Integrating the Kaltura Video Platform with the Photodentro Video Repository: a Case Study

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Abstract—**This work presents a case study for the integration of two web-based systems, the "Kaltura" video platform and the "Photodentro Video" digital repository. The integration is based on the Open Archives Initiative Protocol for Metadata Harvesting and an associated automation, transformation, and push/pull notification strategy. Kaltura is a video management platform, which allows publishers and content producers to distribute, manage, and monetize their videos and other rich-media content. Photodentro Video is the Greek Educational Video Repository for primary and secondary education, based on the DSpace open source digital repository management system. The architecture and the orchestrated workflow of the integration of Kaltura and Photodentro Video are presented, with emphasis on the addressed challenges. Furthermore, the technologies for scaling up the video service provided by Kaltura to a massive number of end-users are reviewed and discussed along with the proposed solution. Finally, the performance of the overall integrated platform is evaluated.**

Keywords—Open Educational Resources; DSpace; Kaltura; Photodentro; Open Archives Initiative; Metadata Harvesting

I. INTRODUCTION

Digital educational content is a key priority of the Greek National Digital Educational Policy for primary and secondary education. The key action lines of the Greek National Policy for Digital Educational Content [1] were defined in line with the directions of the Digital Agenda presented by the European Commission as part of the Europe 2020 Strategy, international trends, as well as the experiences and lessons learned from past national initiatives. A core component of these action lines is digital learning resources in the form of Open Educational Resources (OERs) that are openly available for use by educators and students, without an accompanying need to pay royalties or licence fees [2].

In response to these action lines, the Greek Ministry of Education launched in 2010 a five years national initiative for the modernization of school education named "Digital School". The "Digital School Platform, Interactive Books, and Learning Object Repository" has been a flagship project within this initiative. A key outcome of this project has been "Photodentro", the national digital repository infrastructure for learning resources for schools [1]. The infrastructure consists of an ecosystem of associated repositories of digital learning resources and the "Photodentro National Educational Content Aggregator" (http://photodentro.edu.gr).

This work presents the integration of the Kaltura Video Platform with the Photodentro Video repository, a member of the Photodentro ecosystem. The next part of the paper is structured as following: Section II provides an overview of the Kaltura and the Photodentro Video systems, while Section III presents our approach for the integration of the two systems. The solution chosen for scaling up the Kaltura service to a massive number of users is described in Section IV, the performance of Kaltura server is evaluated in Section V, and section VI concludes the paper.

II. KALTURA AND PHOTODENTRO VIDEO SYSTEMS

The architecture of the Kaltura video platform includes five logical levels. *Layer 1* (Kaltura Core Technology) offers the basic services of Kaltura, including content delivery and streaming, video transcoding, video management, etc. *Layer 2* (Kaltura API Client Libraries) offers access to the Application Programming Interface based on the "representational state transfer" architectural style (REST API). The API provides endpoints for the execution of various actions, like querying, setting, updating, and listing. *Layer 3* (Kaltura Widgets) provides numerous graphical widgets based on Flash or HTML technologies. *Layer 4* (Kaltura Application Framework) provides an extensible, feature rich configuration framework that streamlines the integration of Kaltura's rich media capabilities into different online publishing applications. Finally, *Layer 5* (Kaltura Applications) provides a virtual marketplace for publishers, developers, integrators and web sites to "trade" video applications related to Kaltura.

Various deployment options exist for the installation of Kaltura [3]. Given our requirement for full access to and control of the Kaltura server, we have opted to deploy the Kaltura Community Edition on premices, hosted on a cloud-based virtual machine (VM) with the following operational specifications: 4 CPU cores, 4 GB RAM, and 60 GB hard disk. The "Kaltura Video Platform - CE 10.11.0-1" version has been deployed and the service has been launched at http://vs.photodentro.edu.gr.

Similarly, the Photodentro Video system is deployed on cloud computing infrastructures over a cluster of VMs, all using the GNU/Linux Debian OS. The cluster is configured for high availability, both in terms of hardware / software failures, as well as for handling excess usage and peaks of demand for service delivery. In the case of a VM's or a process's failure, the overall system stability is not affected and all services remain operational, by dynamically re-routing the network traffic to the operational VMs. The current overall system architecture of Photodentro Video, includes four sets of VMs: the first which handles the dynamic routing of incoming traffic and the caching of the repository's static content; the second which provides the core functionality of the repository, based on the DSpace open source software for digital repositories; the third which hosts the system's relational database; and the fourth which provides a network-attached filesystem shared by all VMs in the cluster. All videos of Photodentro Video have been organized and classified according to their pedagogical use, and are extensively annotated with metadata according to the Greek LOM Application Profile of the IEEE 1484.12.1-2002 standard for Learning Object Metadata [4]. Photodentro Video, is available to all members of the Greek K12 community, as well as to any interested user and other associated software systems. It currently hosts approximately 1,000 educational videos distributed with an open license, their common characteristics being: short length (up to 10') curriculum-related, core-concept, and suitable for in class use.

III. Integration of Photodentro Video and Kaltura

The main objective of the integration of Photodentro Video and Kaltura is the flexible distribution and efficient streaming of the educational videos hosted at Photodentro Video, using the advanced services provided by Kaltura. Five design principles have driven the integration: (a) *transparent operation of Kaltura:* Photodentro Video shall continue to be the single point of distribution of the educational videos, there shall be no need for users to directly interact with Kaltura whatsoever, neither for accessing nor for uploading or managing videos; (b) *separation of control:* installation of Photodentro Video and Kaltura at separate server infrastructures, so that the Kaltura video platform can become offline and unavailable for some period of time, without disturbing the services offered to end-users by the Photodentro Video infrastructure; (c) *autonomous operation of Photodentro Video repository*: in the case that a video is not able to be served by Kaltura, then the video must be served by Photodentro Video; (d) *single point of reference:* while the encoded streams in various formats and multimedia codecs are managed by Kaltura and stored to its filesystem, in order to be readily available and streamed to end users when requested, the original source of the video is always available through a persistent unique identifier from the digital asset store of the DSpace backend of Photodentro Video; and (e) *REST architectural style:* usage of well-defined and documented REST APIs and associated web services for the implementation of the integration between the two systems.

Taking into account these design principles and associated requirements, the following communication and automation workflow has been designed and implemented between Photodentro Video and Kaltura (Fig. 1): (a) Any user (Producer) granted with the appropriate privileges uploads videos at the Photodentro Video repository, which are stored at its digital asset store, (b) Kaltura periodically checks for new videos that may have been uploaded, by polling a web-service of the Photodentro Video, (c) any new videos together with their metadata descriptions are harvested using the Open Archives Initiative Protocol for Metadata Harvesting (OAI-PMH) [5], and (d) the new videos are transcoded by Kaltura to various formats so that when an end-user requests a video playback from Photodentro Video, the media player of Kaltura is incorporated in the Photodentro Video user interface and the video data-stream is served by the Kaltura server. The following paragraphs provide an in-depth description of the most important phases of the integration of the two systems.

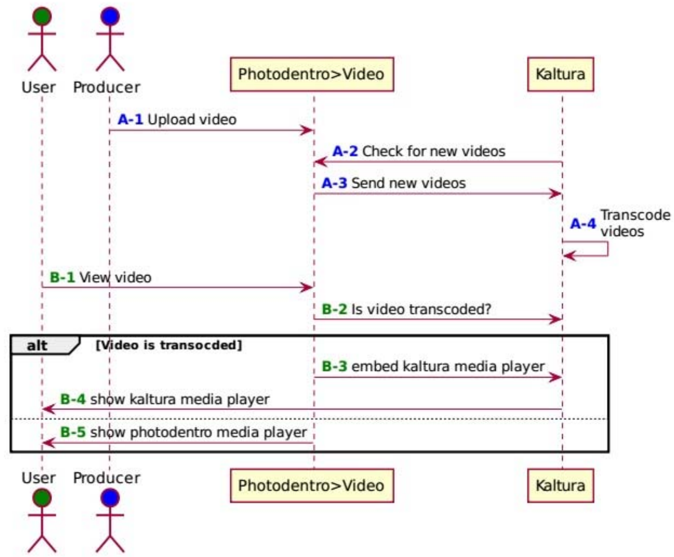


Fig. 1. Kaltura and Photodentro-Video integration

A. *Harvest of videos from Photodentro Video to Kaltura*

Photodentro Video uses the OAI-PMH protocol, which provides an application-independent interoperability framework based on metadata harvesting and supports two classes of participants: Data Providers, who administer systems that support the OAI-PMH as a means of exposing metadata, and Service Providers, who use metadata harvested via the OAI-PMH as a basis for building value-added services. The OAI-PMH protocol defines six requests or, so-called, verbs [5]. For metadata harvesting of videos from Photodentro Video to Kaltura, we reused and adapted the "OAI-PMH PHP client", which is publicly available on Github in the form of free open source software [6]. This PHP script implements a class with three methods: (a) a method that creates an XML file (with instructions to upload the videos to Kaltura). This method was used for metadata harvesting of Photodentro Video records, making use of the "ListRecords" OAI-PMH verb and returning the XML elements describing these records in a XML scheme compatible to Kaltura; (b) a method that is used to submit the XML file created to Kaltura, in order to upload the harvested videos and make them available through the Kaltura Management Console. This method calls another method, which creates a new Kaltura client and defines the credentials to be used for the connection to the Kaltura Management Console; and (c) a method that returns the date of the last execution of the PHP script.

B. *Embed Kaltura Media Player to Photodentro Video*

For the integration of Kaltura Media Player to Photodentro Video two calls of the Kaltura API are used: (a) the user:login API call, used for authorization purposes, every time a call to the Kaltura API is performed. This API call expects as input parameters the identification number of a "publisher" at Kaltura (partnerId), the user's id (userId), and the user's password, and after successful validation returns a unique session id for communication with Kaltura (ks); and (b) the media:get API call for the collection of information concerning the videos hosted at Kaltura. This API call expects as input parameters, the id of video (entryId) and the session id, and returns the description of the video (KalturaMediaEntry).

The actual integration takes place when a user asks for the playback of a video through the Photodentro Video pages. At this stage, the Photodentro Video viewer is used, a specially designed web page integrating a media player (e.g. http://photodentro.edu.gr/v/item/video/8522/1021). The HTML and JavaScript code of this page performs the following steps: (i) it makes a REST call to the media:get Kaltura API endpoint, using the Photodentro Video id (e.g. 8522/1021); (ii) it receives the response in JSON format; and (iii) if the response is valid (i.e. the video is properly encoded by Kaltura), the Kaltura Media player is embedded in the web page, otherwise the local (Photodentro) video player is used as a fallback.

This "smart" logic allows for a seamless integration of the two systems, making the operation of the Photodentro Video viewer independent from the operational status of the Kaltura Video Server. In effect, this approach follows the "loose coupling" model of the "Chain-of-responsibility" design pattern: *the subject (Photodentro Video viewer) attempts to dispatch responsibility for video playback to the first handler (Kaltura player) and continues to the next handler (Photodentro Video viewer) if needed*. It also uses the concept of the "Decorator" object-oriented programming pattern, which allows *behavior to be added to an object (Photodentro Video viewer), either statically or dynamically, by delegating some of its operation to an object of another class (Kaltura player)*.

IV. Scaling Up Of The Kaltura Service

This section deals with the scaling up of the Kaltura service for the efficient delivery of videos from Photodentro Video to a massive number of users. The available solutions are different with regards to the technologies used and the type of services supported; they are grouped in two categories: Wide Area Network (WAN) optimization [7] and Content Delivery Networks (CDN) [8].

In the case of WAN optimization, various technologies are used in order to optimize data transmission in terms of bandwidth, delay, congestion, jitter and discarded packages. The most common techniques used for WAN optimization are: (a) *WAN acceleration* by reducing the volume of transmitted data using appliances; this technique is suitable in the case of networks characterized by low speed links and high congestion; (b) *Traffic Shaping* or *Quality of Service* techniques, enabling grouping of traffic to different categories and prioritization of every category's traffic according to the needs of network operators; and (c) *Caching* techniques, which are used for caching the content closer to the end user. With regards to the type of services that are more suitable for each of the aforementioned techniques, WAN acceleration is more suitable for non-real time applications, Traffic Shaping is more suitable for real-time applications (e.g. Voice over IP), and Caching is more suitable for real time applications and applications with static content (e.g. streaming services).

The CDN technology implements a globally distributed network of proxy servers deployed in multiple areas (e.g. data centers), its main objective being to provide content from network locations close to end-users in order to achieve high availability and performance. CDNs can serve a variety of Internet content and services, like web objects, web applications, live streaming media, on-demand streaming media, social networks, etc. The techniques used by a CDN for the efficient delivery of Internet content vary, the most common being web caching, server-load balancing, request routing, and content services.

Each one of the two aforementioned solutions holds specific advantages and disadvantages, while the optimal solution and architecture for the efficient delivery of educational videos of Photodentro Video needs to take into account the associated costs in terms of required equipment, deployment, operation, and support. Specifically, in the case of a WAN optimization solution the deployment cost is high, while there is no need for local support as the management and support of the appliances can be done centrally. Furthermore, the optimization is applied to all transferred data, regardless of the protocol used and the type of the services optimized. On the other hand, in the case of a CDN, deployment costs are usually lower compared to a WAN optimization solution, while operational and support costs are higher since there is a need for local support of cache servers. Moreover, in the case of a CDN network, the caching technology may only support specific protocols.

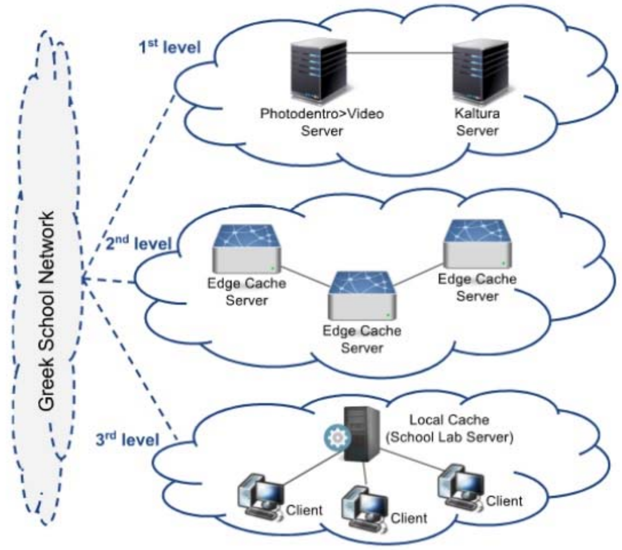
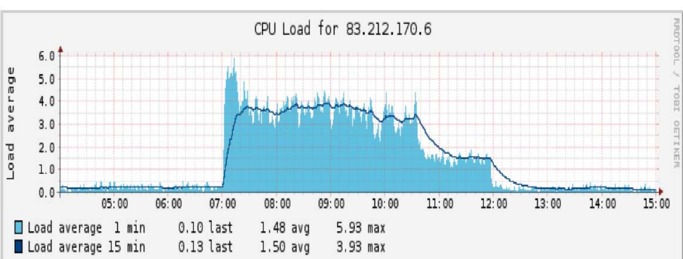


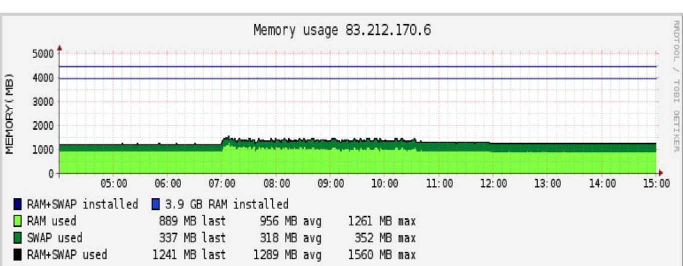
Fig. 2. Architecture of the proposed CDN

The main parameters that have driven the selection of the technology for the case of Photodentro Video and Kaltura integration are two: (a) *Network connections of schools:* This is a dominant factor that affects the quality of experience faced by the members of the Greek K12 community when they access the videos from schools. Today, the majority of Greek schools are connected to the Greek School Network [9] and the Internet, using 24 Mbps ADSL/ADSL2+ circuits. Provided that a potentially very large number of more than a million end users may access the educational videos from schools' labs and in-classroom digital whiteboards, the preferred solution must fit well with the capacity of ADSL/ADSL2+ circuits. (b) *Content delivery architecture and access policy for the digital educational content:* The content delivery architectures supported by Kaltura for the cost-efficient and effective delivery of videos to geographically distributed users provide flexibility and ease of scaling without affecting the access to other services and the performance of local or wide area networks. Specifically, Kaltura supports two content delivery architectures: external delivery through Internet using a CDN and internal delivery in the level of a wide area network or local area network. Given that access to the educational videos of Photodentro Video is open to everyone, connected either through the Greek School Network, or through any other Internet provider, there is no need to distinguish the users to internal and external.

Taking into account the aforementioned parameters and the advantages and disadvantages of WAN optimization and CDN technologies, we propose the implementation of a private CDN for the efficient delivery of the educational videos (Fig. 2), structured into three hierarchical levels that hold different categories of servers: a) the VMs of the Photodentro Video repository and the Kaltura video platform; b) the edge servers of the CDN; and c) the local cache servers of school labs. The typical flow of data is as follows: The first time a user at a school lab asks for a video from Photodentro Video, the video is downloaded from the CDN and cached by the local cache server, in order to be readily available for all future requests by school labs' users, without any delay or jitter. In case the content of Photodentro Video becomes updated, the content of the local cache servers and edge servers is automatically invalidated and becomes again updated with the first request of the video.



(a) CPU load (line) and utilization (area)



(b) Memory usage

Fig. 3. Performance of Kaltura server

V. Performance Evaluation

The performance of Kaltura was evaluated under the scenario of metadata harvesting and copying of an indicative set of 90 videos from Photodentro Video repository to Kaltura. These videos were transcoded to the following formats: (a) initial format of video, (b) Mpeg4, 364 kbps with dimensions 320 x [auto] for access through mobile devices, (c) H264b, 664 kbps with dimensions 640 x [auto] and (d) H264m, 1628 kbps with dimensions 1024 x 720. Fig. 3a presents Kaltura server's average load and CPU utilization during this period: the average load rapidly increases to a maximum value of 5.93 and it then decreases gradually once the harvesting is completed, while it remains high during the transcoding of the videos to various formats. A significant reduction of CPU utilization, can been observed once a big number of videos has been transcoded, while the CPU utilization approaches values equal to zero when the transcoding of the videos is completed. The memory usage (Fig. 3b) remains generally low.

VI. Conclusion

We have presented a case study that concerns the integration of the Kaltura video platform with the Photodentro Video repository, detailing the architecture and the workflow of the integration. Moreover, we discussed the available technologies and the proposed solution for the scaling up of the video service provided by Kaltura video platform and utilized by Photodentro Video Repository. Finally, we evaluated the performance of the Kaltura video platform under the scenario of metadata harvesting and copying of 90 videos from Photodentro Video Repository to Kaltura. Overall, the integration has proven very successful, significantly upgrading the overall experience of Photodentro Video's end users, providing alternative data-streams for videos according to the network's status, as well as the capabilities of users' devices and software.

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