Opencast Matterhorn: A Community-driven Open Source Solution for Creation, Management and Distribution of Audio and Video in Academia

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Abstract

Opencast has emerged as the international community for open, scalable and sustainable podcast/webcast solutions in higher education. One of the major endeavors that has emerged from this community is the Opencast Matterhorn Project to be presented here.

1. Introduction

On November 14, 2008, the U.S. President-elect Barak Obama made history by recording the Democratic Party weekly address on YouTube. "We're living," said Ellen Miller of the Sunlight Foundation, "after all, in the Internet era. This is an individualized version of the 'fireside chats.' It's not delivered between 7 p.m. to 8 p.m. but whenever anyone wants to see it." The 2008 U.S. presidential election was the tipping point for Internet video, demonstrating its indisputable power to communicate powerful ideas and transmit culture. The Obama campaign understood the need to go where the people were.

Universities also want to go where the learners are to share their rich scientific and intellectual knowledge beyond the walls of the academy and to expand the boundaries of the classroom. This desire has become a critical need, as the worldwide economy calls for advanced education and training.

For more than a decade, a small group of international universities have pioneered the promise of accessible knowledge and have strived to realize this promise through the capture and distribution of lectures. However, it is only in the last five years that quantity, quality and use of the recordings have reached a level that makes lecture recording and video management a topic of strategic importance for universities. Through many years of experiences, institutions have realized that their home grown solutions cannot keep up with the constant innovation within the lecture capture domain, and proprietary or commercial solutions costs prohibit long term sustainability.

Founded in 2007, the Opencast Community emerged as a global community to address the relevant facets of this issue and to support different projects to facilitate the sustainable, scalable creation and exchange of audiovisual content.

2. From Podcast to Opencast

Applications and research in the field of lecture recordings, e-lectures, podcasts and webcasts have exponentially grown worldwide. Particularly in the German-speaking countries, applications for recording

and distributing conferences and lectures have been developed for quite some time. Working examples that showcase projects that are related to this field of application are for example:
The E-Chalk project [4], a system to transform the lecturer`s input on a large touch-sensitive screen into an intelligent electronic chalkboard (e.g. process handwriting input of the user). The lecturer's audio in combination with the board strokes video representation can be transmitted over the Internet. A further approach presented in [5] is based on the development of a lecture recording search engine for academic content especially. Also, a number of universities discovered podcasting as an easy distribution possibility for lecture recordings [6].
The virtPresenter lecture recording framework [7] focuses besides a fully automated lecture recording production facility on highly adaptable user interfaces for web lectures that implement social navigation and Web 2.0 features. A further project is REPLAY [11]. It optimizes the lecture recording production process and presents a solution that can be used by universities on an enterprise level. Another example for an automated lecture capture system can be found in the work done by Peter Ziewer [14].
For the most part, these technologies were originally developed as research projects and evolved to meet local academic needs.
In the commercial domain, iTunes and YouTube recognized these efforts and provided innovative distribution platforms to exploit the increasing richness of this content. Ultimately, academic institutions' dependence on these platforms grew at the expense of creating pedagogically relevant technologies. To counter this trend, an alternative concept, Opencast, was announced by UC Berkeley to explore open source audiovisual production, distribution and engagement through free software, technology and access[1].

3. Opencast Project and Opencast Community

Since its onset, approximately 250 institutions have officially expressed interest in Opencast and more than 500 persons have joined its mailing list.

Participating Organizations:	255
North America	154
Europe	40
Asia/Pacific	20
Latin America	1
Middle East	2
Africa	2

Figure 1: Opencast Community – Geographic Distribution of Institutions

The Opencast Community is open to all interested institutions and individuals including commercial providers. Its mailing list[2] and infrastructure has fostered long-term cooperation and coordination under the auspices of the Opencast Community. Notable initiatives, such as the drive for a common metadata standard and "Open U"[3], a free non-commercial alternative to iTunes U have thrived with the support of Opencast. But, at the moment, the most impactful Opencast effort has been the Opencast Matterhorn Build Project.

Opencast Matterhorn – The Community Source Build Project

In 2008, the active core of the Opencast Community consisted mainly of universities who had already developed and/or were using their own solutions for the management of lecture recordings and of other audiovisual objects.
VirtPresenter[4] of the University of Osnabrück, REPLAY[5] of ETH Zürich, PuMuKIT[6] developed at the University of Vigo and the Recollect system from the University of Saskatchewan existed as standalone software solutions, whereas UC Berkeley's "Webcast Next Generation" incorporated Podcast Producer like many universities do these days. However, the evaluation of these programs and the discussions conducted within the framework of the Opencast Community had shown that none of the systems by themselves offered the range of functions universities desired.
To fill this gap, Opencast Matterhorn was launched as Opencast's first community source project[7]. Matterhorn is a collaboration between North American and European institutions, and funded by the Mellon and Hewlett foundations. This collaboration strives to meet the needs of the Opencast Community to ensure its involvement after financial support has ended.
To this effect, the following 13 partners operate under the name of "Matterhorn Partners":

[1] Previously, MIT had introduced a similar alternative conception (to the commercially protected „Podcast") with the term of „Webcast" which, to this day, remains as generic term covering the different distribution technologies (download and streaming) and formats (Flash, Quicktime etc.); cf. http://en.wikipedia.org/wiki/Webcast.

[2] http://lists.opencastproject.org/mailman/listinfo/community
[3] http://www.participatoryculture.org/
[4] http://www.virtpresenter.org
[5] http://www.replay.ethz.ch
[6] http://www.pumukit.uvigo.es
[7] http://www.oss-watch.ac.uk/resources/communityvsopen.xml

UC Berkeley
ETH Zürich
University of Nebraska-Lincoln
University of Osnabrück
Northwestern University
Cambridge University
Indiana University
University of Vigo
University of Catalonia
University of Saskatchewan
University of Copenhagen
University of Toronto
Jozef Stefan Institute

Figure 2: Opencast Matterhorn Partners

As a matter of principle, the Matterhorn Project is open for collaboration with any interested persons and institutions. The project's governance model of "meritocracy" means that the role and influence of the participating institutions are predicated exclusively on their contributions. Key access points are the project's mailing list, wiki, issue tracker, code repository and public virtual meetings that are recorded and documented[8].
The project was launched officially on July 1st 2009 and has funding until June 30th 2010. Major milestones include:

- Release 0.5 (Jan. 2010)
- Services Stabilization (April 2010)
- Release 1.0 (June 2010).

4. Opencast Matterhorn – Technology

Podcasting, i.e. recording and distributing lectures, stands at the centre of Matterhorn's functional requirements. However, discussions within the Opencast Community by the Matterhorn team have led to an extension of the requirements, a flexible service oriented media framework.

Underlying technologies
Matterhorn will be open source; this implies that the product will be fully based on open source products.
The members of the Opencast Community have selected Java as programming language to create the necessary applications and a SOA [1] infrastructure.
The overall application design is highly modularized and relies on the OSGI (dynamic module system for Java) technology. The OSGI service platform provides a standardized, component-oriented computing environment for cooperating network services. Matterhorn is planned to be as flexible and open as possible and further extensions should not increase the overall complexity of building, maintaining and deploying the final product. To minimize the coupling of the components and 3rd party products in the Matterhorn system, the OSGI technology provides a service-oriented architecture that enables the system to dynamically discover services for collaboration. Matterhorn uses the Apache Felix[9] implementation of the OSGI R4 Service Platform[10] to create the modular and extensible application.

Matterhorn provides getting started guides and additional information for developers on the public project wiki-page[11].

Schedule/Prepare & Capture
The recording process begins with determining what is to be recorded, where and in what form. Campus data will be integrated by the universities' IT departments. For this purpose, Matterhorn will be open to both the learning management systems and administrative data bases. Syllabi, lecture and room timetables will not only provide the basic information to answer the question raised above, but in an ideal case, most of the metadata related to the recording (lecturer, title, summary, language, etc.) as well. Recording devices are then scheduled to automatically record in lecture hall X.26, every Tuesday from 10:00 c.t. to 12:00, the lecture on "XYZ" by Prof. ABC.

Process
At the end of the recording the tracks are sent to an "inbox" to be processed. The inbox also serves as "ingest" for other video objects to be integrated in the subsequent workflows of Matterhorn. At most institutions, objects such as self-produced podcasts, image films or digitalized historic recordings would constitute only a small part of the whole audiovisual material (in contrast to the rapidly increasing number of lecture recordings), but Matterhorn should nonetheless offer a uniform solution for all audiovisual materials, that is a "video management system". In this module, the functions are mostly taken from the REPLAY system developed by ETH Zurich. The different recording tracks (audio, content, video) are bundled to a media package, content-indexed (at first through optical character recognition of the slide, later certainly through audio recognition also) and if necessary archived in the most native formats. They are encoded according to the specified distribution parameters.

[8] http://www.opencastproject.org/project/communication_channels

[9] http://felix.apache.org/site/index.html
[10] http://www.osgi.org/Main/HomePage
[11] Opencast documentation: http://wiki.opencastproject.org

Distribution

The distribution demands of the universities are extremely heterogeneous: they go from simple integration of the videos in local WCMS or blogs, to posting in password-protected LMS, to distribution via iTunes U or YouTube. Here, the distribution module must be able to cope not only with the heterogeneous distribution formats (RSS, Atom, Web service interfaces), but also with the recording formats specified at the beginning (cf. "Schedule/Prepare & Capture") which must be transmitted in homogeneous form to external services and platforms. In addition, the distribution channel will re-transmit the information necessary for statistical analysis and user data (e.g. most viewed video or annotations). This is where Matterhorn will provide more than the classical distribution channels.

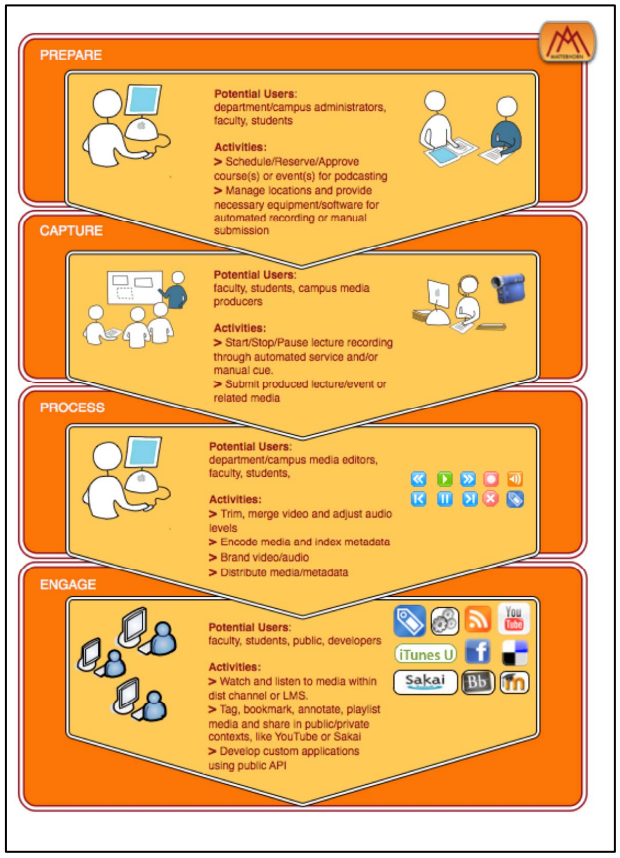

Figure 3: 4 Phases of the Matterhorn Workflow

Engage

Although Distribution and Engage modules are closely linked together since both must manage presentation and use of the objects, applications in the Engage module make it possible to use comprehensive information (metadata, video and audio analysis, annotations, use analysis) for intelligent user interfaces. Likewise, support of learning management systems (LMS) or virtual learning environments (VLE) is an important issue for the acceptance of the project. To make sure that the produced material will be used, Matterhorn video and audioplayer components will be easily integrated in existing course websites, wikis, and blog systems. Just as in the distribution module, collection of user statistics must be supported and the virtPresenter project will be leveraged as the baseline for the Engage applications [10].

Social annotations [12], which can be used to improve search or navigation and feedback possibilities will also flow back to the system like the user statistics already mentioned.

In this module, barrier-free accessibility is more than a catch phrase; components must be designed to support captions, screen readers and keyboard navigation.

Not all channels, external systems and platforms will be supported right from the start of the Matterhorn project. But the open architecture should make it possible to create interfaces to existing systems. Overall, the possibility of integrating existing applications in Matterhorn is one of the main objectives of the planned architecture

Media Analysis

After audio/video material has been sent to the inbox (see "Process"), the media is bundled into a media package. A media package is considered the business document within the Matterhorn system. Besides the media objects, it includes further information from media analysis as well as metadata. Every media package therefore consists of a manifest and a list of package elements that are referred to in the manifest. Package elements are media tracks (audiovisual material; movie container); metadata catalogues and further attachments (slides, pdf, text, annotations). Services are planned to modify media packages (update metadata, change attributes). A media package example as well as service description can be found online in the project wiki documentation.

Media analysis helps to implement not only basic navigation features for engage applications (e.g. slide change, chapters) [8]. By indexing slides as well as (English) audio, media analysis also opens the content of the video over time by creating isochronous metadata. Stored in MPEG-7, they will be the basis for the searchability of the video and its subsequent accessibility. REPLAY from ETH Zurich as well as different research projects have shown successfully that this technology can be used [2, 3]. For its further development, Opencast Matterhorn is looking forward

to benefit from work of the OCRopus[12] group for document analysis and OCR and Sphinx-4-related research[13] for speech recognition [13].

Metadata
While the indexation of slides and audio provides much of the isochronic metadata to search the video, static metadata is still needed to describe and classify the object – and to facilitate its exchange across institutions. While this domain calls for different areas to be covered (standards like LOM/ IEEE 1484.12.1-2002, protocols like OAI-PMH or technologies like SRU/SRW[14]), the Opencast Community has taken the first step to work on a metadata scheme describing academic video and recorded lectures in particular[15].

License, Miscellaneous
Matterhorn will be published under the Educational Community License (ECL) 2.0 developed by UC Berkeley, a license based on Apache 2.0 licensing which takes into account certain particular needs of academic institutions.
The project started on July 1st 2009 and will have a duration of 12 months up until the release MH 1.0. During this first phase of the project, the funding institutions will decide on successive funding.
The software will be developed using Agile software development methodologies to be able to cope with the relatively short duration, the communication between the Opencast Matterhorn consortium and the Opencast Community and a team dispersed over two continents. For the project management, the Atlassian products, Confluence (project management) and Jira (issue tracking) will be used.

Content distribution and Engage Applications
In order to bring the content to the users, Matterhorn will include web and streaming server solutions for media and content distribution. At the moment, open source applications are being evaluated and tested. In addition to the open source streaming server applications Red5 or Mammoth, the corresponding web server applications such as Lighty or Apache with mod_H264 support are also being evaluated for use.
Naturally, apart from the SWF-FLV video format, other formats will also be supported (e.g. MPEG-4, WMV, podcast variations, HTML5 etc.).
In the Distribution and Engage modules, the exchange of information takes places over service interfaces. Data is requested over SOAP or REST and transmitted and processed in form of JSON, XML, ATOM or RSS messages to the relevant components.
For the intelligent user interfaces, Flex programming will be used for the most part in conjunction with Ajax technologies. The virtPresenter system from the University of Osnabrück will be the main source for the development in this area [9].
Fluid[16], an Open Source community project, assists in the development of new user interfaces, providing guidelines and components to achieve barrier-free accessibility and user friendly interfaces.

5. Integrating Existing Applications

As mentioned before, the Matterhorn consortium brings together a range of partners with different focuses and strengths in the process of recording and distributing lectures. The SOA concept and the fundamental understanding that a monolithic system cannot satisfy the heterogeneous needs of international universities should also play a key role in attracting other universities to participate in the project, especially those who already have their own system with respective strengths.
The objective of the Matterhorn partners is to keep the system, its design and its development as flexible as possible.

6. Future Planning and Research

Beyond providing a crucial media bootstrap to academic institutions, Matterhorn hopes to provide an innovative research environment for rich media applications. With academic research initiatives focused on media analysis (e.g. speaker recognition), semantic technologies (from media objects to re-useable learning objects [10]) and adaptive user interfaces, the research community will thrive in the Matterhorn environment. Matterhorn will benefit from these technological advances, as will its users, universities, and students. Matterhorn and the Opencast Community can offer research initiatives a prolific environment with a multitude of partners and a technology developed to be adapted, amended or supplemented by new features, be that voice recognition, face detection, or support for mobile devices. The final objective is to ensure that research initiatives will consider Matterhorn a focal point for their activities.

[12] http://code.google.com/p/ocropus
[13] http://cmusphinx.sourceforge.net/sphinx-4
[14] http://www.loc.gov/standards/sru/;
http://www.ariadne.ac.uk/issue40/morgan/.
[15] http://www.opencastproject.org/project/metadata
[16] http://fluidproject.org

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