Information Extraction in Semantic, Highly-Structured, and Semi-Structured Web Sources

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Abstract—**The evolution of the Web from the original proposal made in 1989 can be considered one of the most revolutionary technological changes in centuries. During the past 25 years the Web has evolved from a static version to a fully dynamic and interoperable intelligent ecosystem. The amount of data produced during these few decades is enormous. New applications, developed by individual developers or small companies, can take advantage of both services and data already present on the Web. Data, produced by humans and machines, may be available in different formats and through different access interfaces. This paper analyses three different types of data available on the Web and presents mechanisms for accessing and extracting this information. The authors show several applications that leverage extracted information in two areas of research: recommendations of educational resources beyond content and interactive digital TV applications.**

Index Terms—**Information extraction, web data processing, semantic enrichment, data mining, web scraping.**

I. Introduction

PRESENTLY, the Web hosts billons of pieces of information of all kinds and origins. A relevant part of this information can be freely accessed and reused. Under these assumptions, it would be possible to collect these freely shared pieces of information to enrich any database, that is, to complete the information stored locally using the huge amount of data available on the Web. This will enable software agents to increase their knowledge from a wide range of sources providing different points of view and levels of detail. This way, potentially complete information may be obtained.

Section II explains different strategies for information extraction depending on the type of source. Sources available may be classified according to the language used to expose this information (e.g., HTML, XML, SQL, RDF, JSON). Each of these types of sources has been designed to satisfy a different need (e.g., to be accessible to humans, to facilitate the communication between applications, to facilitate data storage). Enriching a system's database means taking the most of the available information sources online to complete information stored locally. Insofar automated enrichment is concerned, the most interesting repositories are those specifically designed to be easily readable and interpretable by machines, that is, those offering their information according to a Knowledge Representation language like the ones proposed by the Linked Open Data (LOD) initiative [1]. The reason for that is because the enrichment process' complexity is dramatically reduced, and therefore its automation is greatly simplified. On the other side, other types of sources would need a previous translation or transformation process to represent them according to a normalized language, such as RDF. This latter process will require the active participation of experts.

Section III describes the application of information extraction techniques in the context of the iTEC project, which is the flagship FP7 project in the education area, financed by the Europan Comission with 12 million euros. iTEC tries to contribute to the conception of the classroom of the future, in which technology is complemented with the most innovative pedagogical approaches, which entail a major level of dynamism in the educational practice.

Section IV briefly discusses the use of information extraction techniques in two projects that have to do with the access to services through digital TV interfaces. The first one, Berce TV, is a portal that enables parents to access information on their children in early chilhood education centers. The second one, Emprego, is a project aimed at providing an accessible job search interface though the TV.

Finally, we give conclusions and discuss future work.

II. Information Extraction from the Web

In the Internet, you can find many different sources of information, being a lot of them available for free. The nature of the information that you can freely access to is very heterogeneus. From a technical point of view—and for convenience—, we make a classification of the sources of information by the format they use for encoding information[1][2]—which many times is associated with a particular protocol for accessing to that information. The

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[1]Some of those formats are, among others, RDF, HTML, XML, and JSON.

[2]This idea is not new. See for instance the work in [2].

rationale for having so many different formats for encoding information is that each one is best suited for satisfying a particular need. For instance, RDF is well suited to be accessed from systems that belong to the so-called semantic Web; whereas HTML is particularly well suited to encode information in such a way that a Web browser is able to understand and display it in a computer's screen.

It becomes thus clear that, in order to populate a local database using external sources of information, the more semantic the source format is the less processing we need to perform at the local side. Therefore, purely semantic sources that share information in RDF format are by far the preferrable ones, whereas sources that are meant to represent markup—for presentation—are the less desirable ones, because they need much more processing in order to squeeze them and extract the "semantic juice" out of them. Most of the times, that task is very labor-intensive, and no good automated procedures are yet available.

Below, we describe the three types of sources of information: semantic sources, highly-structured sources, and semi-structured sources.

A. Semantic Sources

The kind of sources of information from which we most easily can extract information are those pertaining to the Linked Open Data (LOD) initiative. The main purpose of the LOD project is to enrich the traditional Web by publishing open datasets—made of data items—which include links to data items in different datasets. Since the purpose of that format for representing information is that it must be easily understandable by machines, those sources are therefore very convinient for extracting information.

In order to be compliant with Linked Open Data conventions, information is represented in Resource Description Framework (RDF) format. Despite the fact that it was meant as a format for representing metadata, RDF is used—in the context of LOD—for modelling general information. The simple model for representing information that RDF implements accounts for its success in representing information beyond the limits of the Semantic Web[3]. RDF stores information as triples, which format every piece of information as an statement composed of subject, predicate, and object.

Information stored in RDF triples and published in public access points is commonly accessed by using the SPARQL query language—in fact, those public access points are frequently called SPARQL endpoints [3]. With SPARQL we can compose queries that are able to retrieve and manipulate data stored in those sources that comply with LOD conventions.

In addition to those sources, there exist a number of services that allow for launching searches on information stored in the LOD network, much like Google does with the traditional Web. Those tools, such as Sindice [4] and SWSE [5] are very useful and enable us to discover a lot of interesting sources of information.

B. Highly-structured Sources

Outside of the LOD world we can find sources of information that, even though they do not use RDF as their information representation format, enable us to access information in a easily automatable way. We are referring to Web sources that expose information that is encoded with formats such as JSON and XML. Those are formats that encode pure–pristine–information, not mixing it with presentation markup. This makes the extraction process from these sources easier than from those in, for instance, HTML.

The main difference of these sources from those belonging to the LOD initiative is that the intended meaning of the information exposed at the remote sites is not automatically translatable to the meaning at the local side[4]. In addition to that, RDF triples are always RDF triples, whereas two different websites may use different strategies to encode their data, even though both use XML as the format for data representation.

In summary, highly-structured sources—using our terminology—enable us to easily retrieve information, but a dedicated processing is necessary for each and every one source in order to extract that information.

C. Semi-structured Sources

We call semi-structured sources to those that encode information in such a way that it is mixed with presentation markup. The most common of its kind are sources that expose information that is represented in HTML—that is to say, traditional Web pages. In order to retrieve and extract information from a source of this type, we need to browse the DOM tree of the page and identify concrete DOM elements that represent particular pieces of information. That is, we need to kind of reverse-engineering the web page in order to figure out the mappings between presentation-related tags and their meanings.

The good news is that the DOM tree is usually nothing else that a blur reflection of the pure information stored in a relational database[5], after having been intermingled with presentation markup. Thus, once we get rid of all the presentation tags, we can get the most precious pieces of information[6].

In summary, information retrieval and extraction from semi-structured sources is more costly that from highly-structured ones, because in addition to a dedicated processing for each and every source we also need to reverse engineer and get rid of a lot of uninteresting pieces of data.

[3]RDF is particularly well suited to represent information in knowledge management applications, as it is able to represent may different and, at times abstract, concepts.

[4]Conversely, LOD conventions allow for sharing information together with its meaning.

[5]According to [6], most Web sites use a SQL database as their persistence solution.

[6]That is the alegory of data mining, to get "gold" from heaps of "dust".

III. Application in the iTEC Project

iTEC promotes an educational practice in which students interact in small projects which include participation in events, speeches with experts, and all that seasoned with the use of technology. The *leiv motiv* of this new paradigm is "Resources beyond Content". Thus, in iTEC educational resources go beyond educational content, frequently consumed in the form of textbooks, and they include technological resources, as well as cultural events and people who are experts on some knowledge area.

The initial assumption was that teachers were going to have a hard time trying to figure out which events could have the greatest relevance among such an enormous offer. This hypothesis was the main motivation for the design, development, and posterior rolling out of the SDE (Scenario Development Environment) [7], [8], which is a software system that works as a recommender, in such as way that a certain teacher, during the phase of preparing an educational experience, may rely on the SDE for selecting the most interesting events to be attended by learners during the performance of the educational experience. The SDE's recommendation algorithm has several factors into account, such as the appropriateness of the event and the proximity of the event to the school [9].

After three years of project and more than 2000 pilots in schools across Europe, that starting hypothesis has shown to be wrong. That is to say, the number of events registered at the P&E directory is not of the scale that it was supposed to be, and thus it does not makes necessary to use a recommender. The main reason for the low number of registered events is that the registering process is very time consuming, in addition to being very error-prone. In order to tackle this drawback, it was implemented and integrated in the SDE an enrichment module, which automatically extracts and processes huge amounts of data coming from relevant Web sites that list applications, events, and experts in different areas of knowledge. Figure 2 shows events that were extracted from the Web in the SDE user interface.

A. Sources of information

All across the Internet there are a great number of websites that offer information on applications, events, and experts. On applications we extract information from three websites that we find particularly interesting:

– Softonic[7] is a huge repository of information on standalone applications. From every entry on that repository we can extract information such as its description, the operating system required, tags, and what is very important: the rating from users.
– Softpedia[8] is, similarly to softonic, a big database of information about applications.
– AlternativeTo[9] is an incredible resource for extracting meaning about the features of an application. For each application, AlternativeTo provides a list of "substitutes"—applications with similar functionalities and that may suit a similar need. This is extraordinarily useful from the point of view of populating a database aimed at serving as the knowledge base of a recommender, because we can extract very relevant information that may lead to more accurate recommendations. As an example, AlternativeTo enables us to extract information such as: Skype is similar to Google Hangouts, and Firefox is similar to Chrome.

Regarding experts, two websites are the most relevant ones:

– Google Scholar[10] is an enormous database of researchers. From each registry we can extract very useful information, such as the name and position of researchers. To extract the information on their location—which in the context of iTEC is a very important piece of information, because experts of a near location should gain relevance in an hypothetical recommendation—we use an mechanism that takes as an input the position of the researcher (which is a text string that usually contains their affiliation) and their email address. The email address, in most cases, enables us to get the IP address of the expert's institution—provided that the institutions hosts the mail server, which is often true. The affiliation can be processed with NLP software[11] to get rid of the position and retrieve the institution, and then geocode the institution.
– LinkedIn[12] is a huge social network targeted at professionals. Unlike Google Scholar, which sorts entries by relevance[13], in LinkedIn we cannot measure the relevance of a particular professional. In order to overcome that difficulty—it is neither reasonable nor efficient to replicate all the LinkedIn public entries—we rely on Google's relevance calculations. Let's see that with an example, if we want to find experts on, let's say, biology we look for "biology site:www.linkedin.com" in Google. In this way, we get a bunch of search results ordered by the relevance that Google assigns to those entries.

In order to get events we need to follow a brute-force approach[14]. All across Europe there are a great number of

[7]http://www.softonic.com

[8]http://www.softpedia.com

[9]http://alternativeto.net

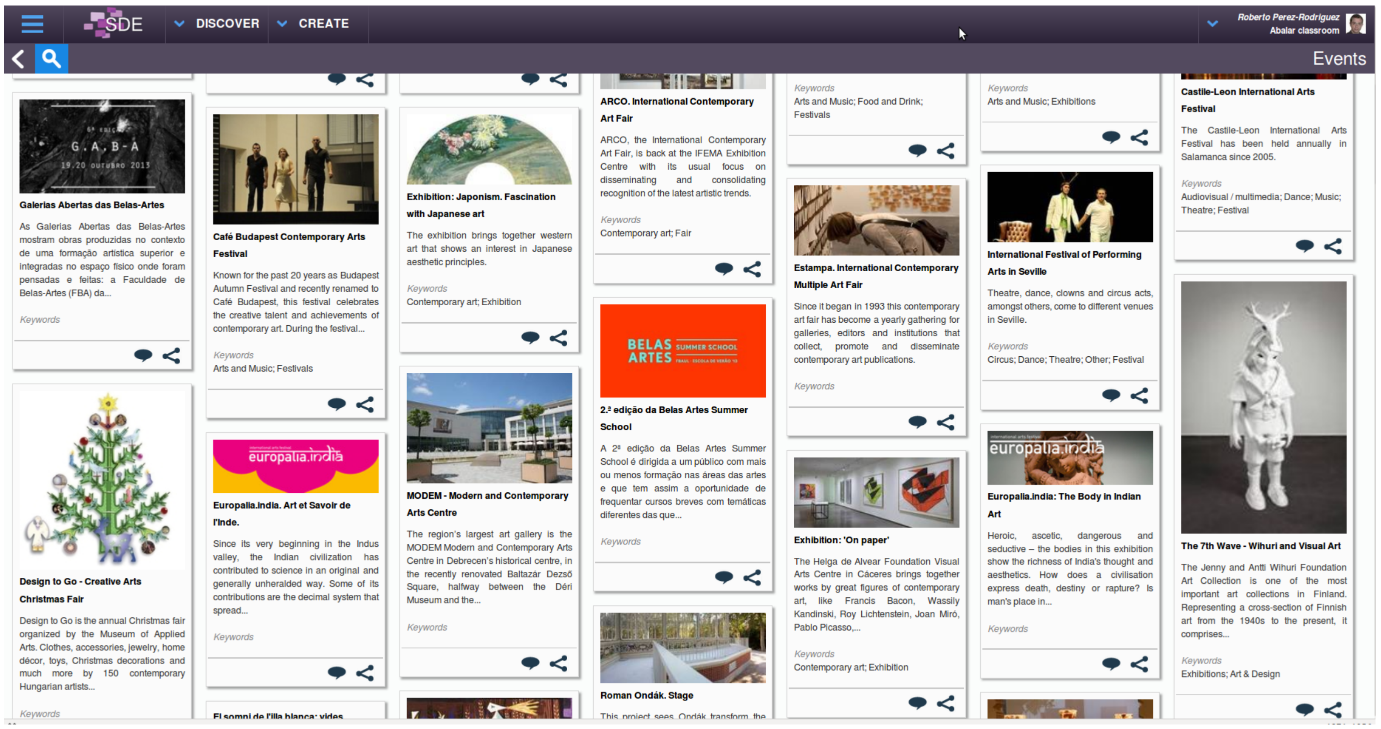
[10]http://www.scholar.google.com

[11]To that end we use the Geocoder library, which is available for the Ruby programming language.

[12]www.linkedin.com

[13]Google Scholar measures relevance as the number of references that researchers gathered to all their publications.

[14]At the time of writing, we extracted information from the following websites: www.spainisculture.com, www.discoveringfinland.com, www.unesco.org, www.finnbay.com, www.openeducationeuropa.eu, www.visitportugal.com, www.ulisboa.pt, www.uio.no (the University of Oslo), visit-hungary.com, visitbudapest.travel, visitbrussels.be, www.belgica-turismo.es, www.ualg.pt (University of Algalve), noticias.up.pt (University of Porto), www.globaleventslist.elsevier.com (worldwide conference registry).



Galerias Abertas das Belas-Artes
As Galerias Abertas das Belas-Artes mostram obras produzidas no contexto de uma formação artística superior e integradas no espaço físico onde foram pensadas e feitas: a Faculdade de Belas-Artes (FBA) da...
Keywords

Design to Go - Creative Arts Christmas Fair
Design to Go is the annual Christmas fair organized by the Museum of Applied Arts. Clothes, accessories, jewelry, home décor, toys, Christmas decorations and much more by 150 contemporary Hungarian artists...
Keywords

Café Budapest Contemporary Arts Festival
Known for the past 20 years as Budapest Autumn Festival and recently renamed to Café Budapest, this festival celebrates the creative talent and achievements of contemporary art. During the festival...
Keywords
Arts and Music; Festivals

Europalia.india. Art et Savoir de l'Inde.
Since its very beginning in the Indus valley, the Indian civilization has contributed to science in an original and generally unheralded way. Some of its contributions are the decimal system that spread...
Keywords

El somni de l'illa blanca: vides

Exhibition: Japonism. Fascination with Japanese art
The exhibition brings together western art that shows an interest in Japanese aesthetic principles.
Keywords
Contemporary art; Exhibition

MODEM - Modern and Contemporary Arts Centre
The region's largest art gallery is the MODEM Modern and Contemporary Arts Centre in Debrecen's historical centre, in the recently renovated Baltazár Dezső Square, halfway between the Déri Museum and the...
Keywords

ARCO. International Contemporary Art Fair
ARCO, the International Contemporary Art Fair, is back at the IFEMA Exhibition Centre with its usual focus on disseminating and consolidating recognition of the latest artistic trends.
Keywords
Contemporary art; Fair

2.ª edição da Belas Artes Summer School
A 2ª edição da Belas Artes Summer School é dirigida a um público com mais ou menos formação nas áreas das artes e que tem assim a oportunidade de frequentar cursos breves com temáticas diferentes das que...
Keywords

Roman Ondák. Stage
This project sees Ondák transform the

Keywords
Arts and Music; Food and Drink; Festivals

Estampa. International Contemporary Multiple Art Fair
Since it began in 1993 this contemporary art fair has become a yearly gathering for galleries, editors and institutions that collect, promote and disseminate contemporary art publications.
Keywords

Exhibition: 'On paper'
The Helga de Alvear Foundation Visual Arts Centre in Cáceres brings together works by great figures of contemporary art, like Francis Bacon, Wassily Kandinski, Roy Lichtenstein, Joan Miró, Pablo Picasso,...
Keywords
Contemporary art; Exhibition

Keywords
Arts and Music; Exhibitions

International Festival of Performing Arts in Seville
Theatre, dance, clowns and circus acts, amongst others, come to different venues in Seville.
Keywords
Circus; Dance; Theatre; Other; Festival

Europalia.india: The Body in Indian Art
Heroic, ascetic, dangerous and seductive – the bodies in this exhibition show the richness of India's thought and aesthetics. How does a civilisation express death, destiny or rapture? Is man's place in...
Keywords

Castile-Leon International Arts Festival
The Castile-Leon International Arts Festival has been held annually in Salamanca since 2005.
Keywords
Audiovisual / multimedia; Dance; Music; Theatre; Festival

The 7th Wave - Wihuri and Visual Art
The Jenny and Antti Wihuri Foundation Art Collection is one of the most important art collections in Finland. Representing a cross-section of Finnish art from the 1940s to the present, it comprises...
Keywords
Exhibitions; Art & Design

Fig. 1. Search results for events on “art” in the SDE user interface

websites that offer information on cultural events. Some of them, such as the Open Education Europa[15] initiative, are at a European scale. Conversely, others such as the Spain is Culture[16] portal are at a lesser scale.

B. *Considerations on the Information Extraction Technique*

There are several factors that you need to take into account in order to make an efficient scraping. The first one is that the scraping process of a web site may take quite a long time, so it should be performed as a background process. Besides, you have to take care of not launching too many requests to a given web server in a short time interval, because that could be seen as a Denial of Service attack, and the web server could block your IP.

Taking all the above into consideration, the scraping process starts with studying the HTML layout of the involved web pages. In order to do that efficiently we use the Firefox Firebug extension. The list of events in the Spain is Culture portal serves an an example of our procedure. We use Firebug for inspecting the HTML structure of the document.The next step is to test CSS selectors using the JavaScript console that is embedded in Firebug, issuing some JavaScript sentences that use jQuery.

Once we identify the concrete DOM elements that contain relevant information[17] we are ready to write some Ruby code that automates the parsing of applications, events, or experts. To that end, we make uses of the Nokogiri[18] library. Nokogiri is an open source HTML, XML, SAX, and Reader parser.

If we are dealing with events, once we got the venue of an event we try to get its coordinates. To that end, we make use of the Geocoder[19] gem, which issues requests to the Google Maps API. Thus, we geolocate all the events. The following snippet of code shows how we parse the text that represents the address and, from that, we get the latitude and longitude of the event using Geocoder:

```
address = event.css('a')[0]['href'].split("/")[3]
coordinates = Geocoder.coordinates(address)
latitude = coordinates[0]
longitude = coordinates[1]
```

[15]The Open Education Europa portal was launched by the European Commission as part of the Opening Up Education initiative. Its main purpose is to provide a focal access point to European OER in different languages. These OER are targeted to researchers, teachers, and students. According to information provided by the portal, it has more than 38000 registered users and receives more than 55,000 monthly visits.

[16]The Spain is Culture portal is devoted to promote and disseminate Spanish culture. The website presents the most outstanding of Spanish culture, and it includes a wide range of cultural offers, such as monuments, artistic styles, artists and places of interest. The navigation through the portal allows for discovering cultural events going from several starting points. You can search by a localisation, a town or autonomous region; by the historic period or artistic style; and, besides these ones, you can also search by the type of target audience.

[17]We identify which element in the DOM tree contains the information on the venue of a certain event in the Spain is Culture portal. The same matching has to be made for each field in the detailed view—the name, the description, the date range and so on. To ease that process, we can use the JavaScript console to test CSS selectors in jQuery until we find the correct one.

[18]http://nokogiri.org/

[19]www.rubygeocoder.com

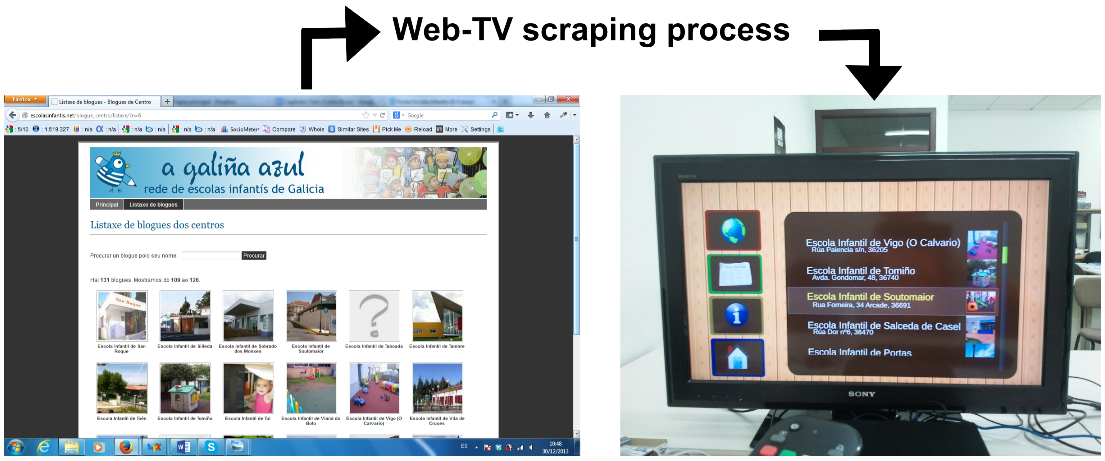

Web-TV scraping process
a galiña azul
rede de escolas infantís de Galicia
Listaxe de blogues dos centros
Escola Infantil de Vigo (O Calvario)
Escola Infantil de Tomiño
Escola Infantil de Soutomaior
Escola Infantil de Salceda de Caselas
Escola Infantil de Portas

Fig. 2. The contents displayed on the TV screen are taken from the Web portal.

One important thing to consider when extracting events is to check if the scraped event is a new event, an update of an existing event, or a duplicate. To that end, we build a hash with the fields that make up an event. If the event is already present in the database but the calculated hash is different, then the update the fields of the event. Conversely, if the event is already present and the hash is identical, then we discard the scraped event because it is a duplicate. The following snippet of code shows how to create a hash with some of the fields that make up an event:

```
hash_event = Digest::MD5.hexdigest(name + description
    + start_date + end_date + latitude.to_s + longitude.
    to_s)
```

The filtering of duplicates is of special importance when dealing with events. Many times, when an event is published for the first time some of the fields might not be set yet. For instance, the final date might not be known yet; or maybe the venue is not fixed yet.

IV. Information Extraction for Interactive Digital TV Applications

Visualisation of content on digital TV depends on how digital information is presented—the same is true on smartphones and tablets. As it can be observed in smartphones, it is increasingly frequent to develop native applications so that the user does not have to access contents on the cloud through a Web browser. Following the same approach, in order to show third-party content on a digital TV we need either accessing an API that offers information in a structured way or accessing directly to content in HTML format, received from HTTP requests; HTML content is then processed in order to obtain and structure the information that will be later shown in the TV screen.

Regarding the way of obtaining the information that will be displayed we can distinguish between two different models for obtaining information: a passive one and an active one. Those depend on the needs of the final system that we are developing for. In the passive model, the user tells the system which information he/she wants to visualise at the time. The application is thus, at that very moment, in charge of obtaining the information requested, processing and displaying it in the TV screen—following the specifications for that information. On the contrary, in the active model, the application is continously retrieving information and processing it so that it may be ready when the user demands to see it.

Following is the description of two applications that were built on environments for digital TV, each one making use of a different model for obtaining information.

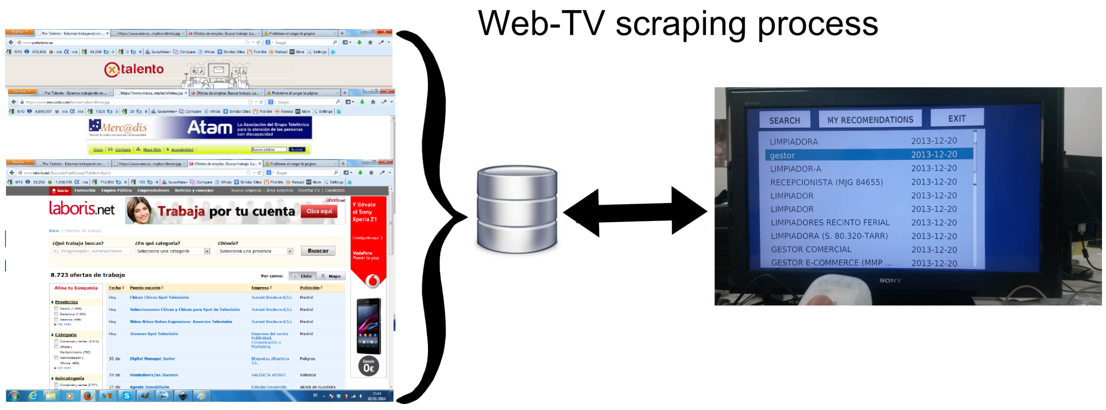
A. *BerceTV*

This native application enables parents of children in early childhood education to access the information that is published in the Galician Portal of Early Education Schools[20] though their digital TVs. Thus, parents are able to access both information of their children as well as diverse public information that is shown in the portal.

The application acts as a middleware between the TV and the Web portal. In this way, every action the user performs is converted—in real time—into an HTTP request that is sent to the portal. The information thus received is processed, filtered, and structured so that it may be displayed in an interface adapted to the characteristics of a TV screen. Figure 2 illustrates this process.

Since all the information is obtained in real time, this can result on requesting redundant information such as images. In order to improve the performance and efficiency, the system includes a cache layer in charge of receiving and managing multimedia information. This operating mode prevents downloading duplicated information; besides, it keeps the response time low, because the obtaining of multimedia information is performed in independent threads, which avoid

[20]http://escolasinfantis.net



LIMPIADORA	2013-12-20
gestor	2013-12-20
LIMPIADOR-A	2013-12-20
RECEPCIONISTA (MJG 84655)	2013-12-20
LIMPIADOR	2013-12-20
LIMPIADOR	2013-12-20
LIMPIADORES RECINTO FERIAL	2013-12-20
LIMPIADORA (S. 80.320-TARR)	2013-12-20
GESTOR COMERCIAL	2013-12-20
GESTOR E-COMMERCE (MMP ...	2013-12-20

Fig. 3. Job offers are gathered from different sources and then displayed on the TV screen.

blocking the normal flow of the program in await for some information.

Besides obtaining public information that everybody can access to, one of the main features of this application is to let parents to access private information about their children. In order to access that information, every parent has a username and a password that enables them to enter the private area of the portal. The middleware uses those credentials to emulate the behaviour of a human person and access to the private information requested by the user. Thus, parents can see in their TV screen diverse information about their children, which is uploaded by educators.

B. *Emprego*

This application enables users to access information on job offers right from their TVs. One of the objectives of this application is to facilitate job search and, therefore, the application integrates tools for filtering search results in accordance with users' preferences. Figure 3 illustrates how information extraction is used in the context of this project.

In order to being able to apply filters on a heterogeneus set of job offers that were published in different Web portals, it is necessary to perform a homogenization task in advance, which entails that job offers must be available before users perform any searches. To that end, the active model for obtaining information is used. Thus, the system gathers information about job offers in an autonomous way. That is to say, the insertion, modification, and deletion of job offers is performed in accordance with information that is retrieved periodically from target sources.

The heterogeneity of information coming from different sources makes necessary to define a model of basic job offer, which is then enriched with the information obtained. All the information gathered is stored in a central database that is accessed by users through a Web Services API. As the system finds and updates information, the entries in the database are modified so that they may be acessed by digital TV clients.

V. Conclusions and Future Work

This paper showed how different information extraction techniques were used in the context of several research projects.

In the context of the iTEC project, information extraction is crucial for having a database of technologies, events, and experts that is big enough to serve as the universe of things to recommend to teachers. The strategy based on information extraction avoids us having to delegate on personnel for entering information about technologies, events, and experts. In a similar way, in the context of the Emprego project, information extraction allows us to delegate on automated software tasks the work of entering information about job offers.

In the context of the Berce TV project, information extraction is used to retrieve information from the Web portal. That information is shown to the user in a way that results suitable for being displayed in a digital TV. This strategy based on information extraction allows for integrating a legacy system in a fully-functional way. In spite of not being the most elegant solution on paper, it is an efficient one in practice, because it allows to add a new user interface based on digital TV without having to tweak legacy code—which would entail a new concession contract.

Currently, we are working on a research line that has as its objective to automatically annotation and categorise information extracted from the Web.

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