OpenFING: A Platform for Video Semantic Annotation as Learning Approach

Fernando Carpani, Matías Parodi, Lorena Etcheverry

Grupo de Concepción de Sistemas de Información , Instituto de Computación. Facultad de Ingeniería. Universidad de la República. Uruguay

***Abstract*— The video-recording of traditional lectures is a low-cost activity for the teacher and can be seen a supplement for the traditional course. According to some studies, recorded lectures can become a helpful tutoring resource. Moreover, useful annotations such as related topics, teacher and students comments, and other web resources, may be added to the recorded lectures to improve their usage or help in search processes. In this work we present OpenFING, a collaborative platform for video annotations.**

***Index Terms* E-Learning, Video Annotation, Semantic Web, Linked Data.**

I. INTRODUCTION

In Uruguay, the *Instituto de Computación* is the research and teaching center in computer sciences (CS) at the *Universidad de la República* (UdelaR), the only public university in the country. It is located within the *Facultad de Ingeniería* (FING, Engineering School) and is responsible for all the undergraduate and graduate programs in CS in UdelaR. The continuous increase in the enrollment rate of students has transformed the basic courses into highly populated/massive courses. This phenomena is not exclusive of our country. All over Latin America, schools are noticing an increase in their matriculation rates and scarce resources, hence they have low graduation rates and high drop-out rates. It has become necessary to adopt new strategies to adapt the scholar system to this reality. In this context, a group of students proposed to film and publish online lectures.

The video-recording of traditional lectures is a low-cost activity for the teacher and can be seen a supplement for the traditional course. According to some studies, recorded lectures can become a helpful tutoring resource, mainly because videos have a slower, more step-by-step lecture style than the classroom lectures; student use of videos is voluntary and can be tailored by students to meet their learning and topic-review needs, and can occur when and where students learn most effectively [1]. Moreover, useful annotations such as related topics, teacher and students comments, and other web resources, may be added to the recorded lectures to improve their usage or help in search processes. In this work we present OpenFING, a collaborative platform to publish and annotate videos.

With this platform, teachers and students can annotate videos with topics, comments, Web resources, and others kind of metadata to improve their usage for teaching and learning. One of our main concerns, from the technical point of view, was to develop an architecture in which new features could be easily introduced to the platform. This lead us to using the Semantic Web technologies [2], and in particular Linked Data [3], to develop the platform.

The rest of the paper is organized as follows. We start in Section II presenting a use case. Then in Section III we talk about some related work. In Section IV we describe the OpenFING platform. Finally, in Section V we present conclusions and in Section VI current and future work.

II. A USE CASE

Carlos is studying for a mid-term exam of Mathematical Logic. The rest of this section presents a set of activities he may perform over OpenFING platform during this process.

A. Search and find.

Using OpenFING search engine he makes the query “induction” on the contents of the course. As a result (Fig. 1), the platform shows him a video of one hour and a half in length, where the title, “Inductive Set Definitions”, matches the criteria. This video contains the complete lecture about the concept he is looking for, and other related concepts. No other user has annotated a specific video fragment about this topic, so Carlos starts to watch the lecture looking for the fragment in which the teacher really talks about “induction”.

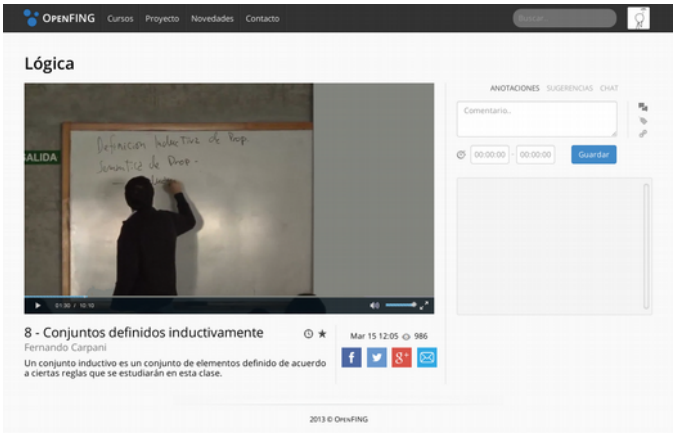

Fig. 1 A Video in OpenFING

B. Fragmentation and annotation.

He finds a specific fragment of the video where the teacher defines inductive sets. He then decides to annotate it with a new topic, “Inductive Sets”. To do this, Carlos writes in the topic text area next to the video and the system takes the start

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time of the player. Whenever he decides that the fragment finishes, based on what the teacher is saying or showing, he saves the annotation. Figure 2 shows the annotation dialog.

Fig. 2 Annotation Panel.

C. Ask others users and add external resources..

Carlos has some questions about the lecture fragment. He may for example search the course forum (hosted on Moodle learning platform) looking for answers. If he finds useful posts he then attaches the posts URLs to the video fragment. Also, he can post a new question or answer and attach de video fragment URL, allowing him to do a better explanation.

D. See system suggestions.

Lucía is also studying the same topic. When she searches for "Inductive Sets" she now finds not only the video of the lecture, but also specific fragments annotated by other users. She starts watching the lecture video, and the suggestions panel shows video fragments related to what she is actually watching. The contents of this panel change dynamically showing not only video fragments of the current video or any other video in the system (potentially of a different course), but also presenting external resources related to the topics annotated within the current video. Figure 3 shows the suggestions panel.

Fig. 3 System Suggestions

E. Teachers Activities.

Students may use OpenFING in an effective way without involving the teachers, but the system also includes some activities that can be performed by teachers to improve the experience.

Some activities for the teacher are:Annotation curation: this consists of assessing the exactitude of students' annotations, and reorganizing topics or resources according to specific ontologies.

- Annotation analysis: the analysis of student annotations may provide statistical and possibly individual conclusions about a lecture, courses, etc.

Also the teachers may include video watching and performing annotations as learning activities in their courses.

III. Related Work

From a educational perspective, some related works deal with the use of annotations as in e-Learning. In [4] the authors review a set of learning experiences that use annotations, and extract some recommendations about the use of annotations as a learning activity. In [5], an experiment about social annotation in an educational environment is presented which concludes that is a good way to engage the students in the educative process. None of the above mentioned works deal with video annotations. Several works treat video annotations, but only a few focus on educational videos. The work presented in [6] is close to OpenFING, but they do not use Semantic Web Technologies. Regarding the use of Semantic Web technologies in e-Learning, some works should be taken into consideration. OpenCourseWare team experience about producing and consuming Linked Data is presented in [7]. In [8] a platform similar to OpenFING is described.

IV. OpenFing: A Semantic Web Based Platform

OpenFING is strongly based on Semantic Web technologies. Its data model is composed of two ontologies, and the video fragments and annotations are recorded as RDF triples in a triplestore. This allows to exploit data via SPARQL[9] queries and reasoning strategies like Entailment Regimes [10]. In the following sections we present the designed ontologies and the architecture of the OpenFING platform.

A. The Data Model as Ontologies

OpenFING data model is composed of two Owl2[11] ontologies: a generic vocabulary about video-fragments and its metadata, called **MMC**, and a specialization of the former to include some particularities of social components, called **OFM**. MMC is a specialization of the W3C Ontology for Media Resources [12], an it includes concepts like Media, Metadata, Topic, etc. OFM has concepts like University, Teacher, Lecture, Course, etc. Figure 4 presents both ontologies and their interrelationships. Classes from MMC are depicted in blue boxes, while classes in OFM are shown in green boxes.

These ontologies are aligned with the following vocabularies or ontologies:W3C Ontology for Media Resource [12], the Academic Institution Internal Struycture Ontology (Aiiso) [13], the Friend of a Friend Vocabulary (Foaf) [14], Skos [15] and Dublin Core [16]. We will refer to this set of ontologies as standard ontologies.

The alignments are performed by declaring concepts in the OFM and MMC ontologies as sub-classes or sub-properties

of the concepts in the standard ontologies. This allow us to not only support queries that use terms from OFM or MMC, but also be able to resolve queries that use terms from the standard vocabularies using reasoning. We think that this approach is not usual in other Linked Data based systems.

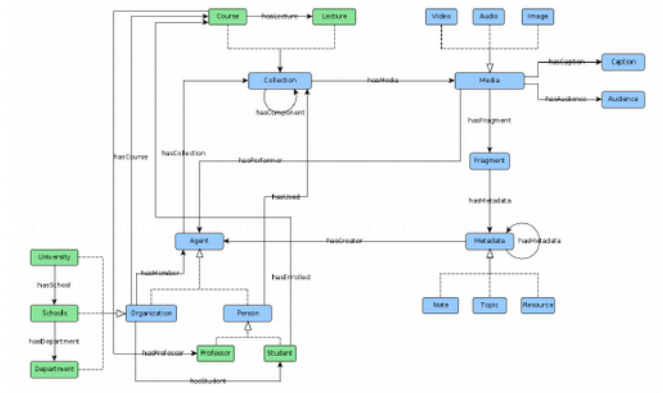

Fig. 4 Ontologies

The choice of implementing OpenFING over Semantic Web Technologies, instead of traditional relational database systems, eases the maintenance and evolution of the platform. We now present some examples:

- **Extensibility**: To add a new type of metadata or agent it suffices to add a new subclass of MMC:Agent MMC:Metadata. In a traditional relational approach this modification may involve the addition of structures (tables or attributes in existing tables) and constraints in the database. Also, the developers may deal with decisions about existing data, like what to do with new attribute values. None of these considerations are needed with the Semantic Web approach.
- **Interoperability**: External users can pose queries over the data without knowing MMC or OFM. These queries can use terms from the standard ontologies, and using inference the system is capable of finding the related concepts in MMC and OFM. It is also possible to use federated queries (using Virtuoso as back-end) in order to locate external resources to be referenced from fragments.
- **Data Evolution**: Data structure may evolve with a minimal impact on the base. As an example, Topics may evolve from something as simple as a tag to a more complex structure with subtopics and other properties or relationships. This kind of evolution is better supported and has less impact on the implementation in the case of semantic web technologies than in traditional data base systems.

B. *Architecture*

Figure 5 presents the functional architecture of OpenFING. We now describe the main components of the platform.

Videos in OpenFING can be hosted inside the platform or in external providers such as YouTube, Vimeo, etc.

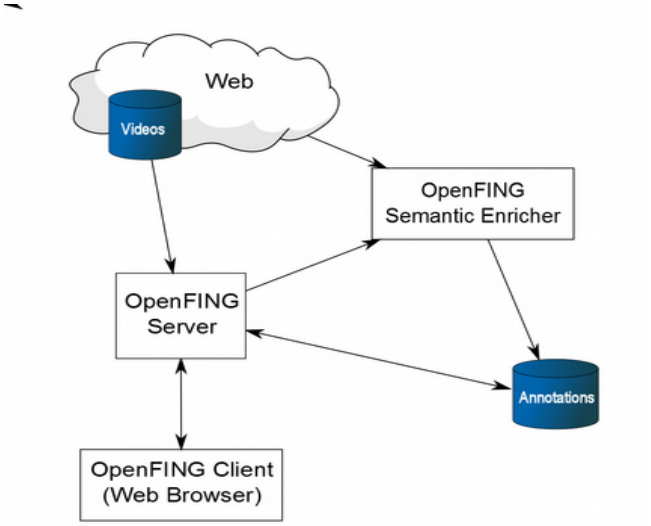

Fig. 5 Functional Architecture of OpenFING.

The *Annotations* are represented in RDF [17] using properties and classes from MMC and OFM ontologies. These annotations can be obtained in a collaborative way directly from the users, or by the *Semantic Enricher* using some kind of process from other systems (NLP over web pages, queries over SPARQL endpoints, etc.) . The annotations are stored in a Triplestore which can be accessed via SPARQL [9], possibly with an Entailment Regime [10] to resolve some issues as ontology alignment. Currently, OpenFING uses Stardog Community Edition [18] as Triplestore, which has sophisticated reasoning capabilities based in Pellet [19]. Virtuoso [20] can also be used, which has supports reasoning for sub-class and sub-property relationships.

The *OpenFING Server* can be seen as an application proxy with some programmed queries to access the annotations stored in the Triplestore. In its current version the server is implemented using NodeJs [21].

Several *OpenFING Clients* may be developed. The current version, available at http://open.fing.edu.uy/, is developed using Ruby on Rails, and we are working on a new version based on HTML5 and standard javascript libraries like jQuery and Bootstrap.

The client annotation can be seen as dynamically generated metadata tracks. In this vision, the communication model with the client is more close to streaming than MVC.

V. Conclusions

We have presented OpenFING, a platform for collaborative annotation of lectures videos, based on Semantic Web Technologies.

From the methodological point of view we believe that our approach presents some advantages with respect to traditional e-Learning strategies. Usually, traditional e-Learning strategies require the development of specific videos. In this sense our approach has lower costs for the teachers, since traditional lectures are recorded and uploaded to the

platform.

We also believe that our approach actively promotes the involvement of students in their learning process, since annotations and video-fragments are mainly proposed by them. In this sense, it is aligned with the ideas proposed in Blended Learning strategies [22].

VI. Current and Future Works

Today, we are testing a previous version developed in Ruby on Rails. Also, we are developing the OpenFING server and clients using NodeJS and HTML5. This version includes support for some of the student activities described previously.

The implementation of teacher activities like analysis or curation may need some modifications of MMC and OFM ontologies. In particular, some kind of log of agents operations must be added. This may need strategies next to reification features in RDF. We also expect to start soon the developing of an advanced Semantic Enricher using two approaches: querying LOD [23], and using Natural Language Processing of documents.

The integration of OpenFING with other Semantic Web based platforms, such as OpenCourseWare, via ontologies alignments is also in our future plans.

In the educational dimension, we are starting to develop strategies to study the effects of using OpenFING over students and teachers.

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