WP-3: Cross-Layer Adaptation and Quality of Service

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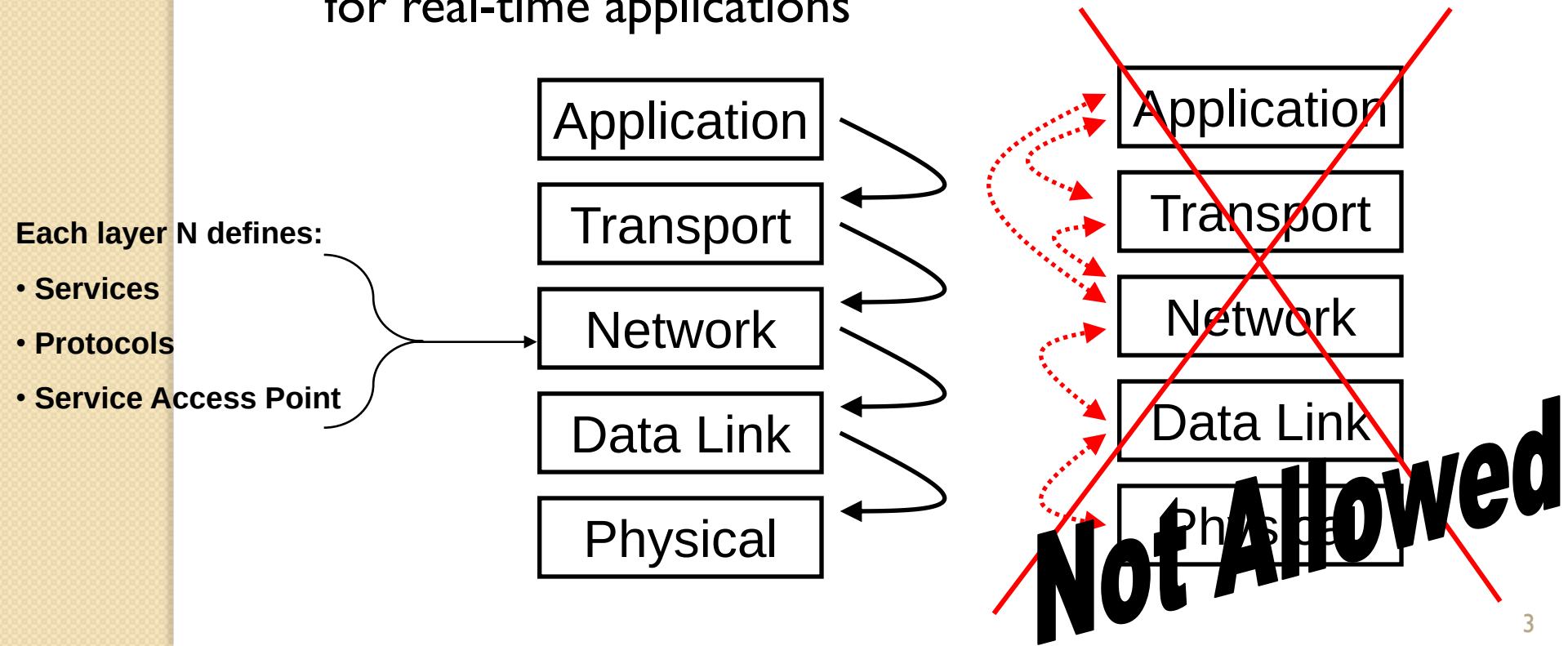
Outline

- Background on Protocol Stack design
- Cross-layer (XL) design : Think globally, act locally
- ENTHRONE XL Model : Meet in the Middle (MIM)
- Performance evaluation of MIM
- MPEG-21 Adaptation Decision Taking
- DRM support for decision taking

Background on Protocol Stack design

- The IP stack was designed for wireline networks
- It works perfectly for simple applications such as email, web, ftp.
- Many drawbacks appear in wireless communications, and for real-time applications



Toward cross-layer design : Think globally, act locally

- How to efficiently transmit different traffic over wireless links ?
- Specific problems related to :
  - time-varying fading, multipath, …
  - co-channel interference, hostile jamming, …
  - mobility, dynamic network topology, …
- Diverse requirements
  - Real time applications (Video): high-bandwidth, delay and loss sensitive up to tolerent
  - Real time applications (Voice): low-bandwidth, delay and loss sensitive
  - Data applications : bandwidth-requirement, elastic application, zero-loss,
- Cross-layer (XL) : Think Globally, Act locally
  - providing end-to-end QoS,
  - Providing QoS Continuity among layers

Cross-layer model

- Cross-layer model investigates approaches where different layers may cooperate to improve the ability of applications to ensure certain objectives such QoS guarantees, power saving, or users preferences, etc.

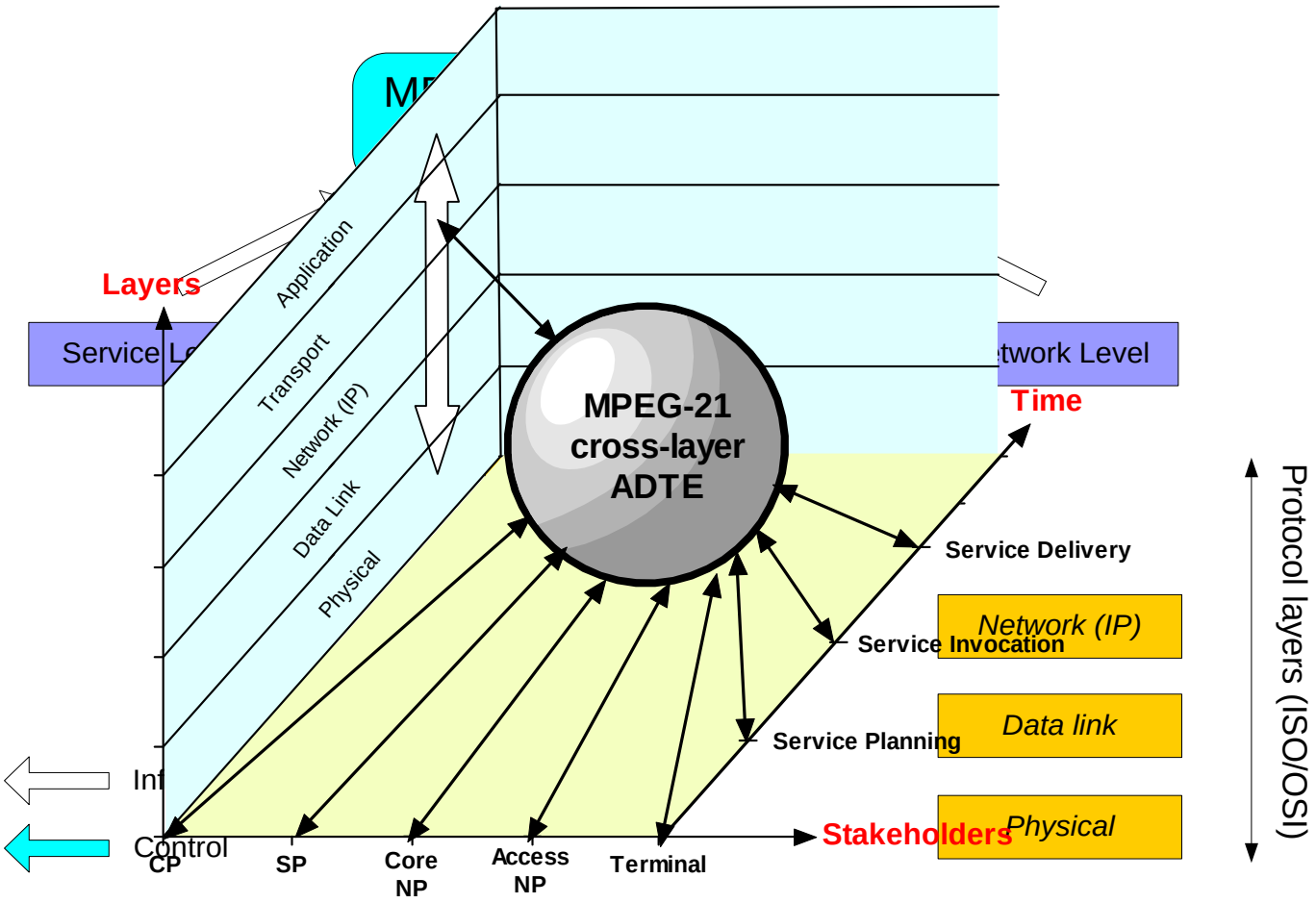
- Cross-layer model may be achieved by either integrating functionalities of different layers in a single protocol or simply establishing tight cooperation between adjacent (or separated) layers.

- The cross-layer model may use top-down, bottom-up or integrated approaches.

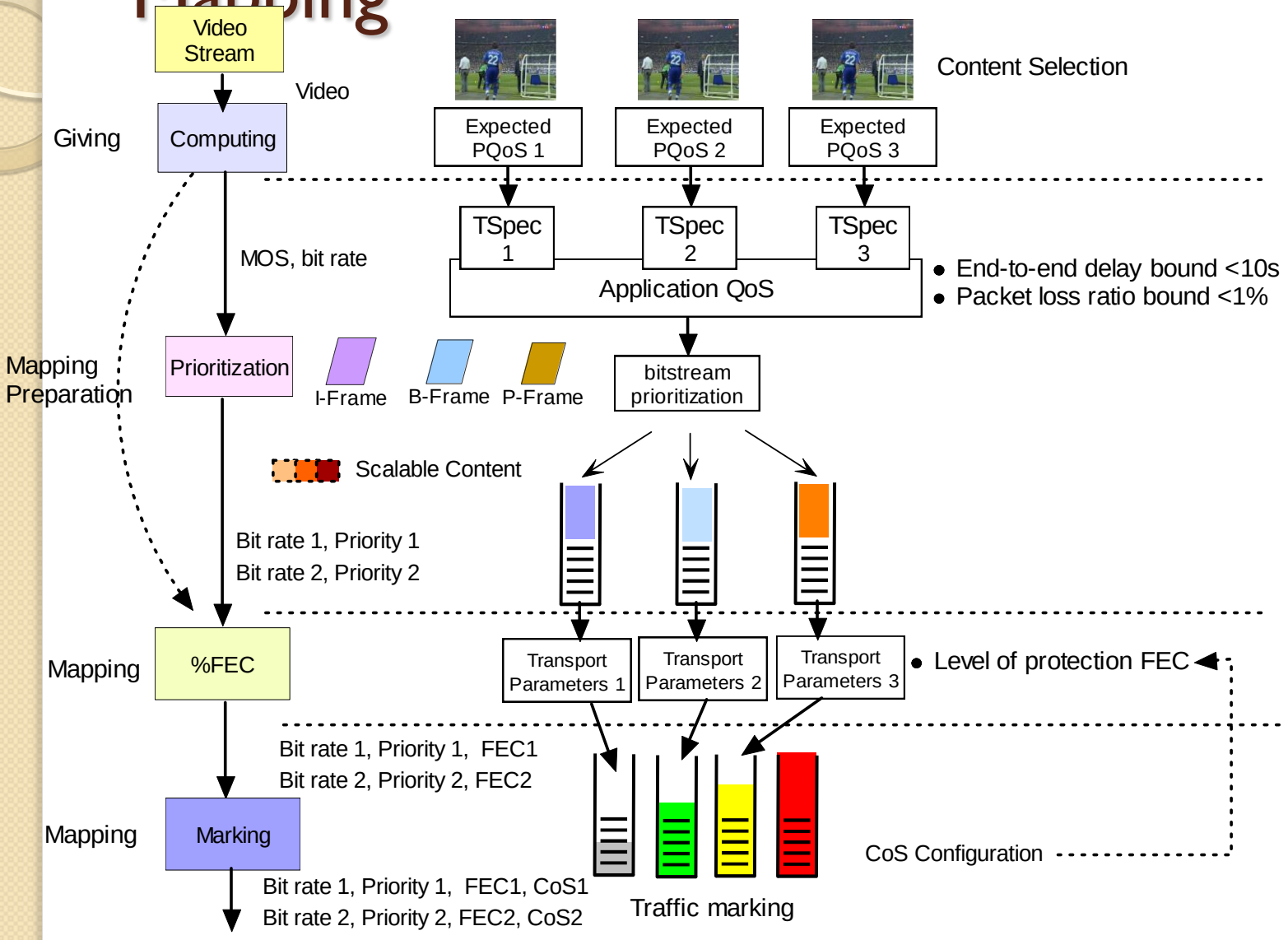
ENTHRONE XL Design -I

- Enthrone proposes to use mechanisms for :
  - Ensuring QoS continuity between different stakeholders (NOs, SP, CP, TE) ➔ **horizontally**
    - Service Level Agreement
  - Ensuring QoS persistence (continuity) at different system layers (TCP/IP stacks) ➔ **vertically**
    - Different layers have different QoS mechanisms
- Three epochs :
  - Before service request (service planning)
  - At service invocation
  - At service delivery / consumption

ENTHRONE XL Design -2

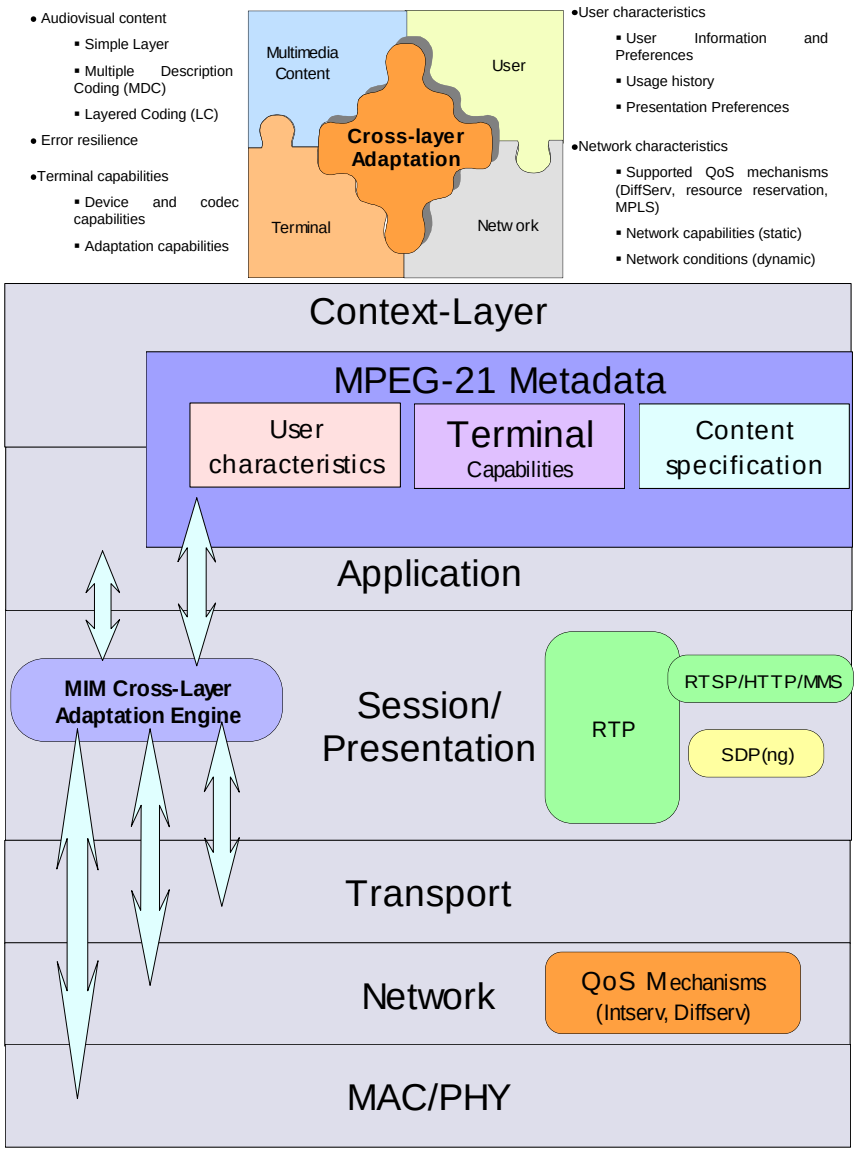


Model for XL continuity using XL – QoS Mapping



Model for XL continuity using XL – QoS Adaptation

- Proposal for MIM (Meet In the Middle) approach
- QoS Adaptation :
  - **At service invocation** : context information is carried using signaling protocol
  - **At service delivery** using end-to-end feedback for QoS adaptation



MIM XL QoS Adaptation Strategies

- Link layer rate adaptation
  - different channel coding and modulation ➔ different link layer rate
  - MIM adapts the video content according to link layer rate and the received signal strength ➔ awareness of link layer
- Adaptive Forward Error Correction (FEC)
  - Packet loss is a problem that considerably affects the quality of received video quality.
  - FEC allows to regenerate lost packet ➔ awareness of network layer
- Content adaptation
  - Adjusting temporal, spatial, and SNR for a particular video content ➔ awareness of content

Implementation of MIM

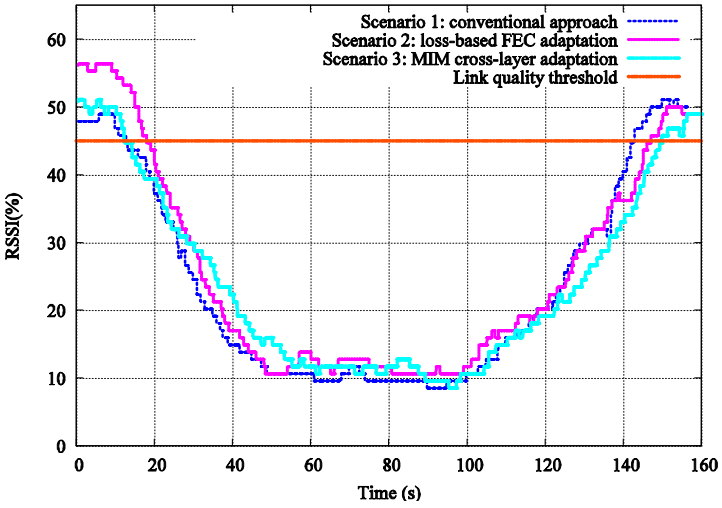
- **Scenario 1:** reference sequence streaming with a conventional streaming system.
- **Scenario 2**: reference sequence streaming with adaptive streaming system

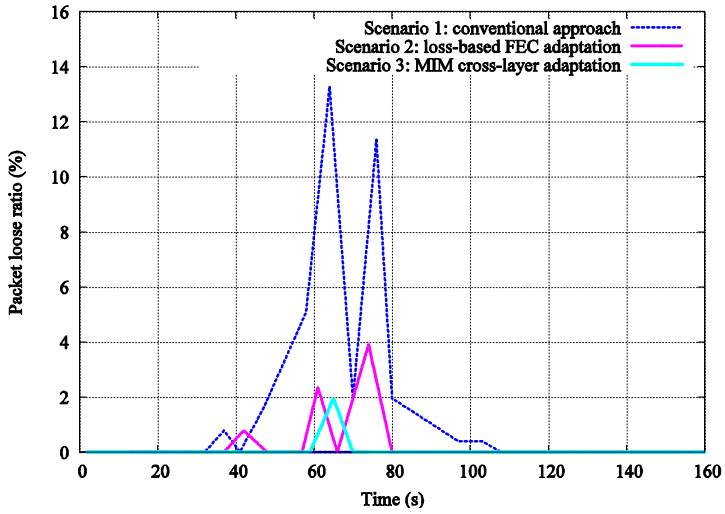
Packet loss rate	No loss	No FEC No overhead
	<5%	FEC(10,8) ➔ Overhead +25%
	>5%	FEC(10,7) ➔ Overhead +42%

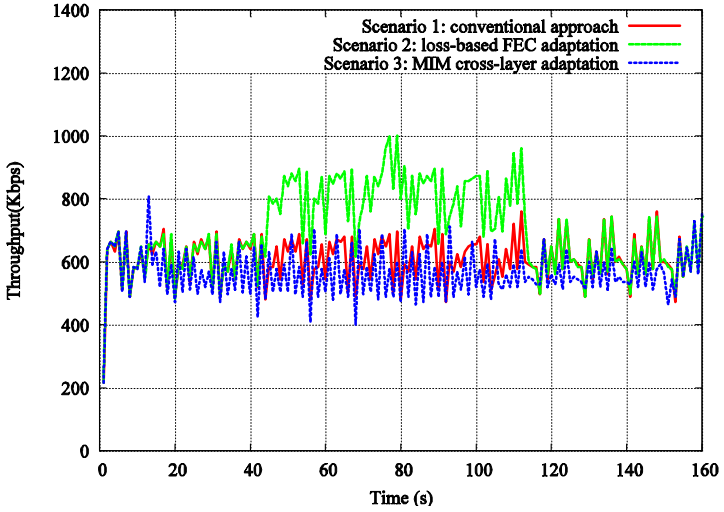
- **Scenario 3:** reference sequence streaming with the MIM cross-layer adaptation

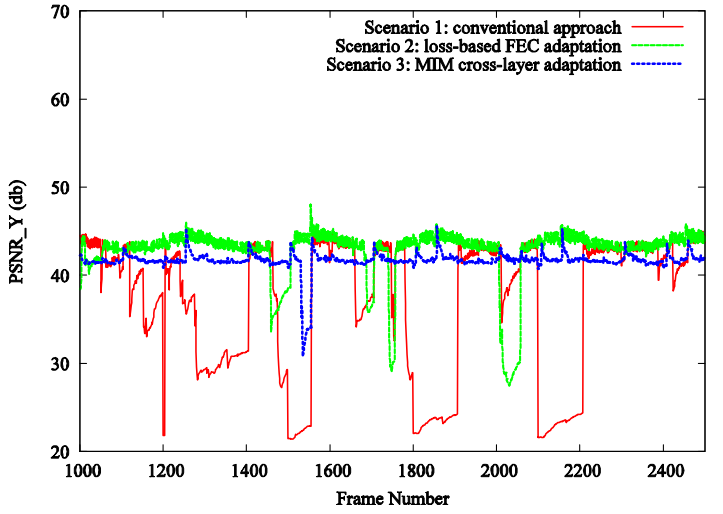
		Packet loss rate		
		No loss	<5%	>5%
RSSI level	**Good** **[45% - 100%]**	- No FEC - No transrating	- FEC(10,8) ➔ **Overhead +25%** - Adapt the video ➔ **Transrating the video -25%**	- FEC(10,7) ➔ **Overhead +42%** - Adapt the video ➔ **Transrating the video -42%**
	Bad **[0%-45%[**	- FEC(10,8) ➔ **Overhead +25%** - Adapt the video ➔ **Transrating the video -25%**	- FEC(10,7) ➔ **Overhead +42%** - Adapt the video ➔ **Transrating the video -42%**	- FEC(10,7) ➔ **Overhead +42%** - Adapt the video ➔ **Transrating the video -42%**

Performance evaluation of MIM









Performance evaluation of MIM

original frame

scenario 1

scenario 2

scenario 3 MIM

adaptation decision-taking

- content can be adapted along different dimensions
  - video: spatial, temporal, quantization …
  - audio: number of channels, sampling rate …
- selection of adaptation parameters influences
  - content properties, e.g., video resolution, frame rate
  - bitrate of the content → required network bandwidth
  - objective and/or subjective quality
- adaptation-decision taking (ADT) is about … finding adaptation parameters that lead to the best quality for a given set of constraints imposed by the usage environment

MPEG-21 Digital Item Adaptation

- part 7 of the MPEG-21 standard
  - deals with the adaptation of Digital Items
  - uses the notion of a tool (description with defined syntax + semantic)
  - XML-based metadata

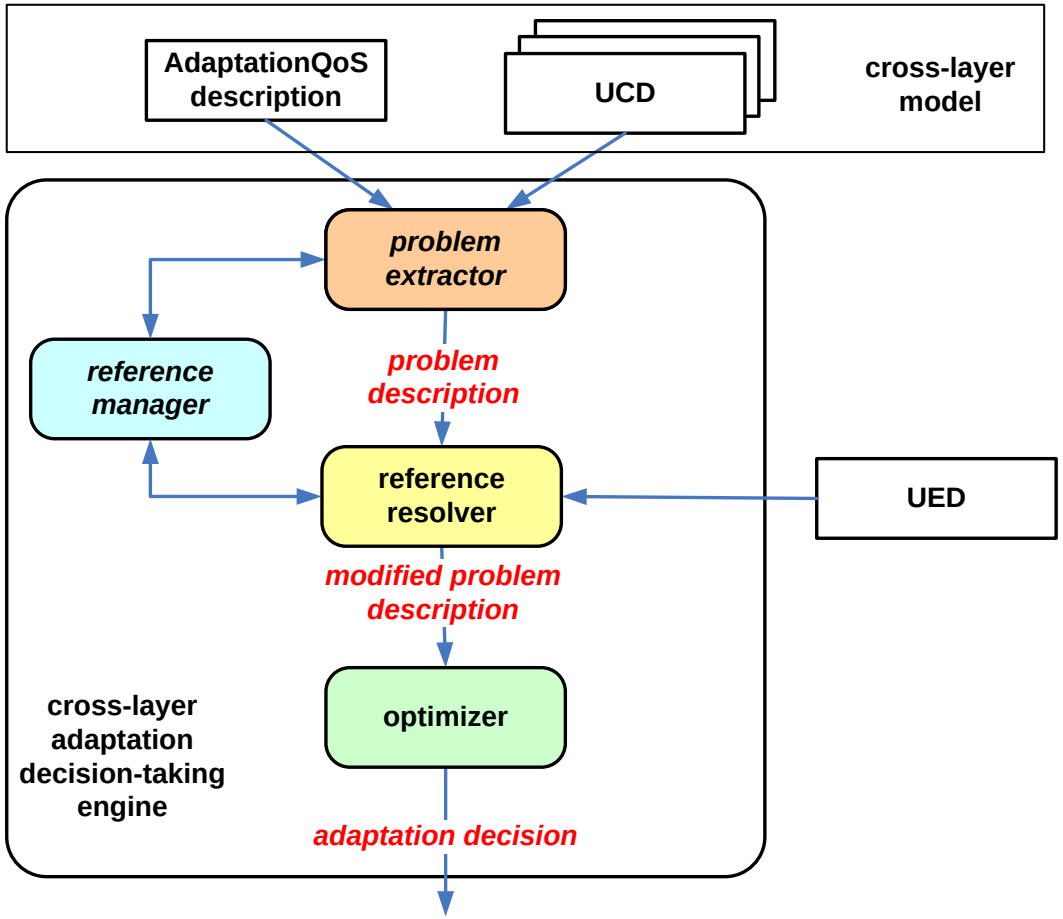
- offers relevant tools for steering the adaptation
  - Usage Environment Description (UED)
  - Adaptation QoS (AQoS)
  - Universal Constraint Description (UCD)

ENTHRONE approach

- cross-layer model using MPEG-21 metadata
  - functional dependencies between parameters and their effects (AQoS)
    e.g., *video_bitrate* = f(*temporal_layers*, *enhancement_layers*)
  - constraints limiting the value of certain parameters/properties (UCD) e.g., *video_bitrate* <= a * *physical_rate* with *a* < *1*
  - objective functions to select an adaptation decision (UCD)
    e.g., maximize *video_bitrate*
- control logic represented by metadata (AQoS, UCD)

- mathematical optimization problem
- input to Cross-layer Adaptation Decision Taking-Engine (XL-ADTE)

architecture of the XL-ADTE



DRM support for ADTE

- use case
  - content provider (CP) should be able to define constraints on the adaptation of his content
  - e.g., I don‘t want my content to be adapted below a certain spatial resolution (CIF)

- idea
  - CP issues a licence to adapt the content – but with restrictions
  - licence expressed using MPEG-21 Rights Expression Language (REL)
  - licence is part of the Digital Item (DI)
  - service provider (SP) and adaptation provider (AP) are allowed to adapt the DI only if they adhere to the restrictions specified in the licence

DRM support for ADTE - licence

- relevant parts of the licence
  - issuer – subject that grants the permission (the content provider)
  - subject – whom? the holder of the right (content & adaptation providers)
  - right – what? … to adapt the Digital Item
  - object – which DI? (reference to the Digital Item)
  - change constraints – under which circumstances?
- impact on decision-taking
  - constraints impose further limits on adaptation space
  - handled as ordinary constraints within the decision-taking process

```
<r:license ...>
 <r:grant>
  <mx:adapt/>

   <mx:diReference><mx:identifier>DI:URN:...</mx:identifier></
   mx:diReference>
   <r:allConditions><dia:changeConstraint><dia:constraint>
    <dia:AdaptationUnitConstraints>
    <dia:LimitConstraint>
      <dia:Argument xsi:type="dia:SemanticalRefType"
   semantics="urn:mpeg:mpeg21:2003:01-DIA-MediaInformationCS-
   NS:17“/>
      <dia:Argument xsi:type="dia:ConstantDataType">
      <dia:Constant xsi:type="dia:IntegerType">
      <dia:Value>640</dia:Value>
    </dia:Constant></dia:Argument>
    <dia:Operation operator="urn:mpeg:mpeg21:2003:01-DIA-
   StackFunctionOperatorCS-NS:39"/>
   </dia:LimitConstraint>
   </dia:constraint></dia:changeConstraint></r:allConditions>
 </r:grant>
</r:license>
```

frame width >= 640

Conclusions

- ENTHRONE proposes an MPEG-21 based XL QoS adaptation
- design and implementation of an adaptation decision taking engine
  - flexible design, control logic based on XML metadata
  - interoperability through standardized interfaces(MPEG-21, SOAP)
- digital rights management (DRM) support
  - based on MPEG-21 REL licences
  - constraining the space for possible adaptations

Thank you for your attention

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