the XML Schema meaning) the BSD against its BS Schema
  - parse a BSD and generate the bitstream
  - parse a bitstream and generate its BSD

example: BSDL

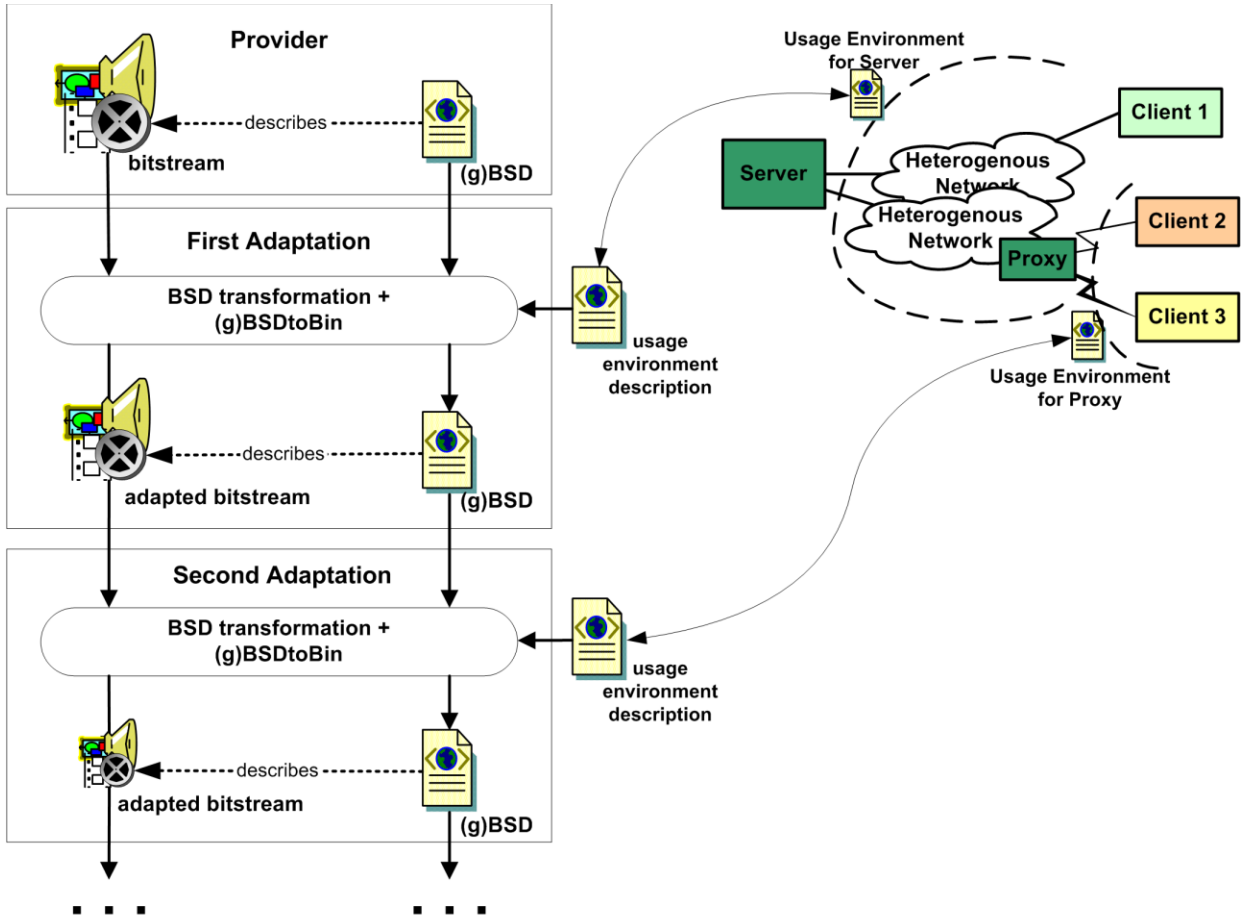




BSD – generic Bitstream Syntax Description

- **gBS Schema is conforming to BSDL**
- **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: multi-step adaptation



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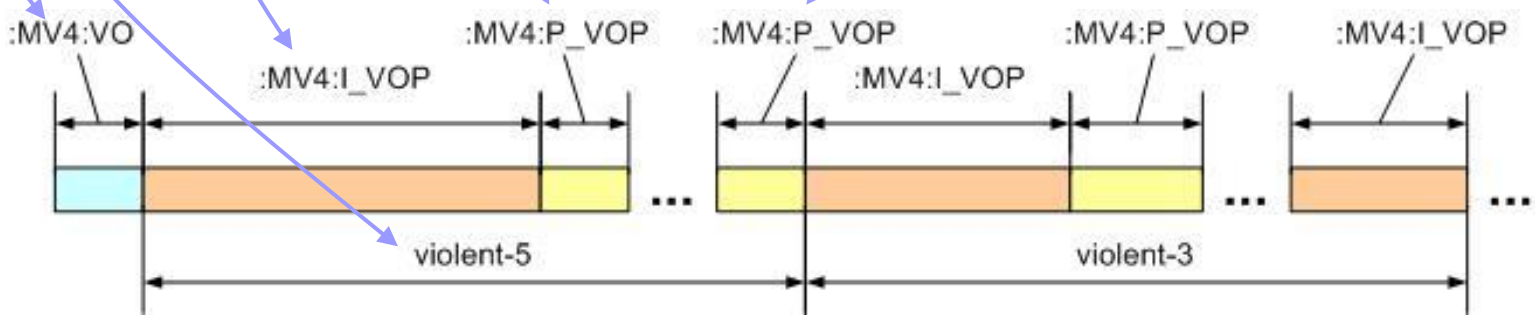
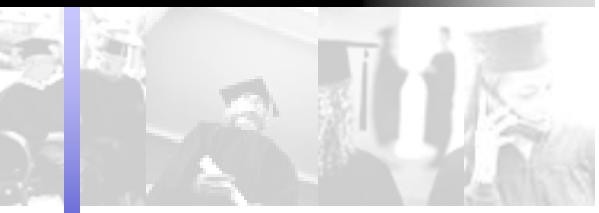
example: gBSD

```
<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 ... -->
```

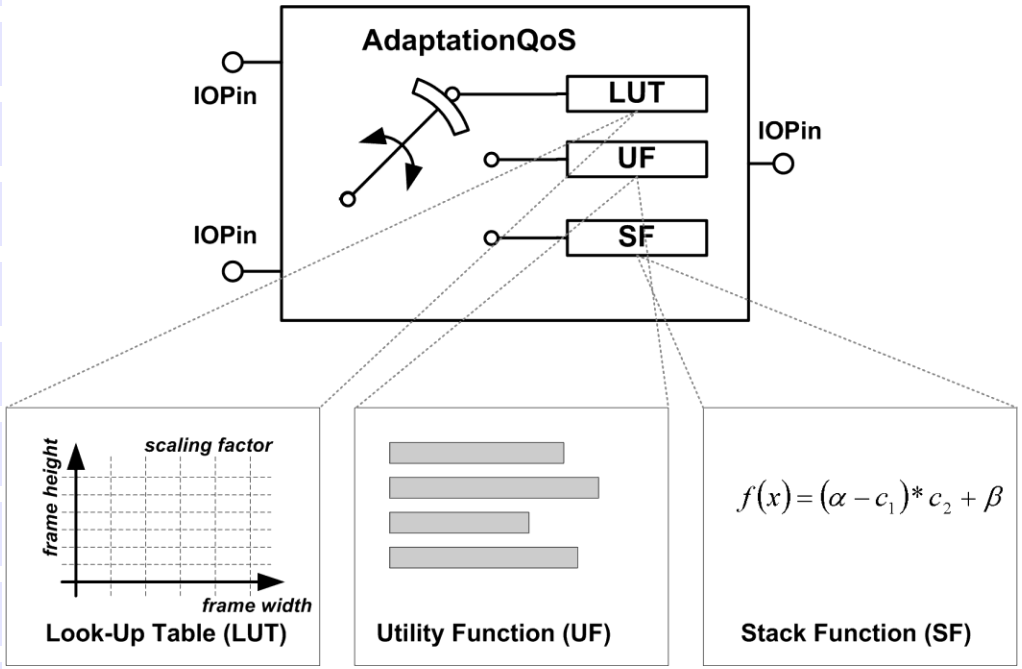




terminal and network quality of service

- **aka AdaptationQoS (AQoS)**
- **goal**
  - select optimal parameter settings
  - for media resource adaptation operators that
  - satisfy constraints imposed by terminals and/or networks
  - while maximizing Quality of Service
- **establish a priori resource budgets on various platforms**
- **select/drop information at different level of scalability**
- **specifies the relationship between**
  - constraints,
  - feasible adaptation operations satisfying these constraints, and
  - associated utilities (qualities).

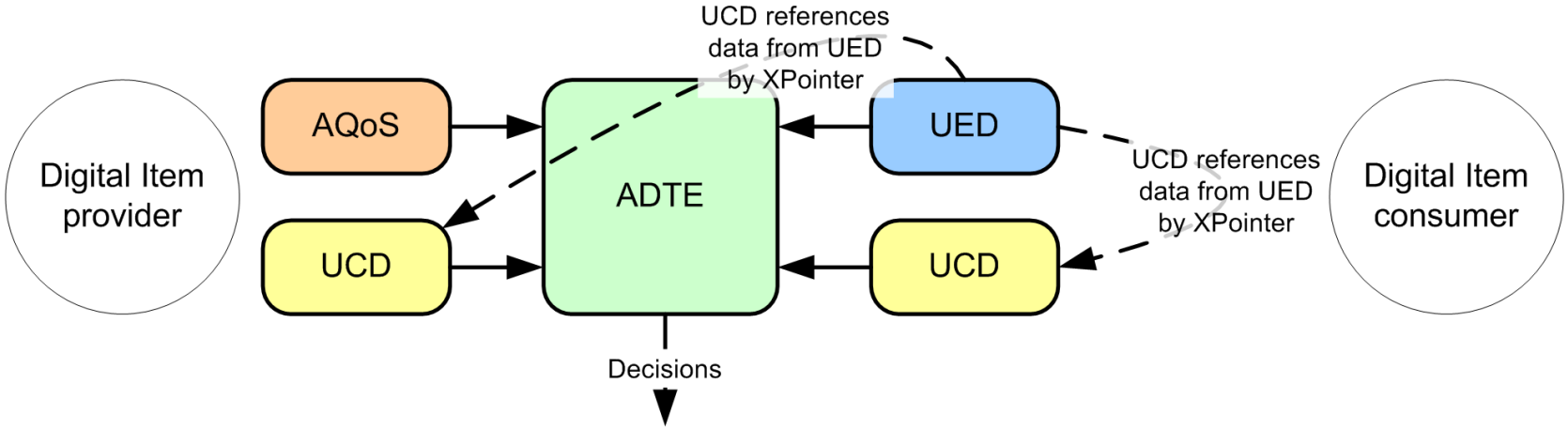
aqos – modules and iopins



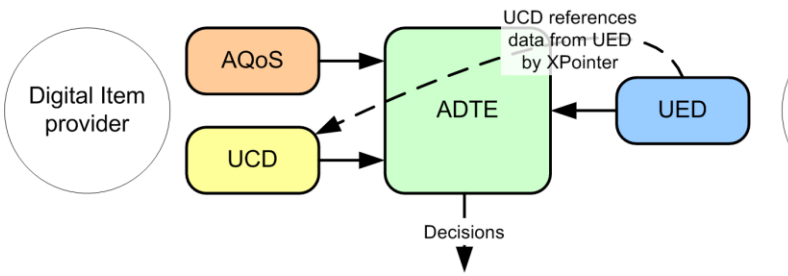
- **three types of modules**
  - look-up table: non-sparse, discrete data representation
  - utility function: sparse, discrete data representation
  - stack function: functional, continuous data representation
- **generic interface to these modules**
  - input/output pins (IOPins)

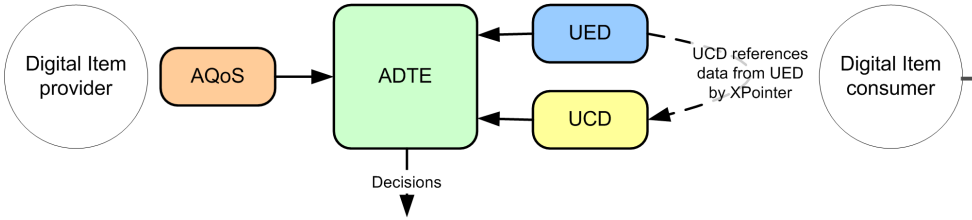
universal constraints description

- **allows to further constraining the *usage* and *usage environment* of a Digital Item**
- **types of constraints**
  - limitation constraints
  - optimization constraints
- **formulated using the stack function syntax**



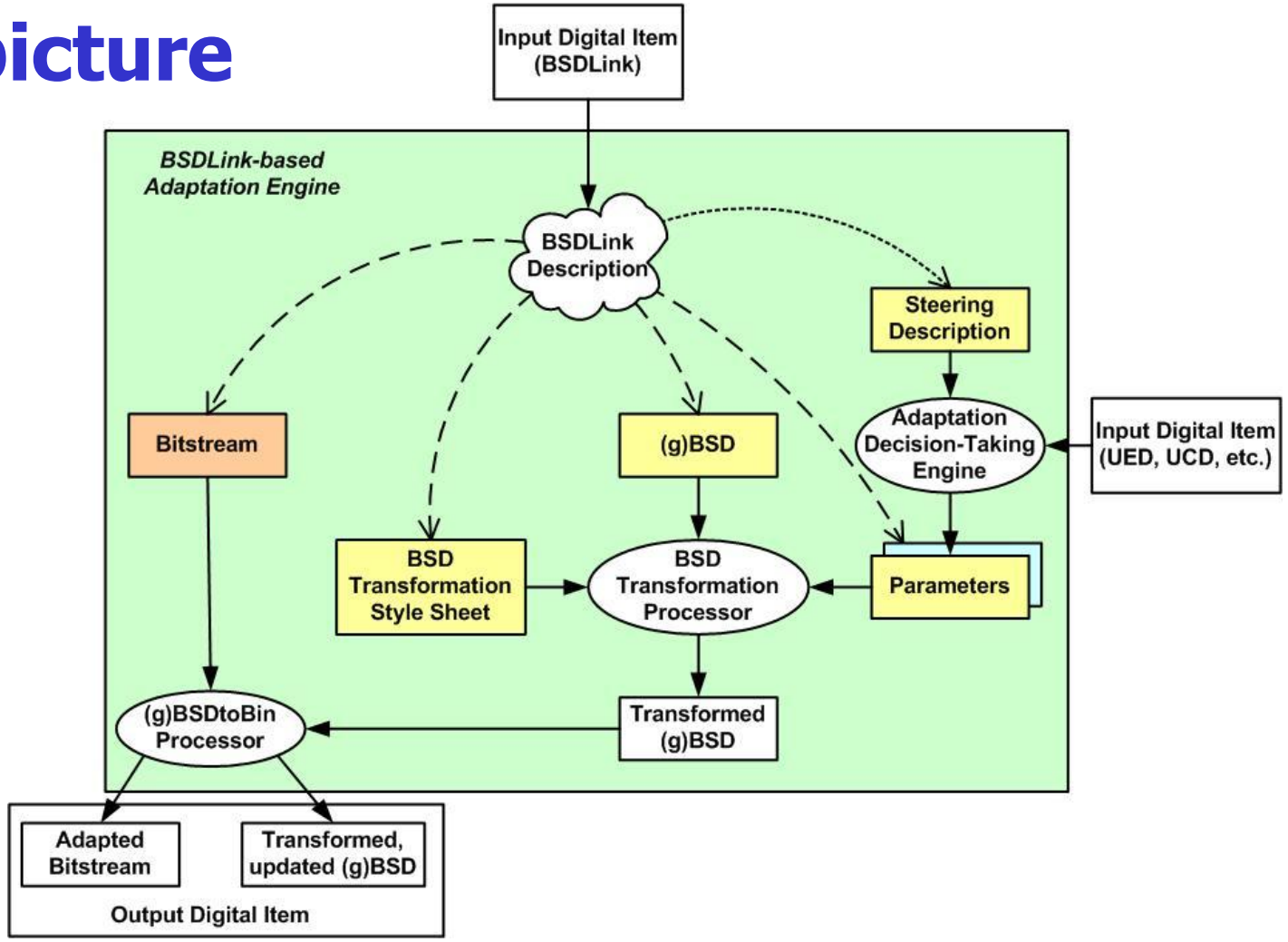
example: universal constraints description

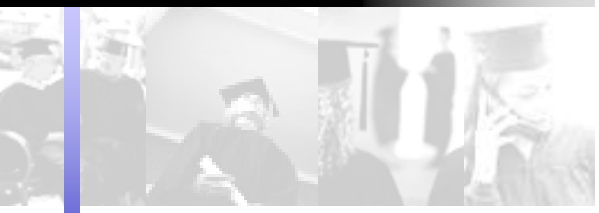




- **usage**
  - ! (image resolution < 20% of display resolution)
  - max. image dimension
- **usage environment**
  - image resolution < 75% of display resolution
  - max. according to the available network bandwidth

adapting the multimedia content – the big picture





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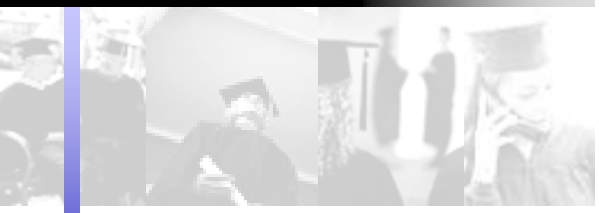
outline

- **introduction, goal, scope, and overview**
- **tools enabling device independence**
  - usage environment description
  - universal constraints description
- **tools enabling coding format independence**
  - (generic) Bitstream Syntax Description
  - AdaptationQoS, universal constraints description tools
  - BSDLink
- **miscellaneous**
  - metadata adaptation
  - session mobility
  - DIA configuration
- **amd.1: conversions and permissions**
- **amd.2: dynamic and distributed adaptation**
- **conclusion**



adapting metadata

- **metadata associates additional textual information to multimedia content**
- **allows for search, retrieval, content navigation**
- **adaptation of metadata**
  - content is adapted ➔ the associated metadata must also change accordingly
  - metadata is transmitted and consumed ➔ scaled in order to meet terminal and network constraints
  - given a very rich and detailed description ➔ filtering to obtain only the necessary or interesting parts
  - multiple sources of metadata for the same resource ➔ integration into a singe description

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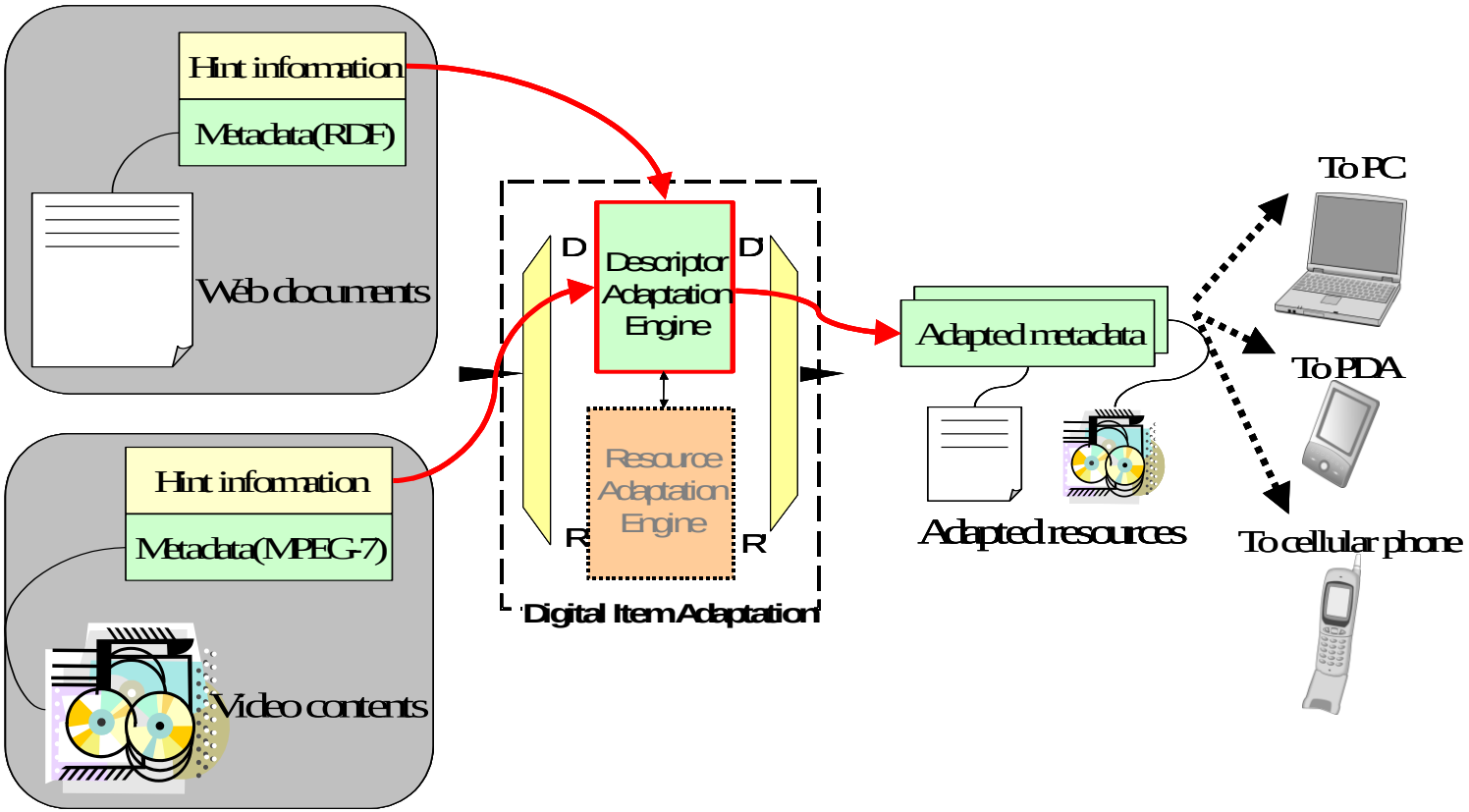
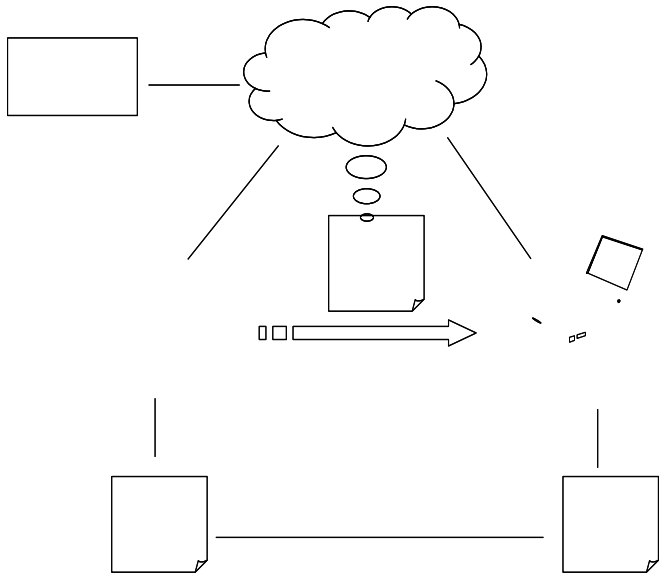
adapting metadata (cont'd)



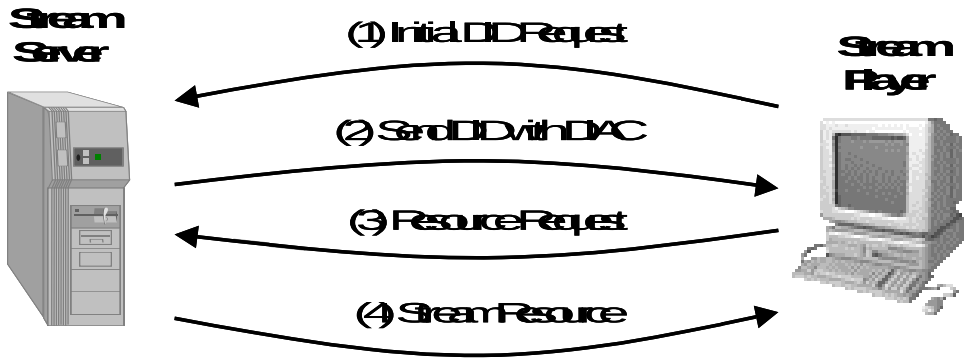
session mobility

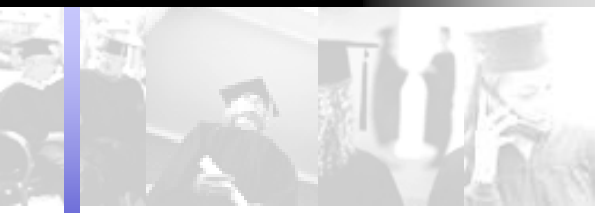
- **transferring Digital Items from one device to another device (cf. peer-to-peer networks)**
- **the DID provides the structure for resource and associated metadata**
- **what needs to be transferred?**
  - instantiation of choices and selections provided by the User – *configuration state*
  - information specific to the application currently rendering the Digital Item – *application state*



DIA configuration

- **guide adaptation process considering intentions of the author**
  - specify useful DIA descriptions that would help to either configure the DID or adapt the resources according to the usage environment in which they will be consumed
  - provide guidance on how the DID Choice/Selections should be processed, e.g., automatically or manually configured





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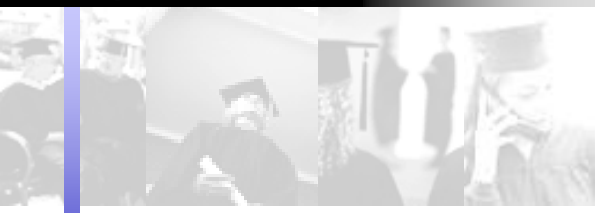
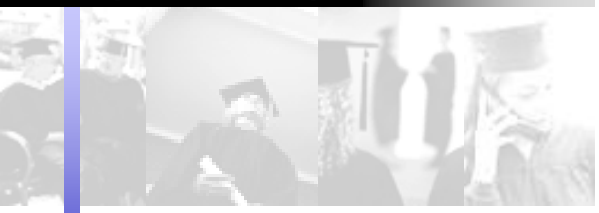


amd.1: conversions and permissions

- **facilitates the description of conversion-related information**
- **capabilities**
  - description of adaptation capabilities of a terminal
- **conversion link**
  - description of adaptation operation (e.g., image cropping) and parameters of the adaptation (e.g., x-y offset, width and height of cropped region)
- **cross conversion QoS**
  - relationship between different conversion options and its utility (e.g., transcoding, transmoding, transforming)
- **change conditions**
  - distinguish permitted changes from change constraints



amd.1: conversions and permissions (cont'd)

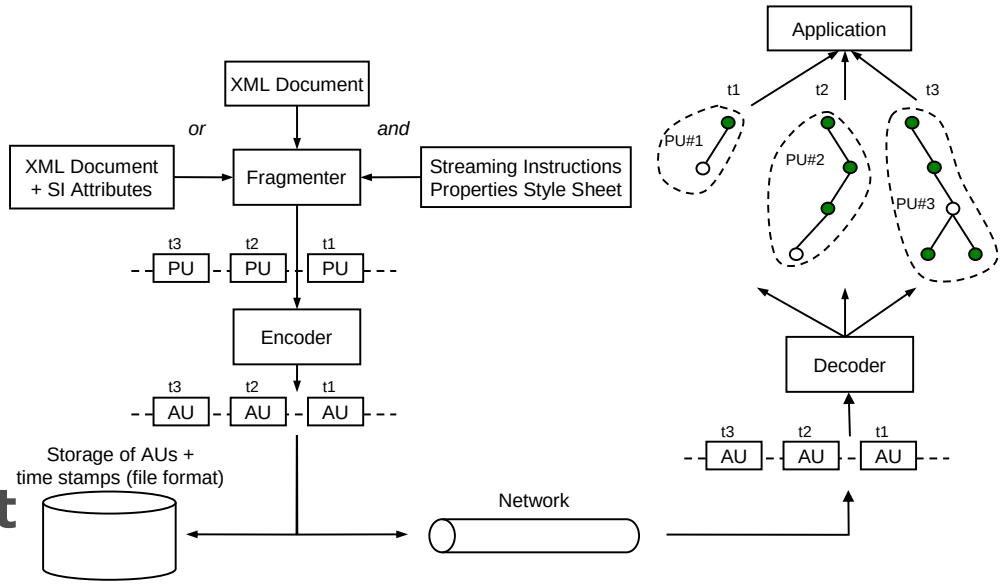
- **enables constraints to be imposed on adaptation**
  - using UCD, can limit adaptation operation itself and/or result of adaptation
  - to express the rights associated with an adaptation, a license conformant to the Rights Expression Language (REL: MPEG-21 Part 5) is needed
  - a license indicates permissible changes as detailed by the conversion info
  - for interoperability, conversion description info should be mapped to terms in the Rights Data Dictionary (RDD: MPEG-21 Part 6)

note that REL and RDD already provide tools to permit playing, modifying, and adapting; however, only with coarse control

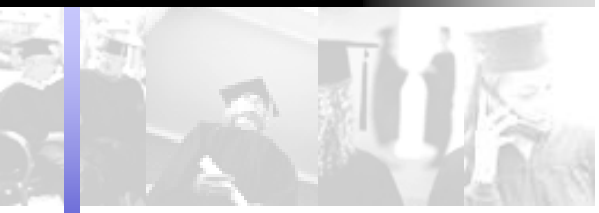
amd.1 of DIA essentially enables finer-grained control over the changes that can occur when playing, modifying, or adapting Digital Items and their component resources

amd.2: dynamic and distributed adaptation

- **defines set of properties and attributes**
  - fragmentation
  - timing
  - random access point
- **used for streamed processing and transport**

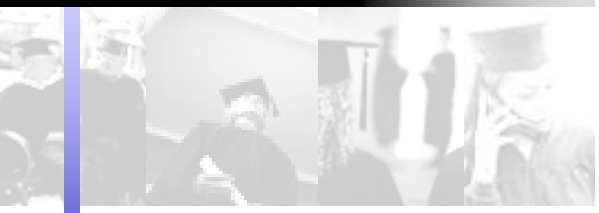


- **dynamic adaptation**
  - refers to the adaptation of Digital Items according to dynamically changing usage environments
- **distributed adaptation**
  - multiple adaptation steps successively performed on different MPEG-21 peers



conclusion

- **DIA provides means for describing the usage environment/delivery context**
  - enables device independent universal multimedia access
- **DIA provides means for describing the structure of bitstreams**
  - enables format independent multimedia adaptation
- **DIA provides means for**
  - metadata adaptation
  - session mobility
  - configuration of a DIA engine
- **DIA specification is available (⇨www.iso.org)**
  - needs to be adopted by the industry or other standardisation bodies
  - additional standardization activities, research topics, and open issues
    - adaptation in constrained & streaming environments
    - transport, negotiation & exchange of DIA descriptions
    - semantic clues for adaptation
    - maximize the User experience
    - end-to-end Quality of Service



references

- **published standards ➔ ISO**
  - http://www.iso.org
- **standards under development and working documents ➔ MPEG Website**
  - http://www.chiariglione.org/mpeg/
  - http://www.chiariglione.org/mpeg/working_documents/mpeg-21/dia/dia_fcd.zip
- **A. Vetro, C. Timmerer and S. Devillers, "Digital Item Adaptation", The MPEG-21 Book, John Wiley & Sons, 2006.**
- **A. Vetro and C. Timmerer, "Overview of the Digital Item Adaptation Standard", IEEE Trans. on Multimedia, *Special Issue on MPEG-21*, vol. 7, no. 3, June 2005.**
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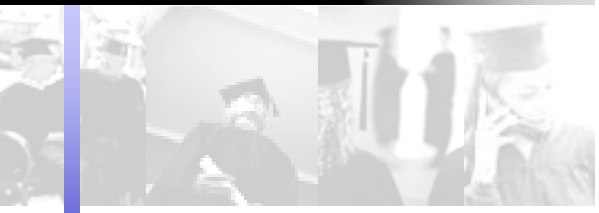
- **G. Panis, et. al., "Bitstream Syntax Description: A Tool for Multimedia Resource Adaptation within MPEG-21", EURASIP Signal Processing: Image Communication Journal, vol. 18, 2003.**
- **http://mpeg-21.itec.uni-klu.ac.at**



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thank you for your attention

questions, comments, etc. are welcome ...

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