Teleteaching Anywhere Solution Kit (tele-TASK) Goes Mobile

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ABSTRACT

Tele-TASK is a tool for recording lectures and presentations. It does not only record the audio and video of the speaker but also everything happening on the presenter's computer. No matter if he is showing a Powerpoint presentation, a software demo or even the BIOS configuration of the computer, tele-TASK is able to record, encode and stream the whole presentation out of the box. The result is one synchronized and platform independent multimedia video in the RealMedia format. Hundreds of Tele-TASK lectures are already available online (http://www.tele-task.de).
Apple has a big success with the release of the iPod series and accessories. It enables the user to carry around music and videos, play them back while he is on bus or even use it as a digital multimedia library accessible via your TV set. Unfortunately the video iPod is neither able to play videos encoded in Real format nor to play back several videos at once.
Current development in e-learning technologies aims to make learning and teaching available everywhere. In the stream of this evolution, the Web-University Project at the Hasso-Plattner-Institute explores and studies novel Internet- and IT-technologies with the aim to enhance university teaching and research. This paper describes how we extended our teleteaching system to supply the learner not only with streaming media but also with additional iPod-ready lecture recordings and presentations in order to enable mobile learning wherever the learner likes to.

Categories and Subject Descriptors

K.3.1 [**Computers and Education**]: Computer Uses in Education—*Computer-Assisted Instruction*; K.6.3 [**Software Management**]: Software Selection

General Terms

Management, Reliability, Design, Experimentation

Keywords

E-Learning, Podcasting, Teleteaching, Mobile Learning, iPod, Video encoding

1. INTRODUCTION

The last decades were shaped by the introduction of novel and promising learning and teaching technologies. Initially hopes were high that television would have certain characteristics that would lead to improved student learning [10]. A new vision of the way people learn was triggered by the birth of personal computers in the late 1970s and beginning 80s. The maturity of computer hardware, especially in size and price was for artificial intelligence (AI) scientists the long awaited event to invade the world of education. The tremendous impact of the Web in the mid 90s was perceived as a new change of the educational paradigm. The richness of the Web promised to make home schooling an increasingly popular option for parents. In the recent years, the advances in multimedia technologies and the raising availability of broadband access to the Internet are the base for creating new educational technologies like online education, collaborative learning, virtual reality learning, and mobile learning.

In this paper we focus on the emerging requirement of learning independently of location and time. We introduce our novel approach of the fully automated generation of video podcasts and thus explore a solution how new technologies like podcasts can be used to transform authentically recorded lectures and presentations into mobile multimedia learning objects of high quality. These learning objects can be played back on simple, small and mobile devices that allow the learner to access some learning content nearly everywhere and off-line.

The remainder of this paper is organized as follows. We start in section 2 with an overview of current state-of-the-art mobile learning technologies. We present in section 3 and section 4 technologies that we use, i.e., tele-TASK and Apple's iPod respectively. Our solution of converting tele-TASK lectures into podcast clips is described in section 5, and discussed in section 6. We conclude in section 7 with a short summary of the achieved results and some ongoing work.

2. NEW TECHNOLOGIES IN THE AGE OF MOBILE LEARNING

We start in this section with an overview of some advantages of using e-learning technologies that foster mobile learning. Then we focus on the novel topic of podcasting.

2.1 Education and New Technologies

Using new technologies in education has multiple advantages for the learner and the teacher, e.g., a more attractive — maybe clearer — way to present information in a multimedia form, advantages in deploying modern learning approach like exploratory and student-centered learning, and the ease to use and access learning objects about all possible topics in digital libraries.

Following the law of least effort, students explained that one might not need to look in several books to find information about a topic. One of the most appealing qualities of the Web to the students was the speed in which they could find information [5].

New technologies like distance learning or online learning allow potentially everyone to acquire new knowledge, and still continue his/her professional occupation, thus it initially focused on an adult public. It is however interesting to notice that for example at the University of Colorado at Denver almost 80% of those who enrolled an online course turned out to be on-campus undergraduates [2]. Since the introduction of online-lectures at the Hasso-Plattner-Institute (HPI) in Potsdam in 2004, we witness that some 40% of the students stay on campus while some 30% follow the lectures online, and the rest claims to watch it later. Other surveys describe similar tendencies; more people require access to learning content outside the campus and also off-line, e.g., on the way home from work, or at home later in the evening. At lot of scenarios can be imagined, where mobile learning can be perceived as ideal complement to traditional classes.

2.2 Podcasting

It seems that "podcasting" has become synonym for modern e-learning. We introduce that technology and describe its advantages in education.

2.2.1 Podcast Variants

A **podcast** [8] is a digital media file, or a series of such files that is distributed over the Internet using syndication feeds for playback on portable media players and personal computers. A "pod" refers to a container of some sort, and "cast" to the idea of broadcasting. In other words, a podcast is a collection of files (usually audio and video) residing at a unique web feed address.

Video podcast is a term used for the online delivery of video on demand video clip content via Atom or RSS enclosures. From a web server, a video podcast can be distributed as a file or as a stream. Both methods have their advantages and disadvantages. Downloading complete video podcasts in advance gives the user the ability to play the video podcasts off-line, e.g., on a portable media player. A downloaded version can be watched many times with only one download, reducing bandwidth costs in this case. Streaming allows seeking (skipping portions of the file) without downloading the full video podcast, better statistics and lower bandwidth costs for the servers. However, users may have to face pauses in playback caused by slow transfer speeds.

A podcasting client may work with a separate, or inte-

grated player. One such example of the latter is iTunes[1], which is an unusual case of a web feed aggregator being added to a media player rather than vice versa.

2.2.2 First Usages of Podcasts in Education

Using podcasts in education as a complement to e-learning has various advantages [3, 6, 12, 9, 1, 8]. Generally, video podcasts enable students and teachers to share information with anyone and anytime. If a student is absent, (s)he can download the podcast of the recorded lesson. It can be a tool for teachers or administrators to communicate curriculum, assignments and other information with parents and the community. Teachers can record book talks, vocabulary or foreign language lessons, international pen pal letters, music performance, interviews, debates etc. Video podcasting can be a publishing tool for student oral presentations. Audio podcasts can be used in all these ways as well. It also allows people to leave a journal.

Directories on the Web with educational content delivered as podcasts become more and more popular. Here are some examples of such portals.

- The "Education Podcast Network"[2] is an effort to bring together into one place the wide range of podcast programming that may be helpful to teachers looking for content to teach with and about, and to explore issues of teaching and learning in the 21st century. Most of the producers of these programs are educators, who have found an avenue through which they can share their knowledge, insights, and passions for teaching and learning and for the stories that they relish and teach.

- "Ed-Cast"[3], the online higher education podcast repository is intended to serve as an international clearing-house for the sharing of available lectures, conversations, speeches, and related podcasts for higher education worldwide.

- "Learn On The Go"[4] is a directory of carefully selected education and training podcasts aimed to promote the use of audio and video podcasting learning materials for personal and professional development. Currently, it contains some 400 links organized in different categories like history, business, languages, science & technology etc.

The podcasts listed in these directories are usually audio podcasts containing the audio recording of a lecture or presentation. So here only one dimension of a lecture is available for the user of mobile learning content. Our solution are video podcasts created from a teleteaching system which records more dimensions — besides the voice of the lecturer also his/her video and the video of his/her computer (desktop) are included [11]. This gives a much more authentic image of a presentation and thus enhances the learning experience in mobile learning.

When we speak of podcasts in this paper, we usually use this term for our video podcasts.

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[1] http://www.apple.com/itunes/
[2] http://epnweb.org/
[3] http://ed-cast.org/
[4] http://www.learn-on-the-go.com/

3. APPLE'S IPOD

Apple Inc.[5] has a huge success with their iPod series[6]. An iPod is a portable device for multimedia playback. There are different models with different features on the market. Typical for the iPod are the click wheel, an innovative control element, and the white earphones. You can save your multimedia library including music, videos and photos on an iPod and play it while you are away from computer or HiFi set. Apple's CEO Steve Jobs announced the iPod as a Mac-compatible product[7] with a hard drive that puts "1000 songs in your pocket". Since the iPod is one of the most popular among portable multimedia devices[8], we focused on that device for our work. However, our podcast clips will be playable also on other devices like Microsoft's Zune[9] due to the use of standardized MPEG-4 codecs (see section 3.2 and 5).

3.1 Technical overview

The "iPod" and "iPod nano" come with a display and the click wheel as innovative control device. The" iPod shuffle", which is the smallest iPod has no display and buttons for control. The 5th generation of the iPod, which entered the market in October 2005 is video-capable and uses an internal hard drive for data storage, whilst the other iPod models use a flash memory. The video-capable iPod comes with a 30GB or 80GB hard drive and is able to play back several music, image and video formats. For music, the iPod plays MP3, AAC (MPEG-4 audio), AIFF, WAV and others. It can display pictures in JPEG, BMP, GIF, TIFF and PNG. Available video formats are MPEG-4 and Quicktime with restrictions on video dimensions (maximum resolution of 640 x 480) and encoding techniques. Since MPEG-4 is a very versatile video compression standard – will explain video conversion for podcast generation later on – we will address this topic more in detail in the next subsection.

3.2 MPEG-4

MPEG-4 is a standard for compression of audio and visual digital data. It was defined by the Moving Picture Experts Group (MPEG), the working group within the International Organization for Standardization (ISO), and introduced in 1998, MPEG-4 includes a group of audio and video coding standards, which can be used for multimedia data used in the web, CD distribution, conversation and broadcast television. MPEG-4has all features of MPEG-1 and MPEG-2, and extends them with new features like Digital Rights Management (DRM) or object oriented composite files. MPEG-4 is divided into a number of parts[10]. The most important ones for our work are MPEG-4 part 2 (MPEG-4/ASP), which is used by video codecs like DivX or Quicktime 6, and MPEG-4 part 10 (MPEG-4 AVC/H.264), which is used by codecs like x264, Quicktime 7 and next generation formats like Blu-ray Disc. Most of the features proposed by the MPEG-4 standard are optional, so it is up to the developers of codecs whether they want to support these features or not. This

has the inconvinience that a user or developer who wants to use a particular codec cannot be sure if a certain feature is available. To deal with this, the standard proposes a concept of profiles and levels, grouping features to a set in order to give some kind of certainty for the availability of a feature when using a codec .

To put this into a practical context, the iPod of the 5th generation supports H.264 video up to 1.5 Mbps, 640 x 480, 30 frames pers second, Low Complexity version of the H.264 Baseline Profile with AAC-LC audio up to 160 Kbps, 48 Khz, stereo audio in .m4v, .mp4 and .mov file format. This is important to know when you want to create videos for an iPod and don't you want to use an off-the-shelf software.

4. TELE-TASK

The Teleteaching Anywhere Solution Kit (Tele-TASK) is a simple but advanced system for internet video production. It is able to record complete and thus authentic lectures and presentations. In this term authentic means that tele-TASK does not record only a video of the presentation, but includes also the supporting means like PowerPoint slides, software demonstrations and so on. Since it is a mobile system, you can carry it around and install it whereever you need it, no matter if it is in a lecture hall, a seminar room or an office. Tele-TASK comes with a built-in streaming server, so you can even stream your lecture live to the internet out of the box.

The resulting video streams will be player back simultaneously via a SMIL file. SMIL[11] stands for Synchronized Multimedia Integration Language and it is a standard of the World Wide Web Consortium [12]. The SMIL synchronizes the playback of different multimedia files and defines the layout in the user's player. An example of a SMIL file is shown in listing 1.

```
<?xml version="1.0"?>
<smil xmlns="...">
 <head>
  <layout>
   ...
  </layout>
 </head>
 <body>
  <par>
   <video region="1" src="STREAM_video.rm"/>
   <video region="2" src="STREAM_desktop.rm"/>
   <textstream region="3" src="TOC.rt"/>
  </par>
 </body>
</smil>
```

Listing 1: Example of a SMIL file that synchronizes two files which are played back in parallel

Tele-TASK supports different layouts for the resulting video. You can choose whether and where your want to show the speaker's video, the video of his computer (the so-called desktop video), and where to add a logo or a table of contents. Figure 1 shows the default layout: in the upper left corner is the presenter's video, right of it the desktop video and in the lower left corner an interactive table of contents, by which the user can access certain sections in the videos.

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[5] http://www.apple.com
[6] http://www.apple.com/ipod/
[7] The iPod also works with other computers and operating systems like Windows and Linux
[8] http://www.apple.com
[9] http://www.zune.net
[10] For the complete standard see http://www.chiariglione.org/mpeg/

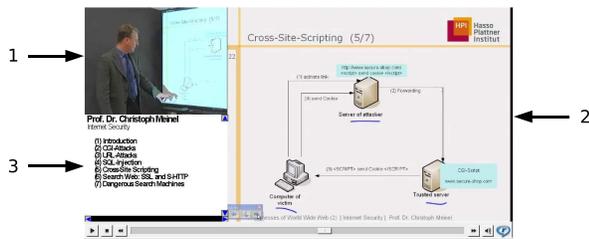[11] http://www.w3.org/AudioVideo/
[12] http://www.w3.org/

Figure 1: Default layout of a tele-TASK video: (1) presenter's video, (2) desktop video, (3) interactive table of contents

The Tele-TASK recordings can be played back with the Real Player[13], a free player component available for many platforms. The Tele-TASK system is a special device for the production of internet movies. To make these movies available for all Web users and not only for our students, we created an online archive[14]. The Tele-TASK online archive has enjoyed overwhelming success, counting about 7,010,000 visits to the website as of January 2007.

5. TELE-TASK MOBILE APPROACH

The original Tele-TASK lectures are streaming media. This gives the user the opportunity to interactively navigate within the recording through table of content entries acting as hyperlinks to certain timemarks (as explained in section 4). This requires that the user has to have an internet connection the whole time he is watching a recording. This aproach is not suitable for mobile learning since most portable multimedia devices like the iPod do nothave any internet connectivity. Or the user wants to enjoy a lecture at a place where no connection to the internet is available. Thus, we had to find a way to make our lecture recordings downloadable and convert it in such a way, that the user can watch it via a mobile device.
The advantages of a video podcast compared to our original streaming solution are:

- The content can be viewed off-line. Once it is downloaded, it can be played back as often as the user likes to without causing additional network traffic.

- By providing small, thematically concluded videoclips, the user is able to choose a topic out of a lecture he is particularly interested in. This might be especially suitable for examination preparation or repetition of difficult topics after class.

Thus the aim was to produce podcast videos as automatically as possible and with least human interaction as necessary.
The process of creating a podcast version for a given lecturel includes cutting, merging and converting. The input needed for these steps are three files: the presenter's video, the desktop video and the table of contents file (TOC file). The single steps will be explained in detail in this section.

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[13]http://www.realnetworks.com
[14]http://www.tele-task.de

5.1 Creating Smaller Clips

In order to generate a video, which is iPod compliant as well as including a whole tele-TASK recording we make use of different open source tools. We have chosen tools which provide a command line interface (CLI) so that we can automate the process of podcast generation.

The first tool is *mencoder* from the *mplayer* package[15]. *Mplayer* is an open source video player supporting many audio and video formats and platforms. Since we think it is better to have smaller clips on the iPod instead of a 90 minutes lecture, we use *mencoder* to split both videos – the lecturer's video and the desktop video – into smaller chunks. The TOC file referenced in the SMIL file is written in RealText, a markup language similar to HTML, so it is very easy to parse it and extract the timestamps from the TOC entries. These timestamps are used as cutting marks indicating the begin and the end of the clip. So we first read the SMIL file and determine the referenced files, especially the TOC file. The TOC file is then parsed to extract the timestamps, which are given to an *mencoder* command as parameters for the start and the end position of the podcast clip (listing 2).

```
mencoder STREAM_desktop.rm \
-ss 00:57:30.000 \
-endpos 01:07:00.000 \
...\
-o tmp_podcast_snippet1.avi
```

Listing 2: mencoder call to cut video into smaller chunks

This command has to be executed for the presenter's video as well as the desktop video several times, according to the number of table of content entries. So if the table of content has 10 entries, after this step we have 20 video clips. We have to take this step and convert the videos to an intermediate format since it is not possible to convert directly from RealMedia to MPEG-4 with the tools we are using. This is a small trade-off we accept with respect to full automation of the podcast creation process.

5.2 Merge Presenter's Video and Desktop Video

A big challenge was to find a suitable format and resolution including both videos and fit to the iPod screen, which has a maximum resolution of 640 x 480 pixels (aspect ratio 4:3). The default layout of a Tele-TASK lecture has a size of 960 x 480 (aspect ratio 2:1). As we cannot use the interactive table of contents on the iPod, we can omit this part and focus on the remaining two videos. We decided to encode these two videos as one picture-in-picture clip. You have the possibility to configure, which video acts as background and as foreground movie as well as the size and the degree of transparency of the foreground movie. The default setup is to put the desktop video as background (which has a size of 640x480 already) and the presenter's video in the upper right corner or left corner. This has been proven as the best way because you can still read the slides and the presenter's video might be put over a logo in the slides and thus does not cover important content.
To join the two video clips we use the streaming and filtering abilities of VLC^{16} [4]. VLC offers filtering mechanisms

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[15]http://www.mplayerhq.hu
[16]http://www.videolan.org

which distinguishes it from *mencoder* respectively *mplayer*. *VLC* comes with a built in streaming server which is able to do some filtering and transcoding, and afterwards streaming to several endpoints. We build up a filter chain. It takes saying two files as input, puts them through the mosaic filter which merges the input videos into a picture-in-picture file, transcodes it to an MPEG-4 video and saves it into a file. Figure 2 shows a schematic picture of the filter chain.
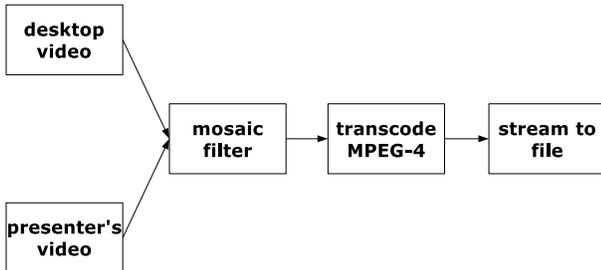

Figure 2: Schematic view of the VLC filter chain

Therefore, an individual configuration file for each pair of video clips is generated and passed to VLC. In this configuration file all needed attributes for the filtering and streaming like filenames, dimensions and positions are set, as well as the description for the filter chain. The result of this step is an iPod compliant video of the size 640 x 480 in MPEG-4 including the desktop and the presenter's video.

5.3   Add a trailer

We want to add a short trailer before each podcast clip, that introduces the subject, e.g. title of the clip, name of the speaker, topic of the lecurre etc.. We can get these information also from the initial TOC file (see section 5.1).

In order to generate a short 5 seconds trailer we first generate an image (a PNG file) that displays the mentioned information about the clip. For this step we use the ImageMagick tools[17]. ImageMagick is a set of open source tools for image manipulation and display. It provides – among other features – a graphical user interface for rendering images as well as command line utilities for image processing. We use the command line tools *convert* and *mogrify* to add text to a prepared background image. Listing 3 shows the command to add text with a certain color and font at a certain position. In this way we add the wanted information to the

```
mogrify -font verdana \
-fill "#3A7499" -pointsize 24 \
-gravity center \
-draw "text 0,0 \
'Lecture: Internet Technologies'" \
trailer.png
```

Listing 3: Command line to add text to an image using the tool mogrify

picture automatically and afterwards create a short 5 seconds video from this picture. This is again done with VLC (listing 4) via its command line interface.

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[17] http://www.imagemagick.org

```
vlc \
fake: --fake-file trailer.png \
--fake-duration 5000   \
--sout "#transcode{vcodec=mp4v,acodec=mp4a}:\
std{access=file,\
dst=movie_from_image.mp4,mux=mp4}" \
vlc:quit
```

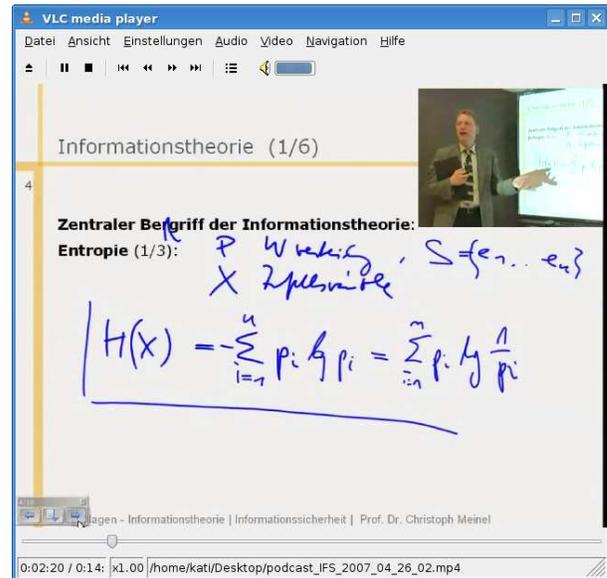**Listing 4: Command line to create a video from an image file with VLC**

Figure 3: Resulting tele-TASK podcast video that displays the mentioned information about the clip

After this step the two videos – the trailer and the iPod clip – will be joined to one file such that the trailer and the podcast video are played consecutively.

5.4   Results on iPod

All the mentioned steps sound very complicated and difficult and they are if you would do this work by hand. But since we can fully automate this process, the SMIL file as input is absolutely sufficient. Everything else is done by an application controlling the tools like mencoder and VLC. An example of a Tele-TASK podcast video is shown in figure 3.

After having created a set of podcast videos for each lecture, we upload them to our online archive's webserver, add the corresponding data to our database and update the RSS feed with the newly added entries. If a user has subscribed to our RSS feed via iTunes or another RSS feed reader, he will get notified about the new content available.
The introduced method to create iPod ready video clips can be applied to other video material in general. If there exists only the speaker's video, you can skip the merging step explained in subsection 5.2. The step of joining several videos explained in subsection 5.3 can be applied if you have several small video clips and want to create one podcast video out of it in a fully automated way.
We will offer our tool as add-on to the editing tool of our

recording system Tele-TASK'[18]. Before some finetuning has to be done with respect to framerates, usage of encoders and other small things that can improve the quality of the result vastly if you know which string to pull.

6. OUTLOOK

The here presented solution to automatically create podcast videos is still under development. Thus ,we see potential for improvement of our method, e.g., regarding the quality of the videoclips.
There are several ideas on what can be added in future work:

- **Digital Rights Management**
  MPEG-4 includes an architecture for Digital Rights Management (DRM) (MPEG-4 Part 13: Intellectual Property Management and Protection (IPMP) Extensions), which allows to extend video content with DRM features and therefore meets requirements like "renewability, secure communications, verification of trust, granular and flexible governance at well-defined points in the processing chain"[19]. Since we deliver content to the users in one file and it can be played back often – other than streaming, where never the whole file is transfered at once – we also have to think about protection of the content. Thus,further investigations in this area will be included into the development of the Tele-TASK podcasting method.

- **MPEG-7 Metadata**
  MPEG-7 is a standard, also passed by the MPEG consortium to describe multimedia content with metadata MPEG-7 is also referred to as "Multimedia Content Description Interface". This metadata can be saved as XML files or in a binary representation. There are only few applications which can handle MPEG-7 metadata by now, but the scientific community sees MPEG-7 as in important standard in terms of semantic description within the Semantic Web. If we can describe and store the content of our videoclips with MPEG-7 metadata, it should be feasible to find relations and similarities between clips in order to create sequences of clips tailored for each users needs. The project "Personal Lecture Butler" [7] in our group is dealing with the issue of the composition of videoclips as semantically described learning objects.

7. CONCLUSION

In this paper we introduced our method to create video podcast clips from recorded university lectures created by the Tele-TASK system. We motivated the use of video podcasts in the age of mobile learning and introduced current technologies. The Tele-TASK podcasting method consists of three major steps:

- Creating smaller clips from the original lecture recordings and transcoding them into an intermediate format,

- Joining the presenter's and the desktop video into one picture-in-picture-video,

- Creating and adding a trailer.

After the creating of the iPod ready video we upload it to our online archive and update the corresponding RSS file. The advantages of podcast videos against the original streaming are the "download once, watch it offline often" approach and the creation of smaller, thematically concluded clips, which might be especially useful for students during examination preparation and repition after class.
Further development of our introduced method aims for example at including DRM mechanisms and MPEG-7 metadata description.

8. ACKNOWLEDGMENTS

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[18] `http://www.tele-task.de`
[19] `http://www.chiariglione.org/mpeg/technologies/mp04-ipx/index,htm.htm`