



Universal Multimedia Access in MPEG-21

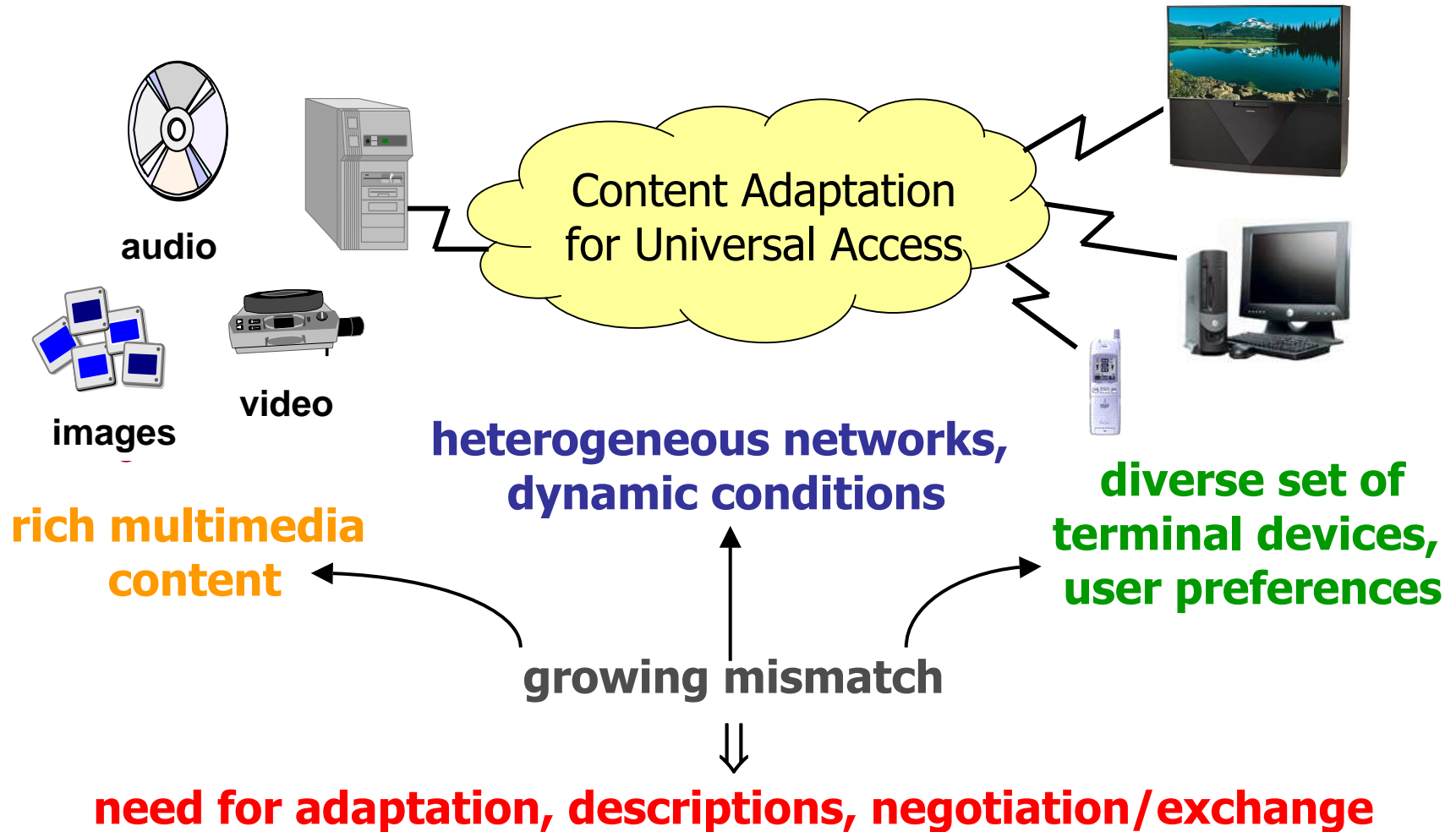
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Acknowledgement to DIA Co-Editor's
Christian Timmerer and Sylvain Devillers



Universal Multimedia Access





Scope of Digital Item Adaptation (DIA)

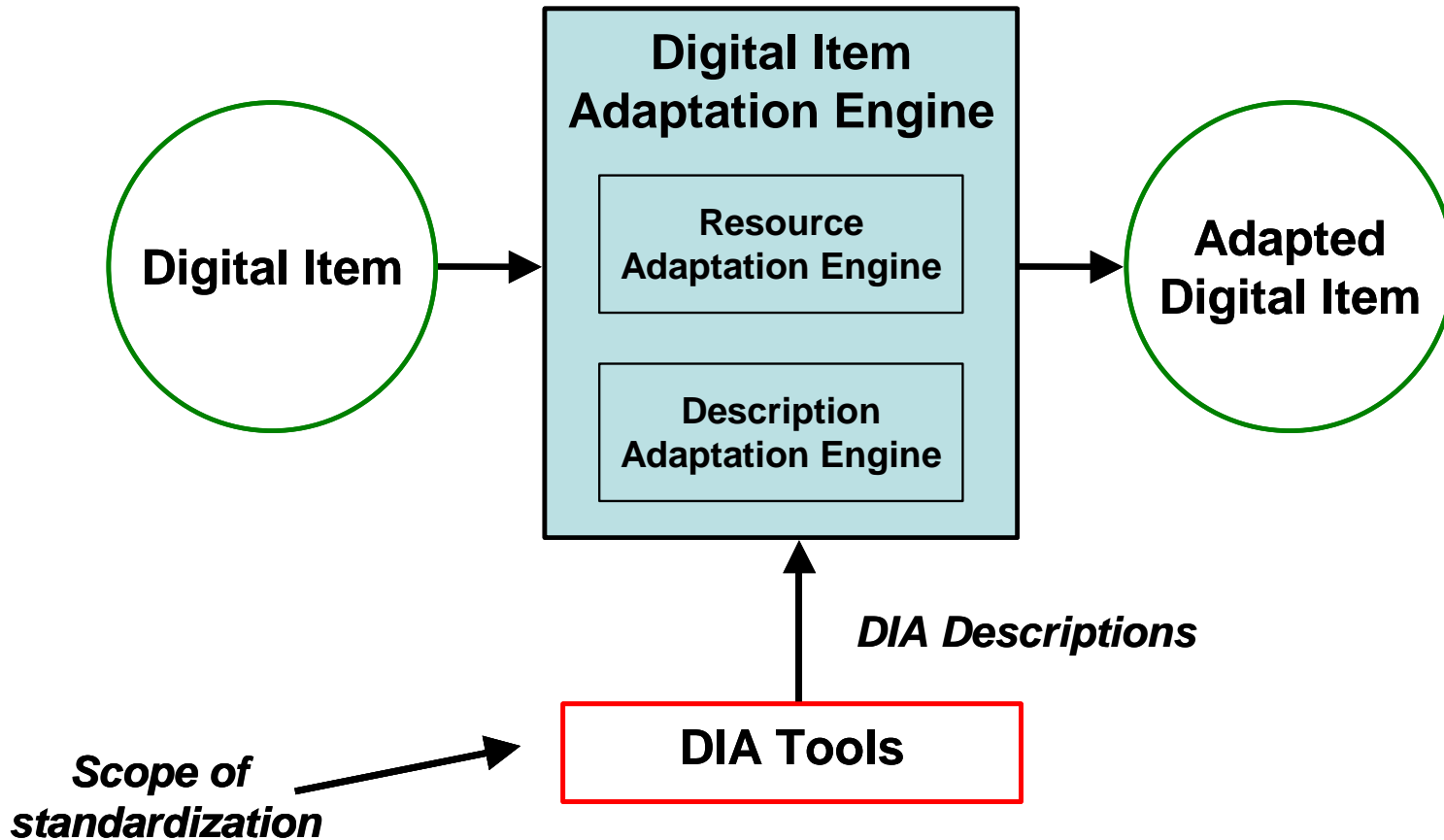
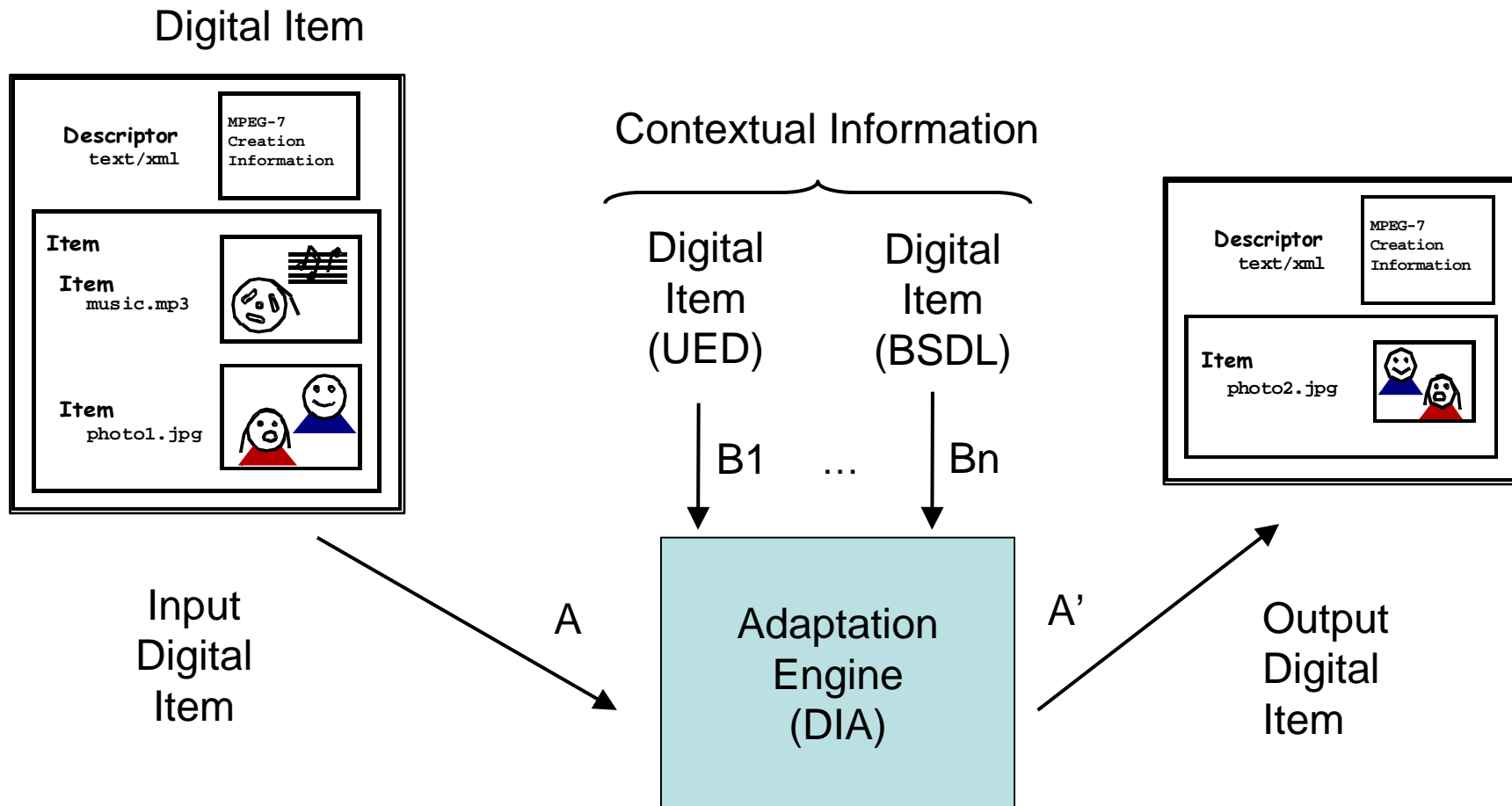




Illustration of DIA





Digital Item Adaptation

- ISO/IEC 21000-7: Specification was finalized in December 2003 and has been published by ISO
- Tools have been standardization that describe:
 - User characteristics, terminal capabilities, network characteristics and natural environment characteristics
 - High-level syntax of a binary media resource
 - Relationship between QoS constraints, feasible adaptation operations satisfying these constraints and associated media qualities
 - Limitation and optimization constraints on adaptations
 - Metadata adaptation hint information
 - Configuration-state information of a Digital Item
 - Information required for the configuration of an adaptation engine





Usage Environment Description Tools

User Characteristics

- User Info
- Usage Preference & History
- Presentation Preferences
- Accessibility
- Location

Terminal Capabilities

- Codec Capabilities
- Device Properties
- Input-Output Characteristics

Network Characteristics

- Capabilities
- Conditions

Natural Environment Characteristics

- Location & Time
- Audio-Visual





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

```

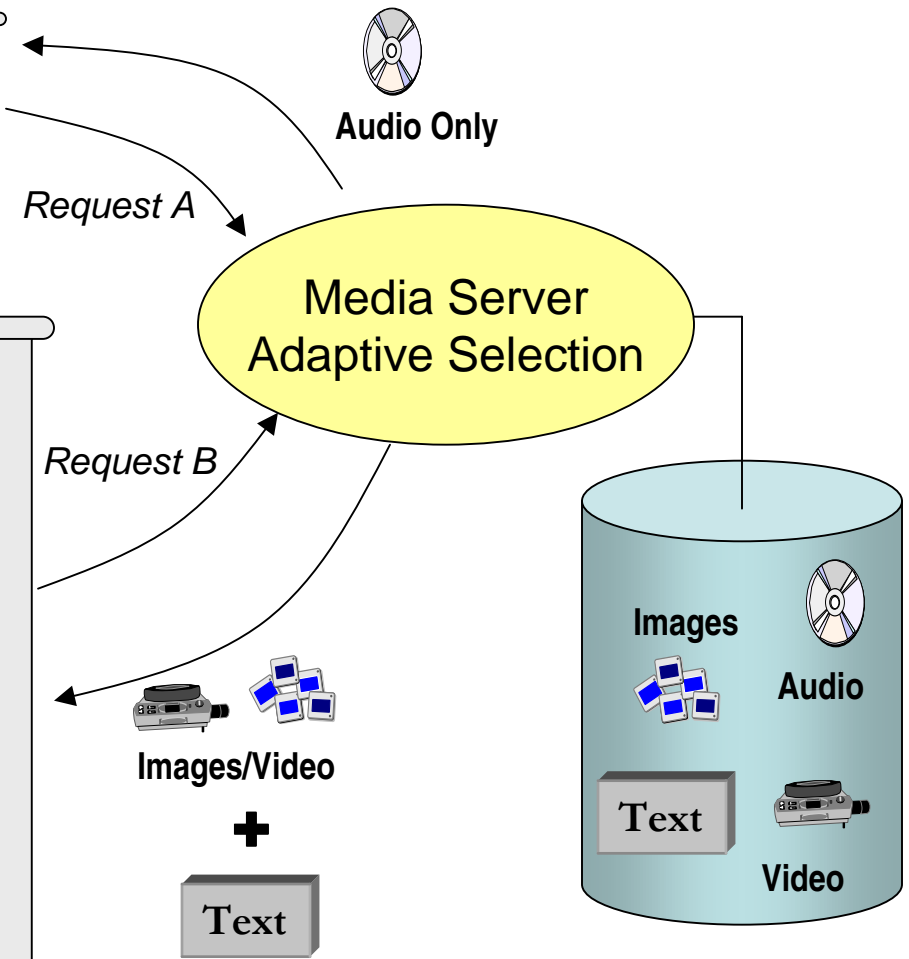
...
<User id="User_A">
  <UserCharacteristic xsi:type="VisualImpairmentType">
    <Blindness eyeSide="both"/>
  </UserCharacteristic>
</User>
...

```

```

...
<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>
...

```





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
 - DeviceClass, e.g., PC, PDA, Set-top-box
 - DataIO, e.g., bus width and speed



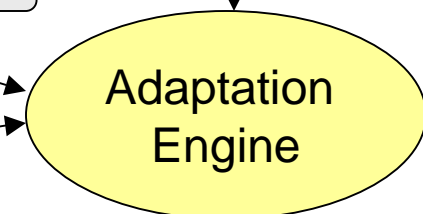
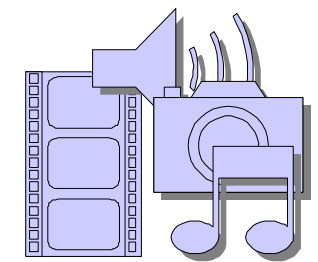
Use Case: Format Compatibility

```

...
<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

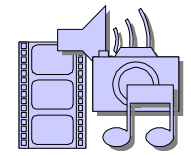


```

...
<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 Characteristics

- 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
- 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: Efficient and Robust Transmission

```
...  
<Network>  
  <NetworkCharacteristic xsi:type="NetworkCapabilityType"  
    maxCapacity="384000" minGuaranteed="32000"/>  
  <NetworkCharacteristic xsi:type="NetworkConditionType"  
    startTime="2004-01-31T15:22:08+01:00" duration="PT2S">  
    <AvailableBandwidth average="44000"/>  
    <Error packetLossRate="0.10"/>  
  </NetworkCharacteristic>  
</Network>  
...
```

- Available Bandwidth
 - Output bit-rate after adaptation should satisfy this constraint
- Packet Loss Rate
 - Use this to guide amount of robustness being inserted into stream
 - Potential Strategies
 - Reduce error propagation with resynchronization markers and/or intra refresh
 - Data partitioning to protect important parts of bitstream



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>  
...
```

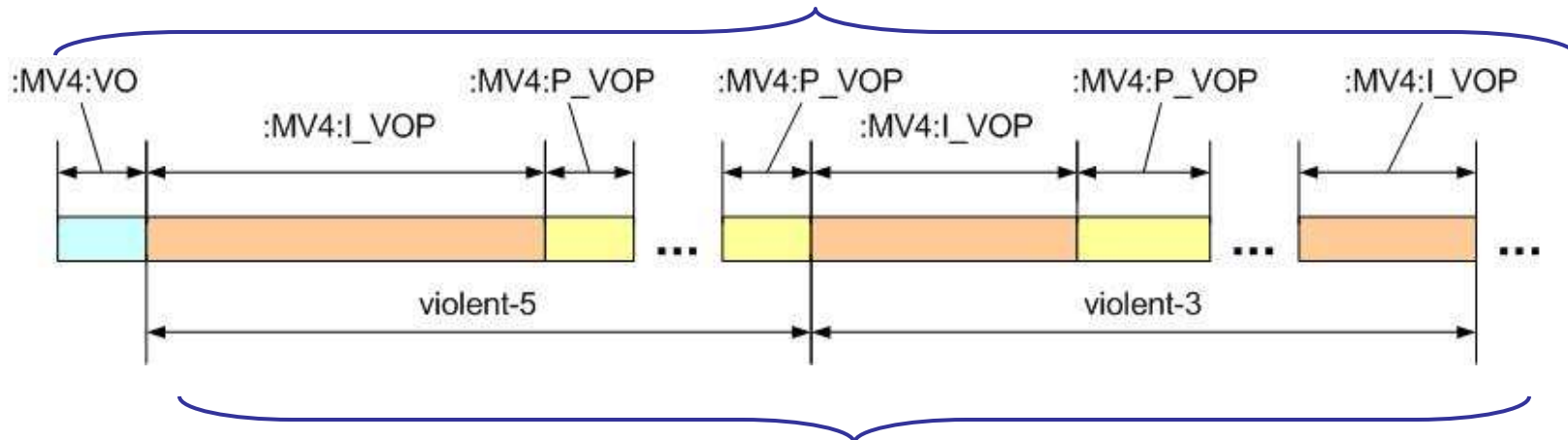
Based on audio noise characteristics, enhancement of the perceived quality could be achieved by masking or attenuating selected frequencies during adaptation



Bitstream Syntax Description (BSD)

- XML document describing the high-level structure of a bitstream
 - E.g., headers, packets or layers... not bit-per-bit
- BSD is not an alternative format, but an additional layer of metadata
- Allows finer or coarser levels of detail, depending on the application

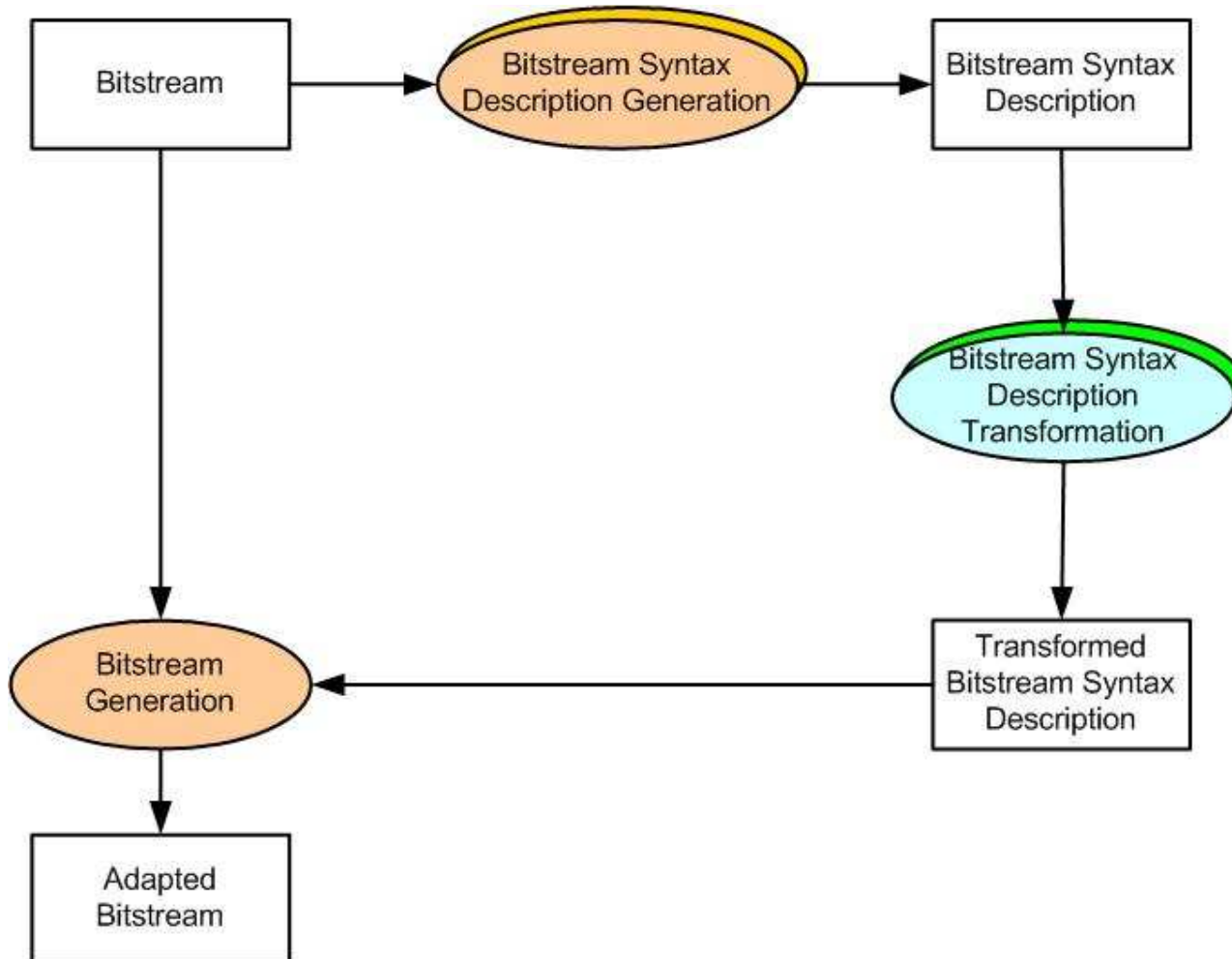
Syntactic Description of MPEG-4 Bitstream to VOP Level



Semantic Description of Segments



BSD-based Adaptation



Adaptation in XML domain





BSD Language (BSDL)

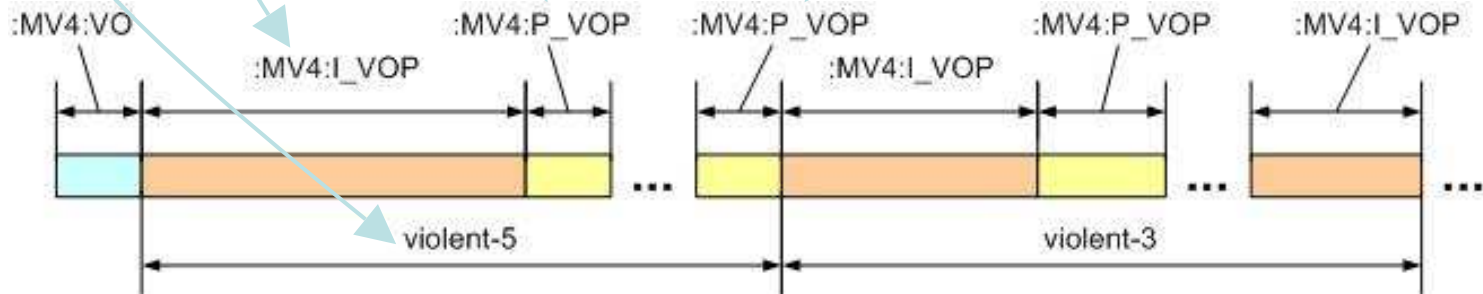
- New language is defined based on W3C XML Schema
 - Restrictions and extensions wrt. multimedia
- Enables the design of BS Schemas
 - Defines constraints on XML documents in terms of structures and data types
- Functionality
 - XML validation of the BSD against its BS Schema
 - Parse a BSD and generate the bitstream (BSDtoBin)
 - Parse a bitstream and generate its BSD (BintoBSD)



generic BSD (gBSD)

- gBS Schema is conformant to BSDL
- Key functionalities include format independence, semantically meaningful marking, hierarchical, flexible addressing scheme

```
<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="58022" 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 ... -->
```





Adaptation QoS

- Goal
 - Select optimal parameter settings for media resource adaptation operators that satisfy constraints imposed by terminals and/or networks, while maximizing Quality of Service
- Specifies the relationship between
 - Constraints
 - e.g., available bandwidth is 384kbps, terminal display is SIF
 - Feasible adaptation operations satisfying these constraints
 - e.g., reduce bit-rate, spatial resolution
 - Associated utilities (qualities)
 - e.g., quality at QCIF/30fps/QP=10 versus SIF/10fps/QP=15



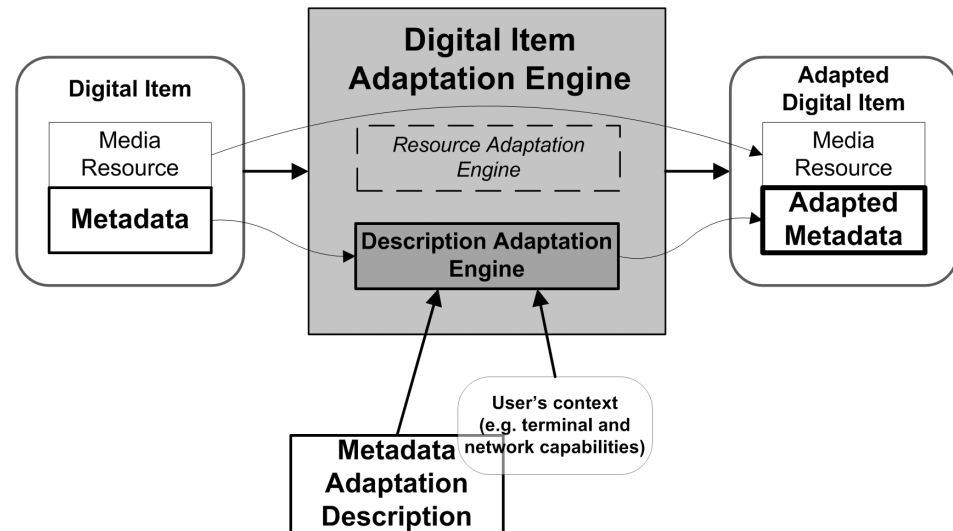
Universal Constraints Description (UCD)

- Tool to express various constraints
 - Limitation constraints (e.g., greater than, equal to)
 - Optimization constraints (e.g., max, min)
- UCD expressions are formulated using a stack function
- Examples
 - Constraint on usage
 - ! (image resolution $<$ 20% of display resolution)
 - max. image dimension
 - Constraint on usage environment
 - image resolution $<$ 75% of display resolution
 - max. according to the available network bandwidth



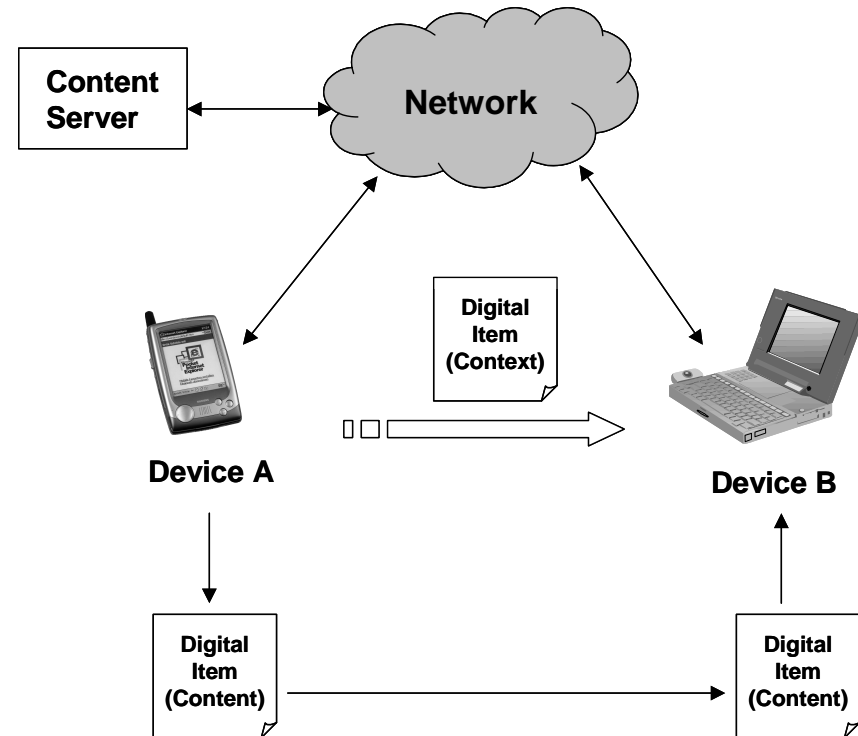
Metadata Adaptation

- Metadata
 - Associates additional textual information to multimedia content
 - Allows for search, retrieval, content navigation
- Needs for metadata adaptation
 - Content is adapted → associated metadata must also change accordingly
 - Metadata is transmitted/consumed → scale to meet terminal/network constraints
 - Given a very rich and detailed description → filtering to obtain only necessary parts
 - Multiple sources of metadata for same resource → integration to single description
- Adaptation Hints
 - Given prior knowledge about the metadata, hint information is used to reduce the complexity of the metadata adaptation process

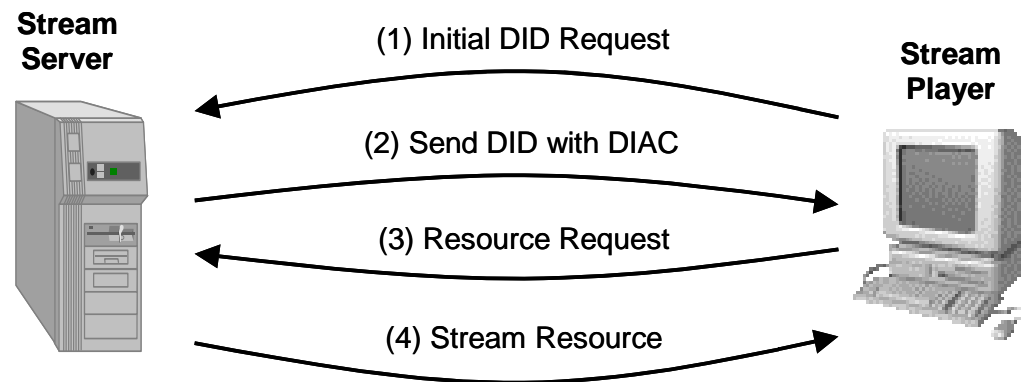


Session Mobility

- Goals
 - Transfer the “state” of a Digital Item from one device to another
 - State information may consist of the following
 - Timing information of a video clip
 - Track number of an audio playlist
 - Synchronization information
- DIA defines a normative means to accomplish this transfer and exchange



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



Adaptation Rights

- Rights expression must be used to enforce adaptations that are permissible, e.g., by content owners
 - EXAMPLE 1: Audio file can be played if the bit-rate is less than 64kbps
 - EXAMPLE 2: Video file can be played if the only formal change is spatial resolution reduction that maintains aspect ratio and the spatial resolution is less than 352x240
- Rights expression must also be used to protect user-sensitive info specified by DIA, e.g., user characteristics



Permissible Adaptations

- Framework specified in Amd.1 of DIA
 - Facilitates the description of conversion-related information
 - Description of adaptation operation (e.g., image cropping) and parameters of the adaptation (e.g., x-y offset, width and height of cropped region)
 - Description of change conditions (distinguish permitted changes from change constraints)
 - 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



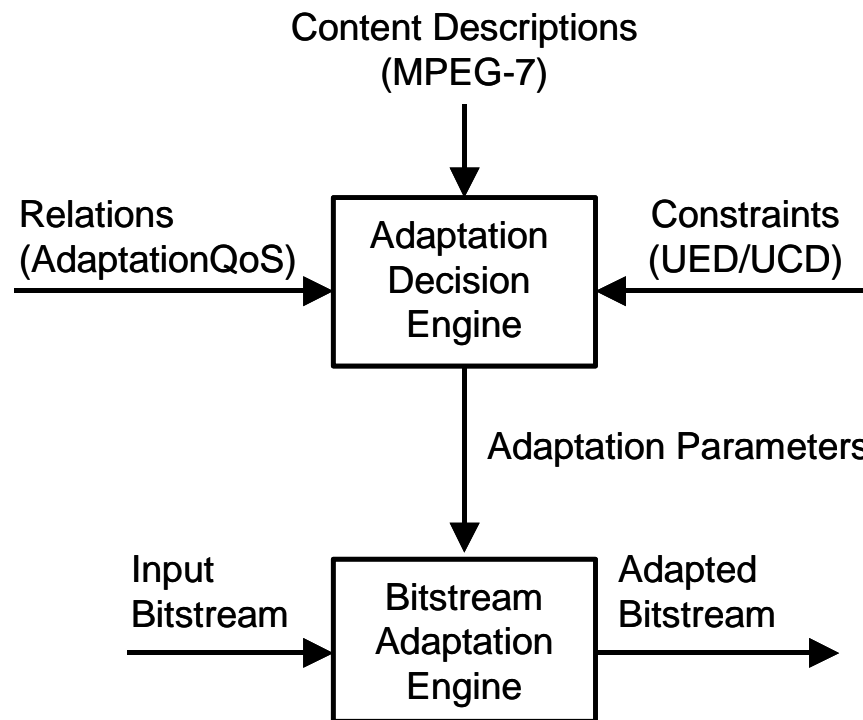
UMA – Where do we stand?

- There is clearly a need to transmit and consume multimedia content in diverse types of usage environments and contexts
- There are various forms of mature adaptation techniques that allow providers to match consumption requirements
- Many exciting applications enabled, e.g., remote/interoperable access to multimedia, personalized media variations, etc.
- Support by several international standards play a key role
 - MPEG-7 and MPEG-21 in particular



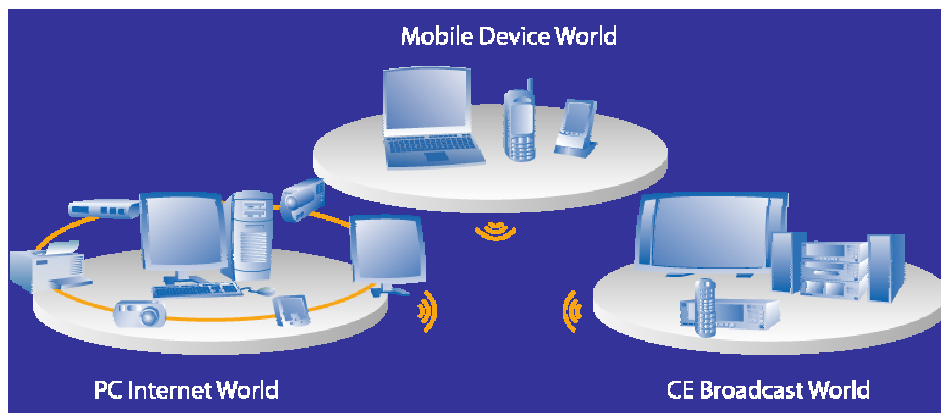
Essentiality of MPEG-7/21 Standards

- Standards are required for effective end-to-end design
 - Strong dependency between components in overall adaptation system, including analysis, transmission and usage environment monitoring
 - Interoperability of adaptation technologies is needed



Next steps?

- We have a very rich set of tools that needs focus → DIA profiles
- Need to work out transport and exchange mechanisms for target scenarios → there is already some activity in MPEG and IETF on this
- Look for potential links within MPEG, e.g., scalable video coding
- Promote technology to relevant industry forums, e.g., DLNA



DLNA: industry forum developing design guidelines based on open standards to facilitate:

- Interoperability among PC, CE, Mobile (ensure seamless operation)
- Content sharing across various devices using Internet based solutions



References

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- S. Devillers, C. Timmerer, J. Heuer, and H. Hellwagner, "Bitstream Syntax Description", [IEEE Trans. on Multimedia, Special Issue on MPEG-21](#), June 2005.
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