Extending MOOC ecosystems using web services and software architectures

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ABSTRACT
This paper present a research project that tries to extend the MOOC ecosystems by integrating external tools like social networks. This integration is developed by using a software architecture that mediate between the different systems and platforms establishing communication workflows and analyzing the information retrieved. This kind of system is applied in a real case, and it allows teachers and managers of the MOOC platform to get enhanced information and insights about users interaction with contents and MOOC tools, as well as some metrics impossible to retrieve or calculate manually in this kind of eLearning platforms with high amounts of users.

Categories and Subject Descriptors
H.3.5 **[Online Information Systems]**: Web-based systems. H.5 **[Information Interfaces and Presentation]**: General K.3.1 **[Computers Uses in Education]**: Collaborative learning.

General Terms
Measurement, Human Factors.

Keywords
iMOOC, MOOC, Moodle, Web Services, Software Architectures, HCI, eLearning.

1. INTRODUCTION
The analysis of interaction among users and systems provide great insights about how users use, understand and take advantage of tools and platforms they utilize to perform any kind of task.

The fact of analyze the interaction and try to extract valuable knowledge from it, have real application in many areas of knowledge and business, as in digital marketing, in education (Learning Analytics), etc. Although in some fields as education, this type of behavior analysis, and interaction analysis is increasingly common, the approaches and tools developed should be updated and adapted to new systems, platforms and paradigms in eLearning. In these new types of learning platforms and paradigms can be highlighted the MOOCs, because they expand the traditional limits in students' interaction with teachers, contents and online learning platforms. Furthermore, MOOCs leverage other platforms (even those that are not purely intended to be applied in education) like the social networks and other online tools, applying by this way multi-platform and multi-context approaches that can improve and upgrade the learning experience [20].

It is because of this use of multiple tools and multiple context that is necessary to design and implement new ways of interaction analysis and platforms that allow to perform it. These new ways and platforms will manage the acquisition of knowledge regarding the learning and interaction with platforms, establishing convergence of knowledge between different learning vectors and context, to finally allow teachers and managers to learn, explore and implement possible improvements that help in the learning process, the design of content and the motivation of students.

The goal of this paper is to explain a modular software architecture implemented to allow teachers and managers of a MOOC retrieve knowledge about how users enrolled in a MOOC course utilize some tools external to the MOOC platform, getting by this way insights about what did users on these external tools, what kind of interaction they perform inside them, and thus, discover possible improvements and solutions for eLearning processes to be applied later in the MOOC platform and its courses.

To explain these contents, the paper is divided into the following sections: section 2 (Aims and goals) presents the main aims and goals of the research presented. Section 3 (iMooc Platform) describes real MOOC platform where is being tested the software architecture proposed and the integration with other online tools. Section 4 (Software Architecture Proposal) explains the software

architecture designed to tackle the integration with other tools and gain knowledge about the MOOC users and their interaction with contents inside or outside the MOOC platform. Section 5 (Services and Crawlers) explains how is being developed the software architecture integration with other tools and platforms (eLearning platform and social networks). Section 6 (Results) shows partial results of the application of this software architecture retrieving data from the integrated environments. Finally, the Section 7 (Conclusions) presents several conclusions about the research work and potential work for the future

2. Aims and goals

The MOOC courses are characterized by a high drop out rates primarily due to the heterogeneity of participants is why further information on their activity on the platform will assist meet the shortcomings of course adapted to the student needs.

It aims to create a model to obtain the maximum information from the MOOC platform combining it with the results obtained in the external elements that support the learning of the course, such as social networks, to give a feedback to the educational process, analyze performing users to adapt the content to their interaction, study the behavior to provide the extra functionality MOOC integrating user feedback analysis.

Thus the analysis of interaction in media is emphasized to obtain a deeper comprehension of users or the use of content analysis possible interest. Detecting those topics that interest students while those resources contributed by students for future editions are reused.

It is important to locate the types of learning according to the proposed activities. It is in the non-formal and informal learning where these foster interactions between users

Because of the massiveness of these many interactions resources and resources making it necessary to use tools to filter and collect all the information generated to recover this. This paper is based on the use of hashtags associated with publications to quickly retrieve the generated content. Hashtag is a character string with a topic associated preceded by a # sign and is used to mark tweets [14], part of the text of these. Although their use is widespread in twitter have extended to other social networks such as Google+. A study of hashtags is posed for the types of learning identified in the elements and course activities.

3. iMOOC Platform

3.1 The iMOOC approach

MOOC courses offer new opportunities for learning, features like massiveness of participants, peer-to-peer interactions, free-of-charge, openness or scalability [28]. There are two main types of courses MOOC, the xMOOC with a behavioral approach (occurs in traditional online courses) and cMOOC with a connectivism and networking based approach [17]. Taking advantage of features of both types of MOOC can apply the cooperative model of Fidalgo et. al. [18] which can be defined by three layers: The first one is the “technological layer” linked to the platform where will find the course content and the social network that will support the learning community. The second layer named "training strategy" refers to the instructional design of the course. This layer is divided, according to the two types of MOOC exposed, into a “behavioral strategy” focused on the acquisition of basic common knowledge and into a “connectivist strategy” dedicated to the generation of educational resources by participants. At this point, the resources generated from both strategies need organized. Finally, the “cooperative layer” shows the outcomes and the content generated with the cooperation of instructors and participants of the course [18]. For more connectivist orientation course based on the interaction between participants will require the use of social tools, a good selection of these is a good way to engage students and promote their participation in the course [1] using these tools we can create virtual learning communities (VLC), it is defined as communities of people who share common values and interests, and that are connect via different communication tools that such networks offer, whether synchronous or asynchronous [5]. The incorporation of VLC may provide greater interaction between participants, support and guidance to people with difficulties and may increase collaborative processes between participants.

Over the life of people not only learn in schools or Universities, so do in other situations in life, this idea is called lifelong learning MOOC one of the developments associated with this item. Based on the concept of lifelong learning are identified three types of learning associated with this concept [16]. Their differences [15] are based on the following items: where does the learning take place, in the case of online learning, the platform becomes as the institutional place for learning; if the learning is structured or unstructured; whether the learning is guided or not by faculty; and if there is any certification [2].

Taking these differences the Formal learning is that occurs in an organized and structured environment and leads to validation and certification, it is the most institutionalized [2]. The following types of learning take place in less organized spaces. Then, with opposite sense to the formal is informal learning, which is voluntary and unstructured. It is based on the intrinsic motivation [11] of the student. In this type of learning, the student chooses the way to acquire the knowledge, the learning is given everywhere and applies to any situations in common life [15] and is not evaluated. Finally there is the non-formal learning, which is structured and guided by the faculty, but is generally voluntary and is usually not evaluated. MOOC elements can be associated with the three types of learning, finding the more formal part in the course platform (xMOOC) and the informal part and non-formal community-associated learning (cMOOC).

3.2 Description and main features of the platform

In 2013, because of the agreement between the Technical University of Madrid, the University of Zaragoza and the University of Salamanca, the platform iMOOC or intelligent MOOC [32] emerges. Based on Moodle 2.6.5 platform [27] was chosen for its versatility. The main MOOC platforms such as edX [13], Coursera [6] or MiriadaX [24] focused on Spanish speaking require a single path for the course. Given the heterogeneity of the participants this can be in many cases the abandonment of them to take the part that interests them, one of the main distinguishing features of the iMOOC platform in front those with a more traditional approach is adaptivity of courses for students. This adaptivity is based on three variables: Depending on the user profile, according to an itinerary chosen by the student or for student progress within the course and the knowledge that he is gained. To achieve this functionality is necessary to use Moodle features such as conditionals and groups, as well as external plugins to create groupings. On the other hand iMOOC provides

an appropriate environment to an Informal and cooperative learning.

Will make use of the tools offered by the platform such as profiles, forums, workshops and secondly external social networks for informal.

3.3 MOOC course "Social Networking and Learning"

To take advantages of iMOOC platform in early 2015 a course based on a test offered by the faculty version along two editions in the Iberoamerican MOOCs platform Miriada X [4] was launched. The course of one-month duration began January 12 and ended on February 8, leaving an extra week to allow students to finish it. A Total of 793 students were enrolled for the course, more than 400 started it, and 183 students finally accomplish the goal.

The VLC was created using the tool communities of Google +, space where students can interact with each other and with content in the network sharing it. Here they can also discuss, submit questions and publish the result of voluntary exercises throughout the course. To do this has been created 9 default categories (presentations, announcements, discussions, questions, resources, Activities and exercises, application examples, contests and more) with which to classify each publication, besides the possibility to use hashtags.

This course is based on the cooperative model [18] at which has been added a fourth layer called "Gamification layer" that interacts with the other three layers, which aims to improve motivation [3]. Depending on types of learning can be divided the course study into three parts, the first section concerns the iMOOC platform itself, which takes place the more formal or formal part of the course and the other two sections relate to the community of external learning the course where interactions among participants are established and where they are generated and share new resources.

The objective of this course is to provide participants, mostly teachers of basic digital skills in social networks to implement in their classrooms with students creating virtual learning communities. Throughout 4 modules consist of lessons, it is theoretically analyzed in depth the social web and learning communities are studied thoroughly Facebook and Twitter networks and finally reviewed with less detail other valid networks for educational use with and support tools to manage social networks. The modules are divided into small lessons that address a specific topic and the content is based on a short video as well as additional information that complements the video.

As adaptive part participants can choose between five educational itineraries: Full course for teachers (additional lessons are given the keys to implement networks studied), complete course for non-teachers (only the different networks are studied), Twitter (only one module on the network), Facebook (only one module this network) and one special itinerary. The special itinerary was addressed to students who had participated in any of the two previous editions, with an extra module focused on learning communities.

The course consists of a series of directed activities and proposals by the faculty to enhance knowledge of the lessons and interaction between course participants:

- Voluntary exercises along the videos. In both cases this activity takes place in the learning community.
- Discussion proposed and discussed in the community.
- Two videoconferences using Google Hangouts, streamed live, where some course participants could make a brief presentation to other peers about an educational project related to his social networks

Table 1. Relationship of course activities on Google +

Activity	Category	Hashtag
Search examples of social networks	Activities and exercises	#RSEEjemplosRRSS
Bad practices in the use of social networks	Activities and exercises	#RSEMalasPracticas
Measuring influence in social networks using Klout	Activities and exercises	#RSEMiKlout
Using Twitter in education	Activities and exercises	#UsosTwitterEnseñanza
Discussion about the possibility of replacing a learning management system (LMS) through a social network	Discussions	
Discussion on digital identity	Discussions	
Hangout		#RSEHangout

These activities can also be performed on Twitter although the official platform is Google +. Course evaluation is based on four questionnaires one per module that participants must overcome to obtain a certificate of participation offered for free.

So this part can be associated to a non-formal learning, since such courses by not offering an official certifications, for example to allow for recognition of credits, can not be considered as formal learning.

About informal learning this occurs in the community of Google + and is associated with the interactions among participants not addressed by the teaching staff, similar to learning which could result in informal settings outside the classroom such as between colleagues in an office. Three types of interactions:

- Creating new hashtags and subsequent interaction
- Discussion proposed by participants
- Resources contributed

The last two actions are included in the categories created for this publication ("debates" and "resources").

4. Architectural proposal

Following the previous experience of the authors in similar cases, where they apply software architectures to extend the functionality of eLearning ecosystems [7-10; 21], authors decided to use the core of a software architecture they built in 2014.

Several layers compose this core, one to retrieve data from each external platform or tool, other that wipes and stores the information retrieved, another to push analyzed information to other platforms, and others that enable searches and interaction between information and users.

The core of the architecture is a system that acts as a mediator between the different social networks and learning platforms that will be interconnected (Figure 1). This mediator system communicates with each external tool through using web services (REST APIs commonly) and crawlers; retrieving data and information from them and analyzing the information in order to convert the raw data in valuable information for teachers and managers of the iMOOC platform (based on Moodle).

In order to implement this software architecture and its layers, has been used for development several technological components and technologies that are listed below:

- Django Framework [12]: This web framework is used to build the software layers and to coordinate the information workflows between the components and systems of the architecture.
- MongoDB [25]: This NoSQL database is used to store the data without the traditional restrictions of the SQL databases, and allows to adapt the database storage schemas to each kind of content retrieved from external tools and platforms [7].
- REST APIs: these web services are used to serve as communication channels between components and systems involved in the MOOC ecosystem. In case of those tools and systems that do not provide this kind of facilities, will be used crawlers to retrieve information (this will be explained in the following section).

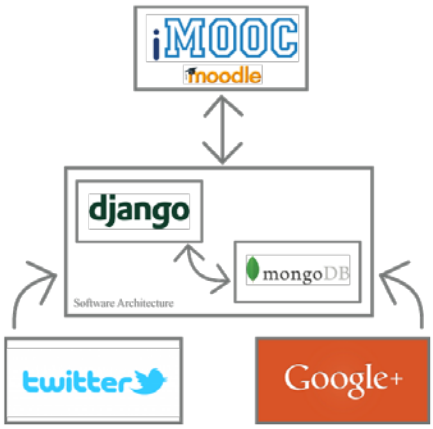

Figure 1. Software architecture proposal

The main idea behind the framework, is that teachers and managers could use the website provided by the architecture to interact with the information and data retrieved from the external tools, so all the assessment and evaluation of the users learning in the MOOC could be centralized in the architecture. The other possible approach, is that the architecture push the analyzed information again to the Moodle platform, allowing teachers and managers to allow them assess and evaluate the learning without leave the MOOC platform, in that case, the data visualization and interaction with the information retrieved depends strictly on the resources Moodle provides.

5. Services and crawlers

In order to implement the information workflows shown in the Figure 1 between the software architecture and the different systems and social networks, researchers need to establish the proper communication channels for the information. These communication channels are based, in this case, in services and crawlers:

- The services are facilities provided by third-party software to facilitate the communication and interconnection with other systems, applications or clients. In this case, researchers have used services for communicating with Moodle and Twitter.
- The crawlers are software applications that find automatically information in third-party systems when they do not provide services for *pull* and *push* information between systems. In this case we are working on crawlers for getting information from Google+ Communities (Google+ does not provide API or other services to get and post activities and other information within the communities).

In the subsections below are explained how have been used these services and crawlers, and how they are implemented within the software architecture.

5.1 Moodle

Moodle provides several API services and API architectures; allowing users and third party applications and systems interact with courses, administration settings, users and configuration information. The API used in this work is based on Representational State Transfer (REST) architecture [19], and it allows several actions in both directions of communication (GET and POST actions, as well as DELETEs, etc.); the full documentation and functionalities of this API can be found at [26].

For example, these API endpoints and functionality allow managers and teachers of the (i)MOOC course to make automatic checks about the tasks completed by users, automatized (and simply) assessment about their participation in the MOOC, etc. In a regular course on Moodle, this usage of the API is not a key aspect, most of these checks and assessment is performed manually by the teachers, but in a MOOC course with more than 700 hundreds (in this case, several thousands in bigger MOOC courses) turns out this resources as a key factor to evaluate the users' interaction with the MOOC and for assessing their learning within the course.

Bellow is presented an example code that allow teachers to retrieve the full list of users enrolled in the course; this result list of users enrolled, for example in the case of the iMOOC course was used to check what users filled their profile with the links to their personal social networks profiles, which was proposed as an activity of the *Twitter in education* lesson. As previously explained, authors implemented the software architecture using Python language, so the code is formatted in the *phytonic* way and includes the main software library used, Requests [30] that allows to implement easily the API consumption.

import requests, json

```
parameters = {'wsfunction': core_enrol_get_enrolled_users', 'courseid':'id',
                'moodlewsrestformat':'json', 'wstoken':'xxxxxx'}
url = "http://gridlab.upm.es/imooc/"

response = requests.get(url, params=parameters)

if response.status_code == 200:
   results = response.json()
   for result in results:
      print result
else:
   print "Error code %s" % response.status_code
```

5.2 Twitter

Regarding the Twitter data retrieval implementation, the authors have implemented collector that gets tweets on live based on their hashtags. This implementation is possible thanks to the Twitter REST APIs [31] and Tweepy library for Python [29]. Using both facilities (specially the Twitter Streaming API) authors built a software that is able to retrieve in real time tweets tagged [23] with the any of hastaghs proposed in the MOOC course and storing the tweets in the software architecture database (enabling by this way MOOC user matching, etc). As example of how is done this data retrieval, below is attached a simplified version of the code:

```
from __future__ import absolute_import, print_function
from tweepy.streaming import StreamListener
from tweepy import OAuthHandler
from tweepy import Stream

consumer_key="xxxx"
consumer_secret="xxxx"
access_token="xxxxx"
access_token_secret="xxxxx"

class StdOutListener(StreamListener):
   def on_data(self, data):
      try:
         print(data)
         return True
      except:
         pass
   def on_timeout(self):
      sys.stderr.write("Timeout, sleeping for 60 seconds...\n")
      time.sleep(60)
      return

   if __name__ == '__main__':
      l = StdOutListener()
      auth = OAuthHandler(consumer_key, consumer_secret)
      auth.set_access_token(access_token, access_token_secret)
      stream = Stream(auth, l)
      stream.filter(track=['#RSEEjemplosRRSS',#UsosTwitterEnseñanza",
                           "#RSEMiKlout "])
```

About Twitter integration in the system, should be highlighted that the MOOC managers and teachers must get permission of the users about storage their tweets, or simply anonymize the personal data present in each tweet (name and username, location, etc.), because the social network specify in their policy rules this restriction.

5.3 Google+

About Google+, the situation is totally different. This social network provides APIs and methods to retrieve information about users, posts, comments, etc. [22], but it does not allow to retrieve information from the users communities within the social network. This disables the possibility of use the same way to get information about conversation and interactions in the communities, regarding this, teachers and managers from the MOOC course were searching other tools that let them to retrieve the desired information; for example, they use currently the tool AllMyPlus (http://www.allmyplus.com/) that allows them to retrieve information of the learners community related to MOOC. This is not the best solution, because it convert the ideal automatic process indeed in a manual process, so the authors are trying to develop a crawler that enables them to retrieve information directly from Google+ website or AllMyPlus website.

6. RESULTS

By using the software architecture and the other tools (AllMyPlus), was possible to retrieve information about users' posts on social networks, information about their profiles on the iMOOC platform, etc. As example below of the utility of this kind of software architecture supporting and expanding MOOC functionalities, are shown several metrics retrieved from the complete learning ecosystem:

- During the course were recorded in the Google+ community 302 publications belonging to 140 users, 57 of whom have used a hashtag. Table 2 shows the times that have been used hashtags and how many of them are depending on the type of learning.
- During the course were retrieved more than 200 interactions of MOOC users with the content and hashtags in the social network Twitter.
- Also, to evaluate the completion of the MOOC activities, for example as mentioned in previous section, related to the number of users that fill their MOOC profiles with the links to their social networks profiles. In this case, the number of users that accomplish this activity was 275, a 33'86% of the total users.
- Hashtags usage and temporal evolution (Figure 2) of proposed hashtags by the teachers (non-formal) and those used by students initiative (informal).

Table 2. Distribution of posts and contents in Google+ community

	Total #	Different #	# misspelled	Users using #
Non-formal	128	8	8	37
Informal	144	82	-	43
Total	272	90	-	23 (both types)

Table 3. Interactions with MOOC contents and proposed hashtags in Twitter

Total interactions	**Twitter**
Publications	108
Replies	17
Retweets	42
Favorites	45

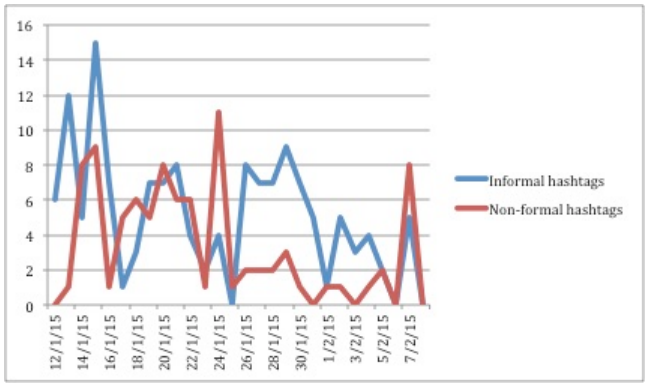

Figure 2. Evolution of informal and non-formal hashtags related to MOOC contents usage

7. CONCLUSIONS

This paper explains a software architecture designed and developed to extend the MOOC ecosystems functionalities and utilities by integrating external tools like social networks. This integration is built by using a software architecture that mediate between the different systems and platforms establishing communication workflows and analyzing the information retrieved. This kind of system is applied in a real case, and it allows teachers and managers of the MOOC platform to get enhanced information and insights about users interaction with contents and MOOC tools, as well as some metrics impossible to retrieve or calculate manually in this kind of eLearning platforms with high amounts of users.

In order to demonstrate the utility of this kind of software architectures, showing also the possibilities and new metrics that could be gathered using it, authors show some data gathered from the iMOOC platform and social networks, showing in these data how the application of this software architecture can help to measure elements difficult to estimate because the vast amount of users enrolled in MOOC courses or because they implicate the usage of external tools like the social networks that teachers can not track without this kind of tools and systems.

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