

# MPEG Standards Enabling Universal Multimedia Access

## MPEG-21 Digital Item Adaptation

**Christian Timmerer**

Dept. of Information Technology, Klagenfurt Univ., Austria

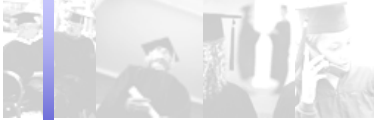
**1<sup>st</sup> Int'l. Conf. on  
Automated Production of Cross Media Content for Multi-channel Distribution  
~AXMEDIS 2005~  
December 1, 2005**

**Acknowledgement:  
Anthony Vetro**



## 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**



## 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

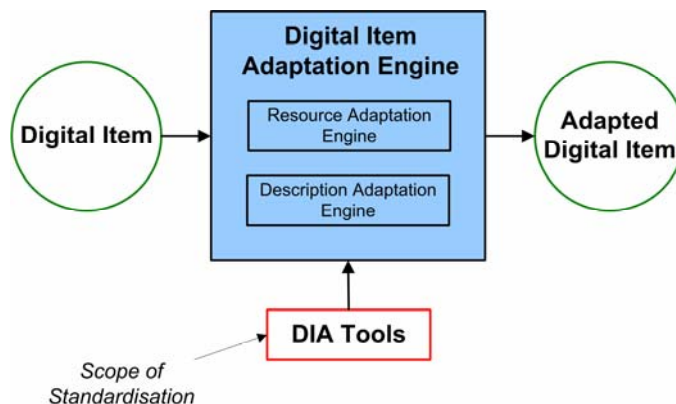
2005/12/01

Christian Timmerer, Department of  
Information Technology, Klagenfurt University

3



## intro – overview and scope

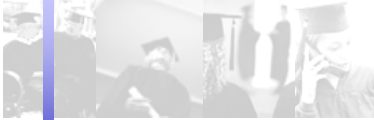


- ... specifies the **syntax** and **semantics** of tools
- ... **assist the adaptation** of Digital Items
- ... used to satisfy **transmission, storage and consumption** constraints as well as **Quality of Service management**

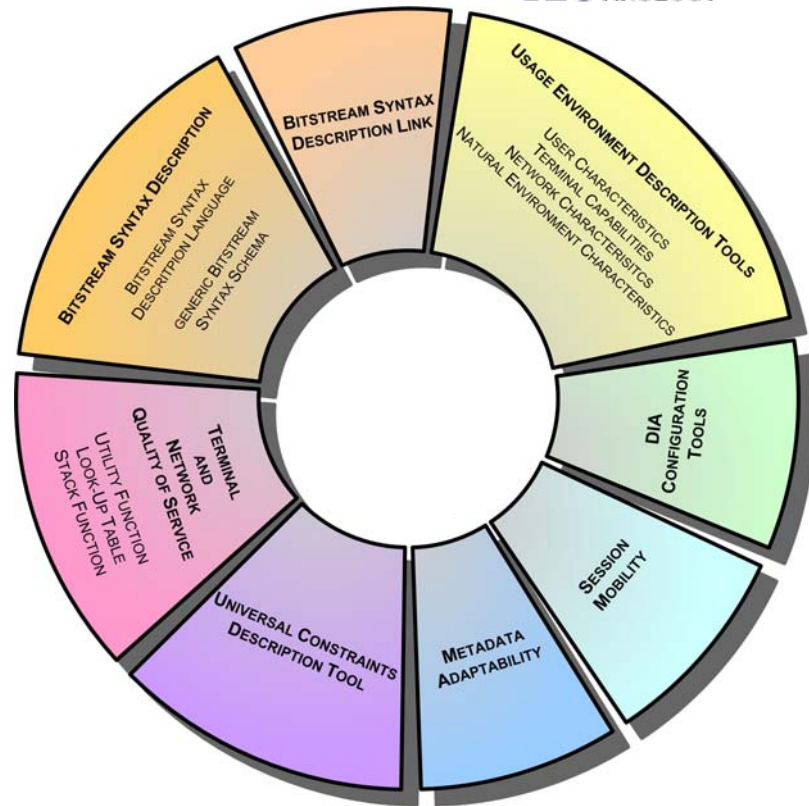
2005/12/01

Christian Timmerer, Department of  
Information Technology, Klagenfurt University

4



## intro – overview of tools



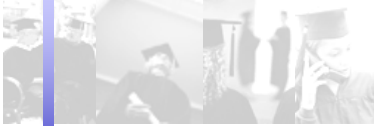
2005/12/01



## 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**

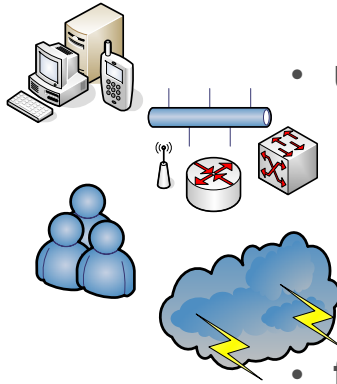
2005/12/01



*W3C DDWG*  
*if you can describe it,*  
*you can adapt to it*



## "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**

2005/12/01

Christian Timmerer, Department of  
 Information Technology, Klagenfurt University

7



## 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

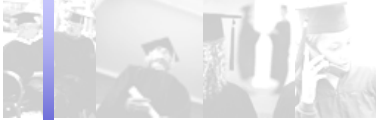
- **device properties**

- 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

2005/12/01

Christian Timmerer, Department of  
 Information Technology, Klagenfurt University

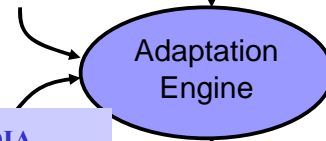
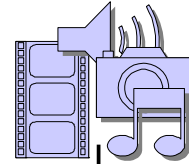
8



## 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



2005/12/01

Christian Timmerer, Department of  
Information Technology, Klagenfurt University

9



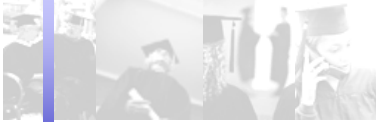
## network capabilities

- **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

2005/12/01

Christian Timmerer, Department of  
Information Technology, Klagenfurt University

10



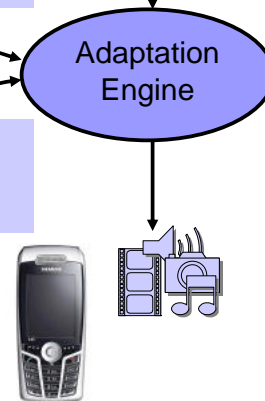
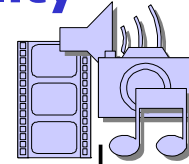
## use case: bandwidth compatibility

```
<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



2005/12/01

Christian Timmerer, Department of  
Information Technology, Klagenfurt University

11



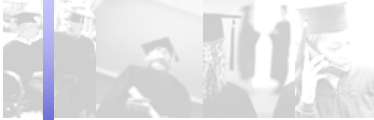
## user characteristics

- **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

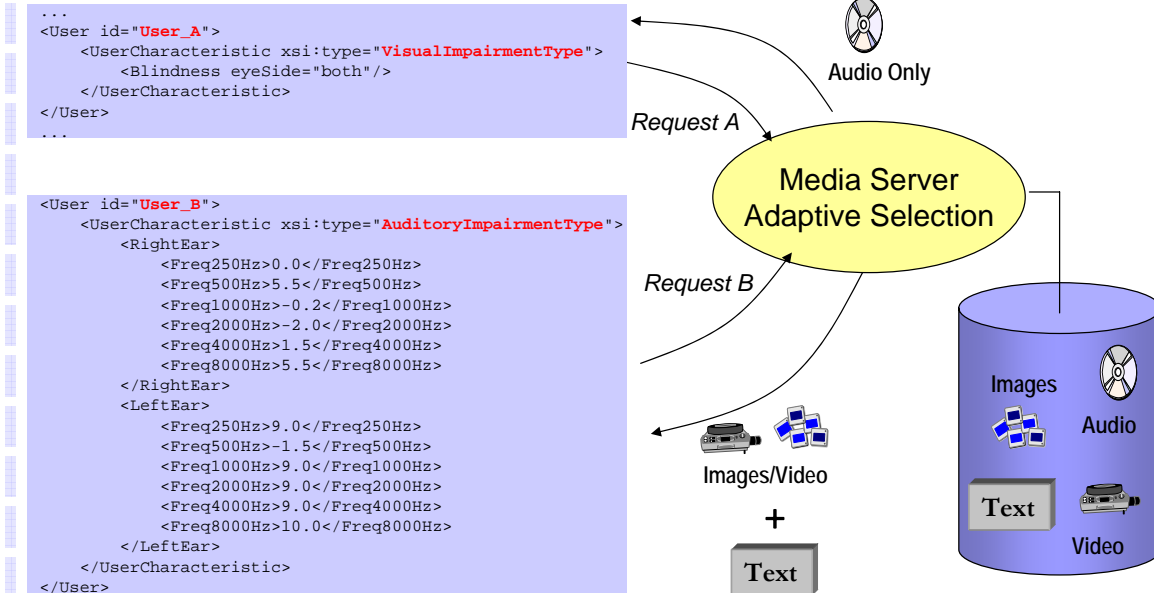
2005/12/01

Christian Timmerer, Department of  
Information Technology, Klagenfurt University

12



## use case: adaptive selection of resources



2005/12/01

Christian Timmerer, Department of  
Information Technology, Klagenfurt University

13



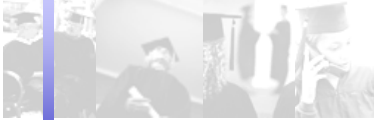
## natural environment characteristics

- **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

2005/12/01

Christian Timmerer, Department of  
Information Technology, Klagenfurt University

14



## 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**

2005/12/01

Christian Timmerer, Department of  
Information Technology, Klagenfurt University

15



## 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**

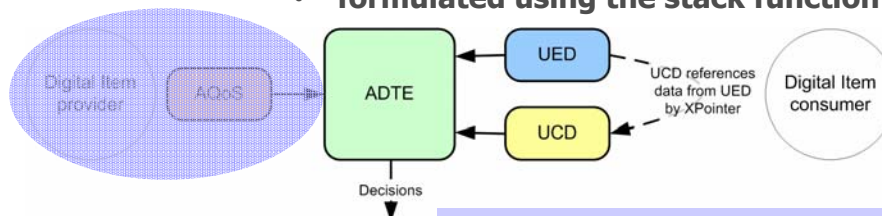
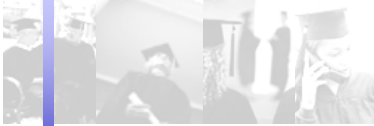


image resolution < 75% of display resolution  
 ◇  
 max. according to the available network bandwidth

2005/12/01

Christian Timmerer, Department of  
Information Technology, Klagenfurt University

16



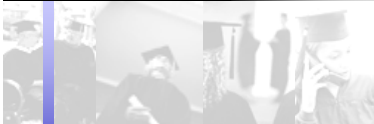
# outline

- **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**

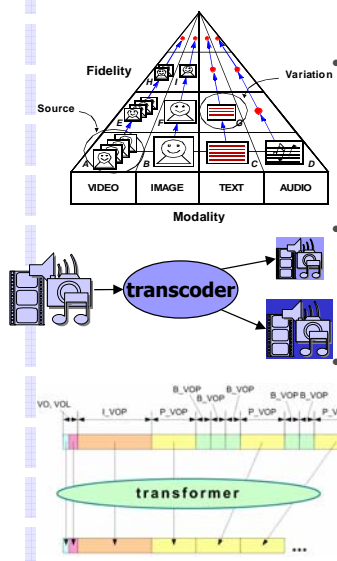
2005/12/01

Christian Timmerer, Department of  
Information Technology, Klagenfurt University

17



# "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

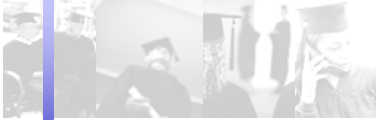
## adaptation by transformation

- 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, ...

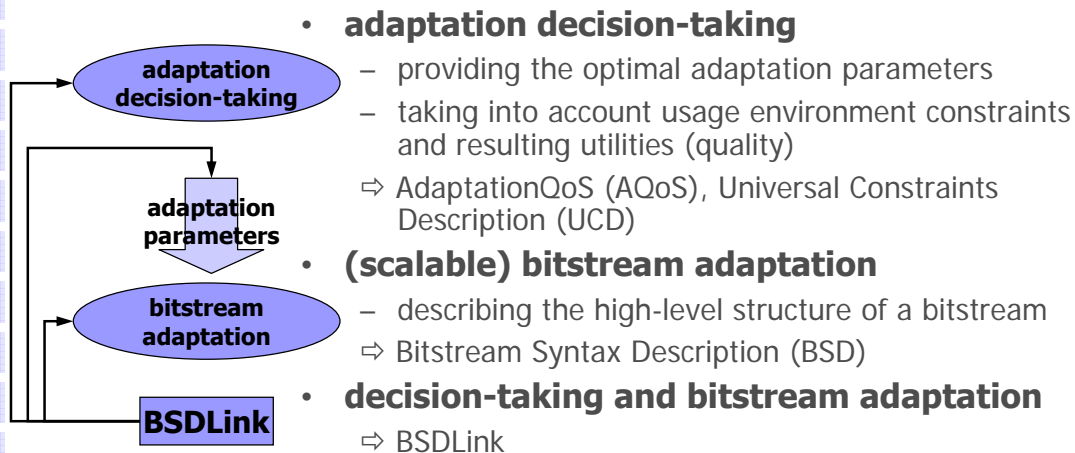
2005/12/01

Christian Timmerer, Department of  
Information Technology, Klagenfurt University

18

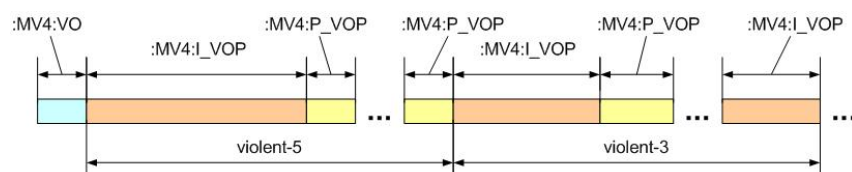


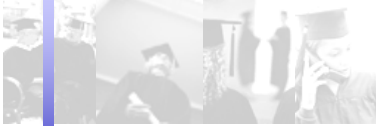
## coding format independence (cont'd)



## 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

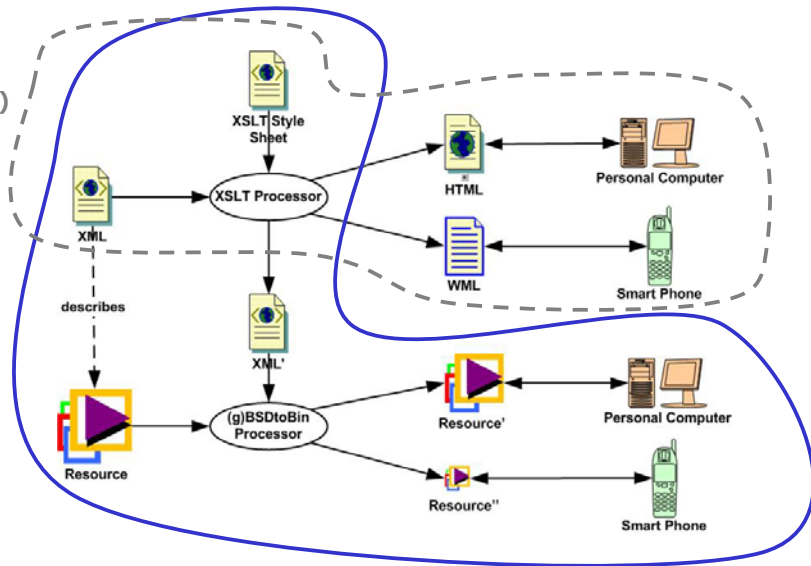




## BSD – introduction (cont'd)

traditional  
Web (XML/XSLT)  
publishing

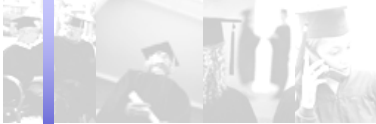
BSD-based  
multimedia  
“publishing”



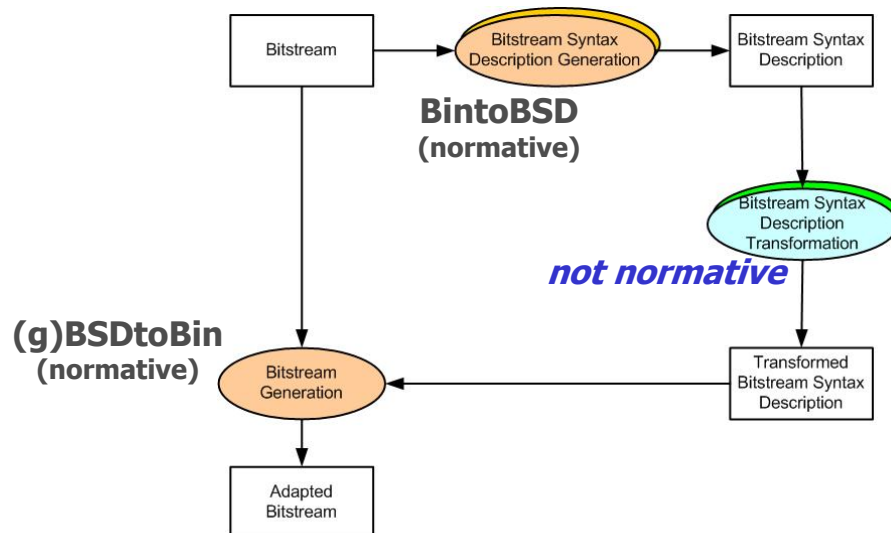
2005/12/01

Christian Timmerer, Department of  
Information Technology, Klagenfurt University

21



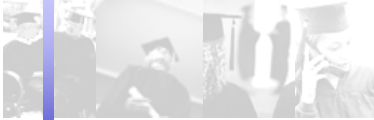
## BSD – introduction (cont'd)



2005/12/01

Christian Timmerer, Department of  
Information Technology, Klagenfurt University

22

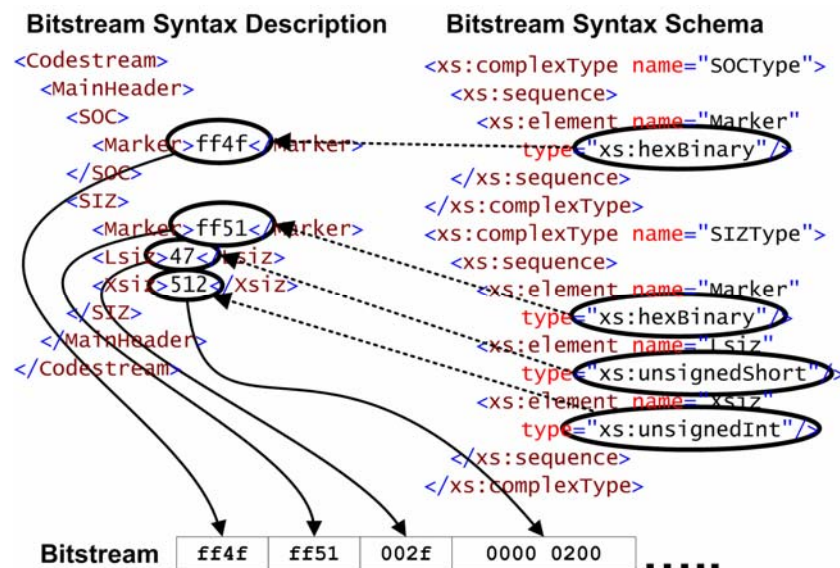


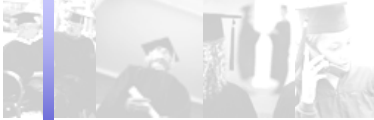
## BSD – Bitstream Syntax Description Language

- **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

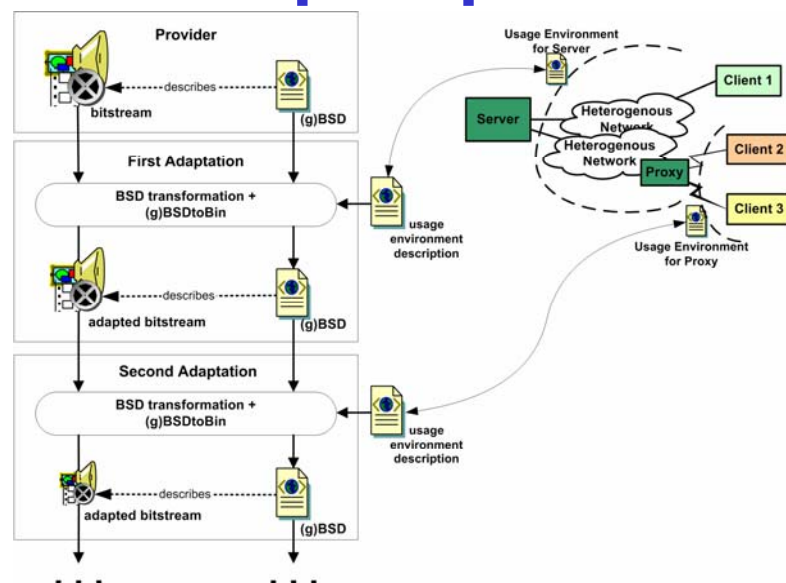
2005/12/01

Christian Timmerer, Department of  
Information Technology, Klagenfurt University

25



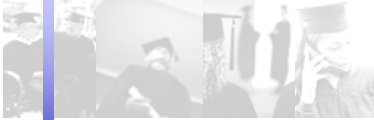
## example: multi-step adaptation



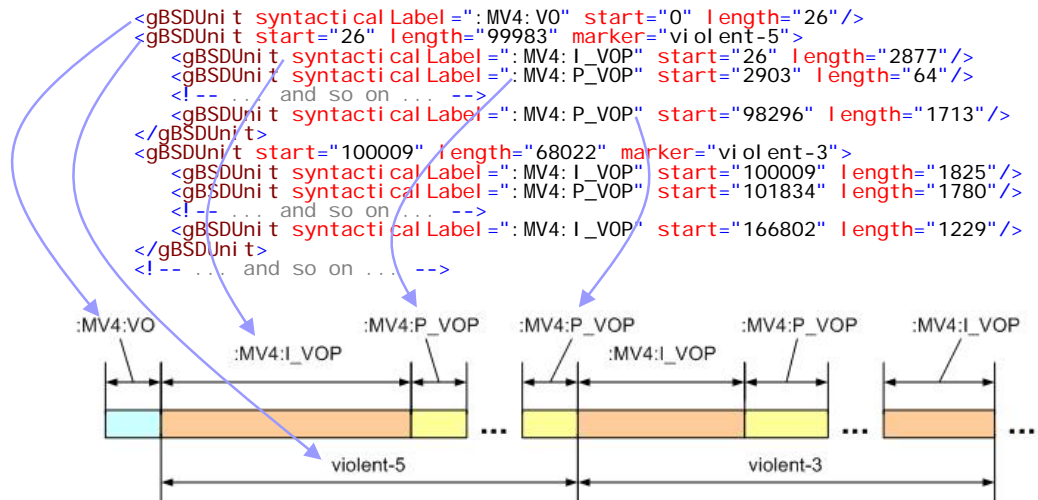
2005/12/01

Christian Timmerer, Department of  
Information Technology, Klagenfurt University

26



## example: gBSD



2005/12/01

Christian Timmerer, Department of  
Information Technology, Klagenfurt University

27



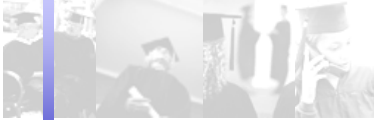
## terminal and network quality of service

- **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).

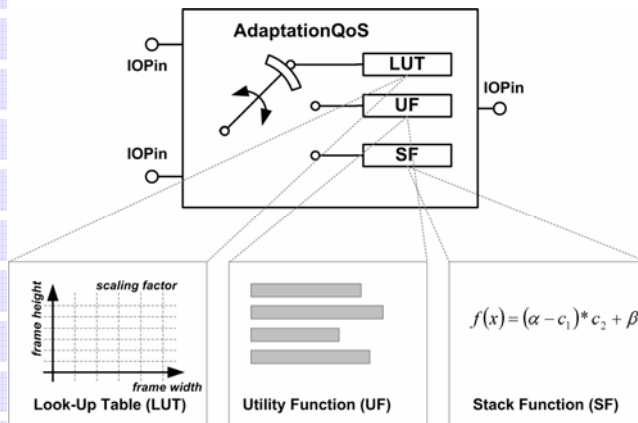
2005/12/01

Christian Timmerer, Department of  
Information Technology, Klagenfurt University

28



## aqos – modules and iopins

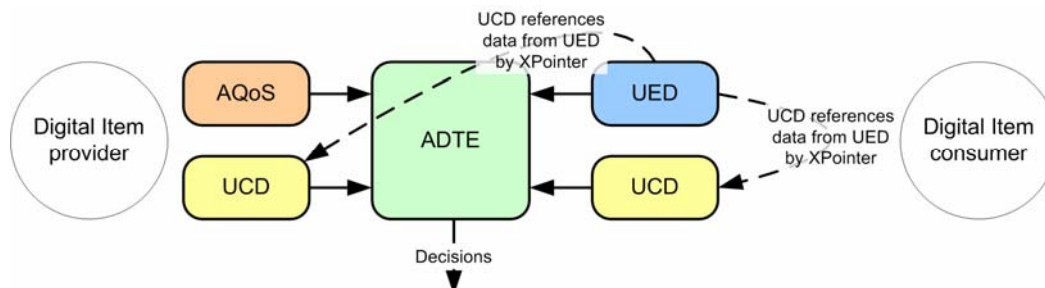


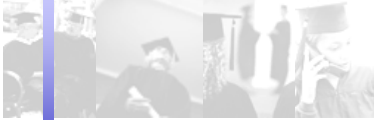
- **three types of modules**
  - look-up table: non-sparse, discrete data representation
  - utility function: sparse, discrete data representation
  - stack function: functional, continuous data representation
- **generic interface to these modules**
  - input/output pins (IOPins)



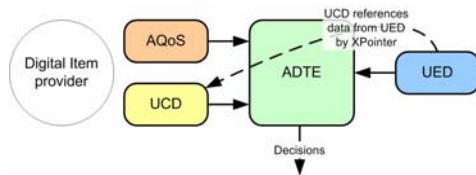
## universal constraints description

- 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

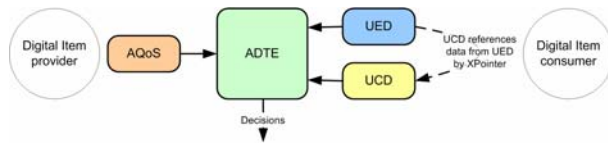


### • usage

- ! (image resolution < 20% of display resolution)
- max. image dimension

### • usage environment

- image resolution < 75% of display resolution
- max. according to the available network bandwidth



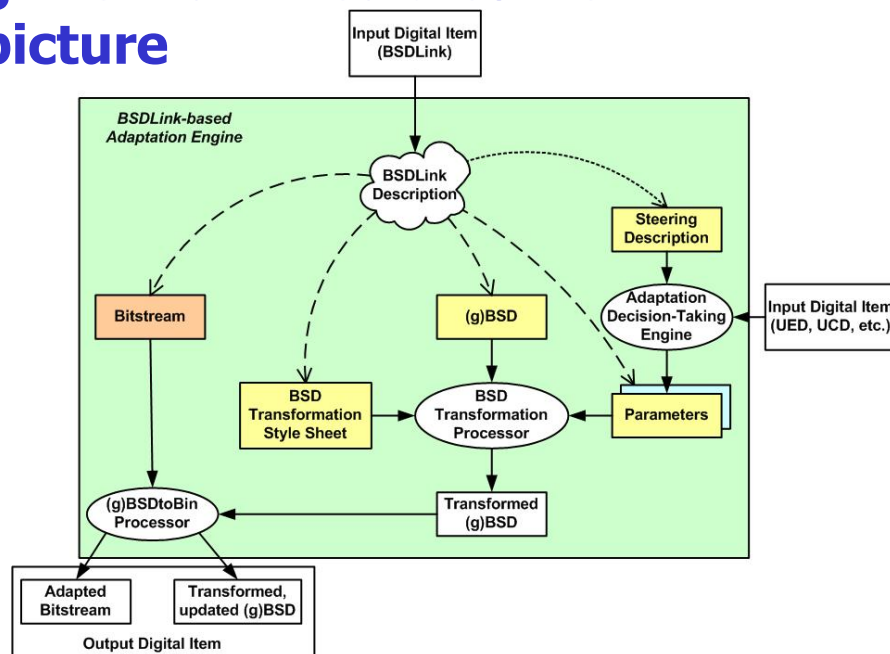
2005/12/01

Christian Timmerer, Department of  
Information Technology, Klagenfurt University

31



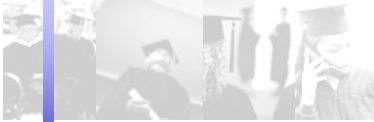
## adapting the multimedia content – the big picture



2005/12/01

Christian Timmerer, Department of  
Information Technology, Klagenfurt University

32



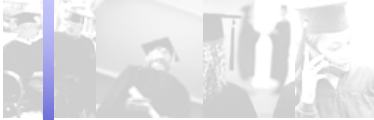
# outline

- **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**

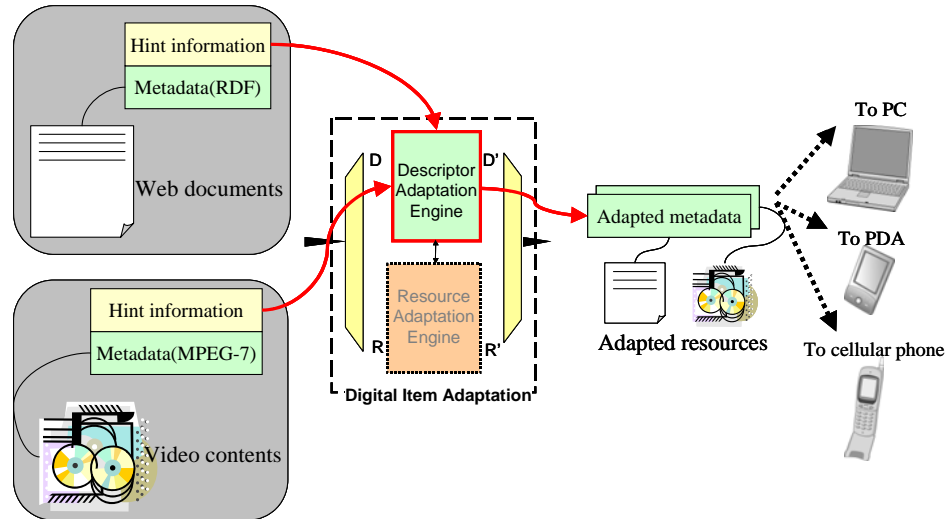


# adapting metadata

- **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 single description



## adapting metadata (cont'd)



2005/12/01

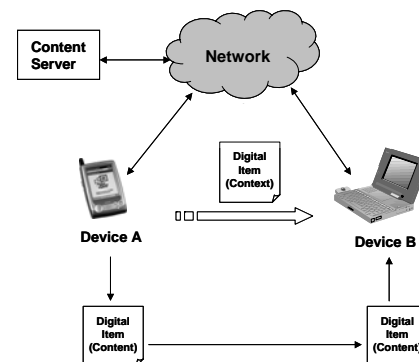
Christian Timmerer, Department of  
Information Technology, Klagenfurt University

35



## session mobility

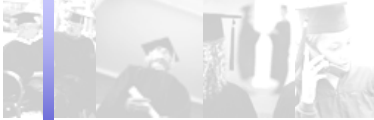
- transferring Digital Items from one device to another device (cf. peer-to-peer networks)
- the DID provides the structure for resource and associated metadata
- what needs to be transferred?
  - instantiation of choices and selections provided by the User – *configuration state*
  - information specific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



2005/12/01

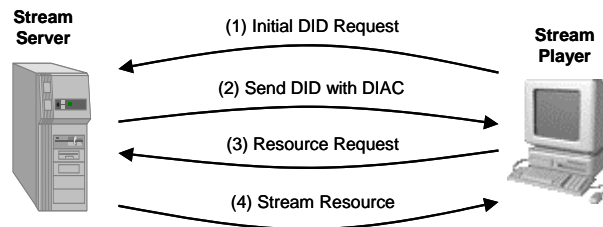
Christian Timmerer, Department of  
Information Technology, Klagenfurt University

36



## 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



2005/12/01

Christian Timmerer, Department of  
Information Technology, Klagenfurt University

37



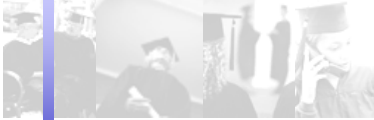
## outline

- **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**

2005/12/01

Christian Timmerer, Department of  
Information Technology, Klagenfurt University

38



## 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

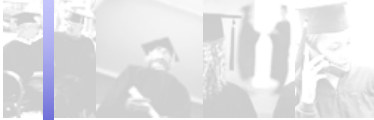


## amd.1: conversions and permissions (cont'd)

- **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*

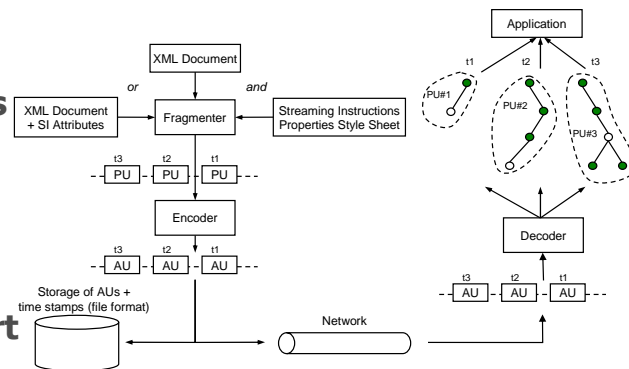


## amd.2: dynamic and distributed adaptation

- **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

2005/12/01

Christian Timmerer, Department of  
Information Technology, Klagenfurt University

41



## 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

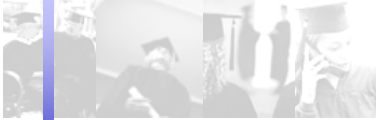
- **DIA specification is available (⇒ [www.iso.org](http://www.iso.org))**

- 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

2005/12/01

Christian Timmerer, Department of  
Information Technology, Klagenfurt University

42



## 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](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.**
- **S. Devillers, C. Timmerer, J. Heuer, and H. Hellwagner, "Bitstream Syntax Description", *IEEE Trans. on Multimedia, Special Issue on MPEG-21*, vol. 7, no. 3, June 2005.**
- **C. Timmerer and H. Hellwagner, "Interoperable Adaptive Multimedia Communication", *IEEE Multimedia Magazine*, vol. 12, no. 1, January-March 2005.**
- **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>**

2005/12/01

Christian Timmerer, Department of  
Information Technology, Klagenfurt University

43



## thank you for your attention

questions, comments, etc. are welcome ...



Dipl.-Ing. Christian Timmerer  
 University Klagenfurt, Department of Information Technology (ITEC)  
 Universitätsstrasse 65-67, A-9020 Klagenfurt, AUSTRIA  
[christian.timmerer@itec.uni-klu.ac.at](mailto:christian.timmerer@itec.uni-klu.ac.at)  
<http://www.ifi.uni-klu.ac.at/Christian.Timmerer>  
 Tel: +43/463/2700 3621 Fax: +43/463/2700 3699

Copyright © 2003 by Christian Timmerer