PCM Audio Data Transport Stream adaptation
from an elementary stream to a HDCP-IAA encrypted data flow

Jochen Klaus-Wagenbrenner / 18.06.2012
Audio sample data alignment
- base are 16 bit samples
- Number of bytes per Audio Packet depends on

16 bit stereo

Audio Packet (2008 bytes)
- Sample 0
- Sample 1
- Sample 501
- Ch 0
- Ch 1
- MSB
- LSB

16 bit 8 channels

Audio Packet (1984 bytes)
- Sample 0
- Sample 1
- Sample 123
- Ch 0
- Ch 1
- Ch 2
- Ch 3
- Ch 4
- Ch 5
- Ch 6
- Ch 7
- MSB
- LSB
Audio Frame Structure

- **Audio sample data alignment**
  - for 20 bit, the 4 LSB will be added at the end of a packet

```
20 bit stereo

Audio Packet (2010 bytes)

Sample 0  Sample 1

Ch 0       Ch 1

16 bit

upper 16 bit of sample

Sample 401

Sample 0  Sample 1

Ch 0       Ch 1

4 bit

lower 4 bit of sample
```
Audio Frame Structure

- **Audio sample data alignment**
  - for 24 bit, the 8 LSB will be added at the end of a packet
Packetizing and Synchronization

- PCR/OPCR/PTS/DTS /ESCR

- PCR - Program Clock Reference
- OPCR - Original Program Clock Reference
- PTS - Presentation Time Stamp
- DTS - Decoding Time Stamp
- ESCR - Elementary Stream Clock Reference

Diagram:
- MPEG2-TS
  - Header
  - Adaptation Field
  - Payload
  - PCR/OPCR
  - 188 Bytes

- PES
  - Header
  - Optional Header
  - Optional Fields
  - Payload (e.g. 2010 bytes)
  - PTS, DTS, ESCR Indicator
  - PTS, DTS, ESCR

- ES
  - Header
  - Payload
Packetizing and Transport

- **Packetized Elementary Stream**

  - **Start Prefix**: 00 00 01 XX XX XX
  - **StreamID**: 0xC0 – 0xDF for audio content, 0xE0 – 0xEF for video content
  - **Packet Length**: 0x00

- **Audio Packet (e.g. 2010 bytes – 24 bit 5 channels)**

- **PES Header (6 bytes)**

<table>
<thead>
<tr>
<th>Name</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start prefix</td>
<td>3 bytes</td>
</tr>
<tr>
<td>StreamID</td>
<td>1 byte</td>
</tr>
<tr>
<td>Packet Length</td>
<td>2 byte</td>
</tr>
<tr>
<td>Optional PES Header</td>
<td>variable</td>
</tr>
<tr>
<td>Stuffing Bytes</td>
<td>variable</td>
</tr>
</tbody>
</table>

- **optional PES Header**

<table>
<thead>
<tr>
<th>Name</th>
<th>Size</th>
<th>Name</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marker bits</td>
<td>2 bits</td>
<td>ES flag</td>
<td>1 bit</td>
</tr>
<tr>
<td>Scrambling control</td>
<td>2 bits</td>
<td>Trick mode flag</td>
<td>1 bit</td>
</tr>
<tr>
<td>Priority</td>
<td>1 bit</td>
<td>Add. copy info</td>
<td>1 bit</td>
</tr>
<tr>
<td>Data alignment</td>
<td>1 bit</td>
<td>CRS flag</td>
<td>1 bit</td>
</tr>
<tr>
<td>Copy right</td>
<td>1 bit</td>
<td>Extension flag</td>
<td>1 bit</td>
</tr>
<tr>
<td>Original or copy</td>
<td>1 bit</td>
<td>PES header length</td>
<td>8 bits</td>
</tr>
<tr>
<td>PTS/DTS indicator</td>
<td>2 bits</td>
<td>Optional fields</td>
<td>variable</td>
</tr>
<tr>
<td>ESCR flag</td>
<td>1 bit</td>
<td>Stuffing bytes</td>
<td>variable</td>
</tr>
</tbody>
</table>

- **StreamID**

  - 0xC0 – 0xDF for audio content
  - 0xE0 – 0xEF for video content

- **PTS**: Presentation Time Stamp
- **DTS**: Decoding Time Stamp
- **ESCR**: Elementary Stream Clock Reference
Packetizing and Transport

- **Packetized Elementary Stream**
  - **PTS/DTS Indicator**
    - 00 no PTS/DTS
    - 01 forbidden
    - 10 PTS available
    - 11 PTS/DTS available
  - **PTS/DTS Data**
    - 5/10 bytes appended on the Header Data Field

### PTS available

| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| 0010 | PTS 32..30 | 1 | PTS 29..15 | 1 | PTS 14..00 | 1 |

### PTS/DTS available

| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| 0011 | PTS 32..30 | 1 | PTS 29..15 | 1 | PTS 14..00 | 1 |
| 0001 | DTS 32..30 | 1 | DTS 29..15 | 1 | DTS 14..00 | 1 |
Packetizing and Transport

- **Packetized Elementary Stream**
  - ESCR Indicator
  - 6 Bytes are appended to the Header

![Diagram showing ESCR available and its positions in a byte sequence]
Packetizing and Transport

- **Transport Stream**

  Header – 4 bytes

  - 0x47
  - 13 bits
  - XX

  e.g. Payload 184 bytes

  - Start Prefix
  - PacketID
  - Continuity counter

- **Adaption Field**

- **TS Header**

<table>
<thead>
<tr>
<th>Name</th>
<th>Size</th>
<th>Name</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start Prefix</td>
<td>8 bits</td>
<td>Scrambling Control</td>
<td>2 bits</td>
</tr>
<tr>
<td>Transport Error</td>
<td>1 bit</td>
<td>Adaption Field Ind.</td>
<td>2 bits</td>
</tr>
<tr>
<td>Payload Start</td>
<td>1 bit</td>
<td>Continuity Counter</td>
<td>4 bits</td>
</tr>
<tr>
<td>Transpot Priority</td>
<td>1 bit</td>
<td>Adaption Field</td>
<td>0 or more</td>
</tr>
<tr>
<td>PacketID</td>
<td>13 bits</td>
<td>Payload</td>
<td>0 or more</td>
</tr>
</tbody>
</table>

- **Adaption Field**

<table>
<thead>
<tr>
<th>Name</th>
<th>Size</th>
<th>Name</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adaption Length</td>
<td>8 bits</td>
<td>Private data Ind.</td>
<td>1 bit</td>
</tr>
<tr>
<td>Discontinuity</td>
<td>1 bit</td>
<td>Extension flag</td>
<td>1 bit</td>
</tr>
<tr>
<td>Random Access</td>
<td>1 bit</td>
<td>PCR</td>
<td>33+6+9</td>
</tr>
<tr>
<td>Priority Indicator</td>
<td>1 bit</td>
<td>OPCR</td>
<td>33+6+9</td>
</tr>
<tr>
<td>PCR flag</td>
<td>1 bit</td>
<td>Splice Countdown</td>
<td>8 bits</td>
</tr>
<tr>
<td>OPCR flag</td>
<td>1 bit</td>
<td>Stuffing bytes</td>
<td>Variable</td>
</tr>
<tr>
<td>Splicing flag</td>
<td>1 bit</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- PCR - Program Clock Reference
- OPCR - Original Program Clock Reference
Transport Stream Multiplexing

- PES to TS muxing

(A) ES (Elementary stream) outputed from Encoder

- Video ES V1
- Audio ES A1

(B) PES (Packetized elementary stream)

- Channel 1
  - Video PES V1
  - Audio PES A1

- Channel 2
  - Video PES V2
  - Audio PES A2

- PAT – Program Association Table
- PMT – Program Map Table
Encryption (HDCP-IIA based)

- Encryption by using the HDCP Interface Independent Adaptation (HDCP 2.x)
  - Packetized Elementary Stream has to be used
  - the method for multiplexing and AV transport is open
Encryption (HDCP-IIA based)

- A/V Data -> Packetized Elementary Stream -> HDCP Encryption -> Transport Stream

- Packetized Elementary Stream

- Encrypted PES

- mandatory for encrypted payload

- Transport Stream Packet 0

- Transport Stream Packet 1

- Transport Stream Packet n
Encryption (HDCP-IIA based)

- **Private data field**
  - mandatory
  - added to every encrypted PES
  - signals that encrypted PES is present
  - 4 byte stream counter
  - 8 bytes input counter
  - used instead of the PES scrambling control bits
HARMAN
WHERE SOUND MATTERS