Towards a Learning Analytics Approach for Supporting discovery and reuse of OER

An approach based on Social Networks Analysis and Linked Open Data

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Abstract*— The OER movement poses challenges inherent to discovering and reuse digital educational materials from highly heterogeneous and distributed digital repositories. Search engines on today's Web of documents are based on keyword queries. Search engines don't provide a sufficiently comprehensive solution to answer a query that permits personalization of open educational materials. To find OER on the Web today, users must first be well informed of which OER repositories potentially contain the data they want and what data model describes these datasets, before using this information to create structured queries. Learning analytics requires not only to retrieve the useful information and knowledge about educational resources, learning processes and relations among learning agents, but also to transform the data gathered in actionable e interoperable information. Linked Data is considered as one of the most effective alternatives for creating global shared information spaces, it has become an interesting approach for discovering and enriching open educational resources data, as well as achieving semantic interoperability and re-use between multiple OER repositories. In this work, an approach based on Semantic Web technologies, the Linked Data guidelines, and Social Network Analysis methods are proposed as a fundamental way to describing, analyzing and visualizing knowledge sharing on OER initiatives

I. INTRODUCTION

The right to education is part of the economic, social and cultural rights defined in the Universal Declaration of Human Rights. Education shall be free. The main purpose of OER movement is to provide open and free access to high quality digital learning materials. For this reason, its effects or implications on higher education are well known.

In the last years, the amount of Open Educational Resources (OER) on the Web has increased dramatically, especially thanks to initiatives like OpenCourseWare (OCW) and other Open Educational Resources strategies. The potential of this vast amount of educational resources is enormous. Therefore, the OER movement could act as a catalyst to promote the universal right to education -applicable to all cultures.

OERs are distributed across a variety of repositories, using a variety of metadata standards, various interfaces and access mechanism. Harvesting OER for use elsewhere can involve complicated metadata crosswalk, and metadata often is incomplete and out of date.

The OER movement poses challenges inherent to discovering and reuse digital educational materials from highly heterogeneous and distributed digital repositories.

Search engines on today's Web of documents are based on keyword queries. Document search engines can't currently provide a level of inference that could locate directly to the final answer. Search engines don't provide a sufficiently comprehensive solution to answer a query that permits personalization of OERs. With a traditional search engine, all users must navigate through the links and read the content of each candidate page the search engine returns. To find OER on the Web today, users must first be well informed of which OER repositories potentially contain the data they want and what data model describes these datasets, before using this information to create structured queries.

Linked Data is considered as one of the most effective alternatives for creating global shared information spaces, it has become an interesting approach for discovering and enriching open educational resources data, as well as achieving semantic interoperability and re-use between multiple Open Educational Resources repositories.

Linked Data relies on linking together entities. Each of the entities defined in a Linked Data model has its own URI and a corresponding set of properties. The currently effort is transform OER data into Linked Data dataset, the result will be globally unique URIs that describe every Subject, Organization, Person, OER Provider, OER type, Place, Concept, etc., defined in the controlled vocabulary.

Education is experimenting with different techniques of data analysis in order to determine patterns and preferences of learners with the aim of improve services and learning experience, it is confirmed by the NMC Horizon Report [1] "Educational institutions are embarking on their own explorations of the science of large data sets, with the aim of improving student retention and providing a higher quality, personalized experience for learners." This emergent discipline applied to educational data is called Learning Analytics (LA). Learning analytics requires not only to retrieve the useful information and knowledge about educational resources, learning processes and relations among learning agents, but also to transform the data gathered in actionable e interoperable information.

In this work, we propose a learning analytics approach for learning OERs unifying two complementary perspectives: (1) structural analysis of the OER contents to integrate and interoperate OER materials; and (2) content analysis to capture dynamics in OER content using SNA. The information that can answer a query to discover OERs should be already available on the Web as linked data. To support both types of analysis, linked data technologies and social network analysis methods are proposed as a fundamental approach to describing, analyzing and visualizing knowledge sharing on OER initiatives. We describe the approach using two real-world OER domains: OCW resources – a large open courses collection, and the Serendipity OAR repositories –a network of open access repositories.

The rest of this document is organized as follows: section II present related work, while section III presents the envisioned approach and their goals, as well as the real-world information systems from which the necessary data are retrieved, transformed to Linked Data and discusses issues related to the SNA metrics to apply. Finally section V concludes the work and outlines future work.

II. Related Works

A. Learning Analytics

Learning analytics share many characteristics with other closely related branches of knowledge, such as Educational Data Mining [2]. Although the practice of analyzing educational data is not new, the field of learning analytics has only recently gained wide support among data scientists and education specialists [1].

The most common type of learning analytics is based on the analysis of extracted learning data from online courses with data mining and other data processing techniques, which is very often followed by some form of reporting and visualization of that data.

Learning Analytics seeks to produce 'actionable intelligence' [3]; the key is that action is taken. Campbell and Oblinger [3] thus set out five steps in learning analytics: Capture, Report, Predict, Act, Refine. Clow [5] builds on these ideas a Learning Analytics Cycle that makes the necessity of closing the feedback loop through appropriate interventions unmistakable. It also draws on the wider educational literature, seeking to place learning analytics on an established theoretical base, and develops a number of insights for learning analytics practice.

Learning analytics can help in identifying the effectiveness of learning elements, can help in engaging students, can guide teachers in the preparation and deployment of the teaching activity. In [3], presents different initiatives carried out at UC3M that include elements of learning analytics for different purposes.

Bienkowski [7] describes experimentation with the current implementation of a distribution system used to share descriptive and social metadata about learning resources, and the learning-resource analytics applications that will use Learning Registry data as their foundation. The Learning

Registry, is intended to store and forward learning-resource metadata among a distributed, de-centralized network of nodes. The Learning Registry also accepts social/attention metadata—data about users of and activity around the learning resource.

Considered as a field of learning analytics, social network analysis is a powerful procedure allowing us to study interactions and relations between nodes in a social network. In [8] social network analysis is presented in its fundamentals and applicability to different social learning situations. Given that educational roles need reliable methods to understand and optimize their social learning environment, it seems clear that social network analysis is the best-suited approximation.

In [9], authors describe an architecture based on linked data to load and transform data from sources of social knowledge and services from Web to find OERs that can be incorporated in the design of MOOCs.

B. *Open Access in the learning field*

The OER movement has tended to define "openness" in terms of access to use and reuse educational materials, and to address the geographical and financial barriers among students, teachers and self-learners [10]. According to a study by the OpenCourseWare Consortium (now, the Open Education Consortium) which results were published on March 2013, over 40% of the users with access to courses OCW type are self-learners and professionals [11].

Different social and economic connotations have produced the Open Access movement; specifically in the learning field the following benefits can be highlighted:

i) It facilitates people to access and use different learning resources,

ii) It promotes the universal right to education, mainly trying to reach communities and individuals who, for economic resources or even time reasons, cannot access to a traditional education system,

iii) It promotes the openness, sharing and creation of knowledge. Specifically, the content and open educational materials have the potential to improve substantially the quality of life of learners worldwide **¡Error! No se encuentra el origen de la referencia.**, and

iv) It improves the key skills that individuals need to participate in the knowledge society (such as self-direction and information management). Looking at the interest of people accessing open educational resources, we have identified that a large group of users are not linked to an institution, they are self-taught or they are immersed in a process of non-formal or informal learning.

C. *The principal purpose of OERs movement*

One of the first educational resources that were put into open was the MIT OpenCourseWare (OCW) offered by Massachusetts Technological Institute in 2001. One of the missions under which this project was conceived was to provide free, virtual and non-commercial access to MIT courses to educators, students and self-learners around the world **¡Error! No se encuentra el origen de la referencia.**. The next aim was to create a flexible movement based on an efficient model that other universities could emulate at the moment of publishing their own educational materials, generating synergies and spaces of collaboration.

One year later, the Open Educational Resources (OER) term was introduced in order to include a wide range of learning objects and free applications, from whole course, open access journals, to lecture material, references and readings, simulations, experiments and demonstrations, as well as syllabi, curricula and teachers' guides [14]. OERs are typically freely available over the Web. Their principal use is by teachers, students and self-learners.

III. Learning Analytics for Supporting the Discovery and Reuse of OER

Learning Analytics (LA) is an emerging domain for educational research and IT-supported learning processes. Learning analytics is defined as "the measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environment in which occurs" [15]. The concept is broad and applies to different approaches to the use of educational data oriented toward decision-making and personalization of learning environments.

Learning analytics are focused on building systems able to adjust content, level of support and other personalized services by capturing, processing, reporting, and acting on data on an ongoing basis in a way that minimizes the time delay between capture and use of data. Sophisticated analytics approaches, methodologies and tools are used to improve learning and education.

A. Overall Architecture

The authors has focused its research in Learning Analytics analyzing, detecting and visualizing data patterns collected from Open Educational Resources, and leveraging those methods to support the open learning experience, in particular through of hybrid recommender systems applied to OER, i.e., combining collaborative and content-based methods.

Its OERs learning analytical approach uses a combination of several technologies, the Web of Linked Data and Social Network Analysis (SNA) highlights. With the Web of Linked Data making an expansion of the search criteria of new information and OER data through related topics, beyond of the syntax of words. On the other hand with SNA finding relevant information from influential users related to learners. In this way, OER learning analytics seeks to combine OER data to predict what specific educational resources users (teachers, students or self-learners) may find useful.

Our approach adopt use the generic term learning analytics to refer to the exploitation of OER data for improvement of teaching an learning based on use and re-use de OERs. The use of Linked Data for data description and data interchange between data providers, will be able to integrate data from in a semantically heterogeneous and distributed environment, and serve as a basic for future expansions.

B. Data Sources and harmonization Layer

The main purpose of OER movement is to provide open and free access to high quality digital learning materials. For this reason, its effects or implications on higher education are well known. On the other hand, looking at the interest of people accessing open educational resources, we have identified that a large group of users are not linked to an institution, they are self-taught or they are immersed in a process of non-formal or informal learning.

Open Educational Resources (OER) provides a strategic opportunity to improve the quality of education as well as facilitate policy dialogue, knowledge sharing and capacity building **¡Error! No se encuentra el origen de la referencia.**.

In the last years, the amount of Open Educational Resources on the Web has increased dramatically, especially thanks to initiatives like OCW and other OER movements. The potential of this vast amount of resources is enormous but in most cases it is very difficult and cumbersome for users (teachers, students and self-learners) to visualize, explore and use these resources, especially for lay-users without experience on searching technologies.

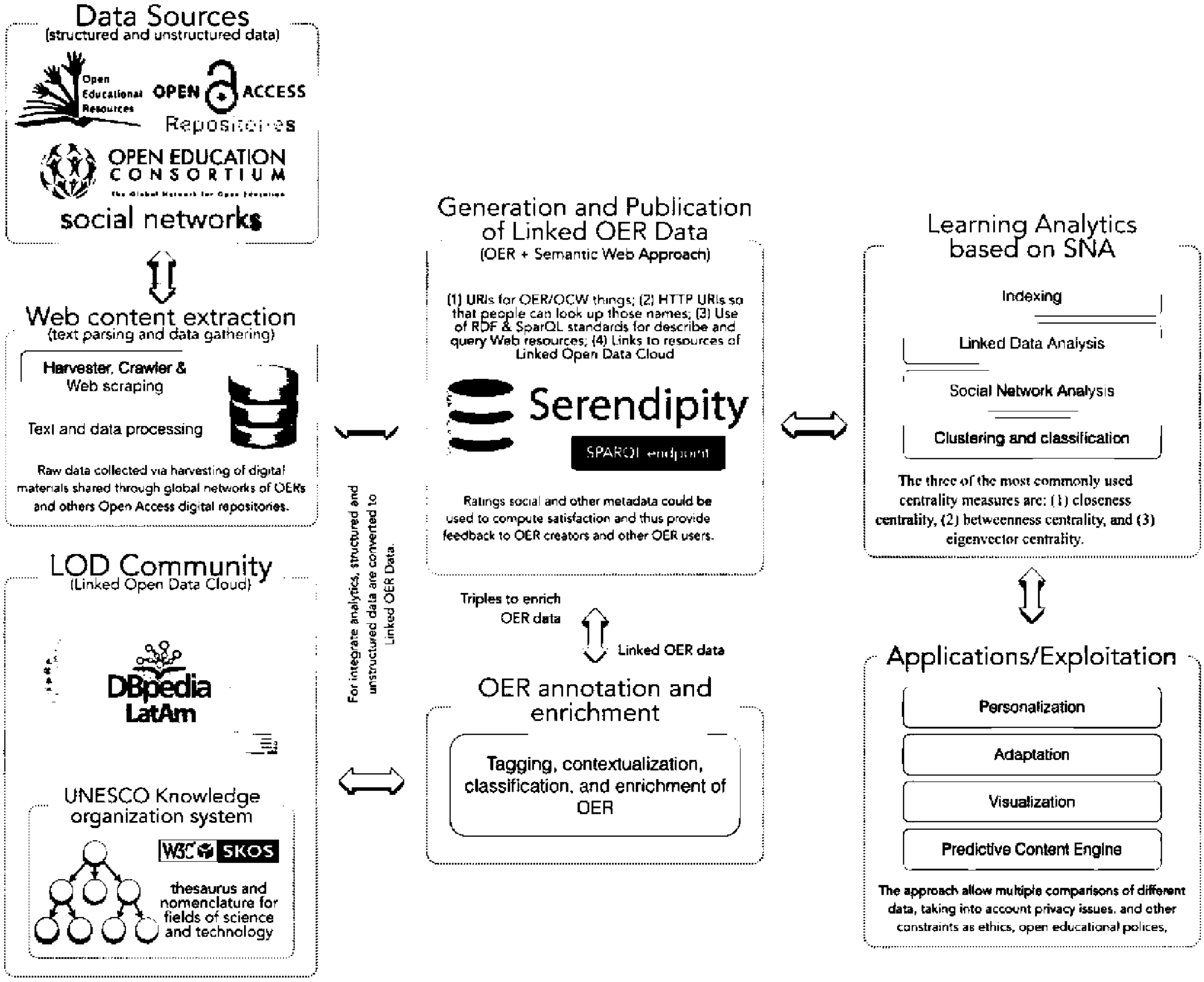

Fig. 1. A comprehensive learning analytics for Open Educational Resources based on Linked Data design issues and Social Network Analysis approach

The approach allows the cross-cultural, cross OER providers, and cross-subjects comparisons in large scale. In addition, our approach attempts to directly target these problems, since it aims at highly usable interfaces that use visualization techniques for the effective interaction with data. Moreover, focuses on collecting and analyzing large amount of data from a variety of data sources to provide information on what works and what doesn't with respect to use of OERs in teaching and learning. This helps to users improve their capabilities in a learning system based on OERs. As we have described, these are all barriers to resource locating, sharing, and reusing.

C. *Data and Semantic Integration layer*

The increasing number of datasets published on the Web as linked data brings both opportunities for high data availability and challenges inherent to querying data in a semantically heterogeneous and distributed environment. Approaches used for querying siloed databases fail at Web-scale because users don't have an a priori understanding of all the available datasets.

Linked data exposes previously siloed repositories as Web-data graphs, which can be interlinked, integrated and interoperated with other datasets, creating a global-scale interlinked data space.

The last stage of the Web is the Semantic Web approach. According to the W3C, the Semantic Web is a Web of Data. Data can be in different formats, languages, styles and structures. This approach of the Semantic Web is aligned with the original vision that Berners-Lee had the Web in the late 1980s in which the meaning of information plays a key role and the information is stored in a global database, distributed and linked data through the web.

Unlike the current Web of linked documents, the Semantic Web is a Web of linked data that can be used for describing data models, concepts and data properties.

Linked Data is the way that the Semantic Web has to link and interoperate data that are distributed on the Web, so that they are referenced in the same way they do the links of the web pages. Furthermore, connect, query and recombine data from the Web, as if they were simply part of a global database. These advances can be a way to support interoperability, accessibility and reusability of all types of data.

The Linked Data Design Issues, outlined by Tim Berners-Lee back in [17], provides guidelines on how to use standardized Web technologies to set data-level links between data from different sources [18]. Linked data is an opportunity to mitigate complexity in OER reuse. These Linked Data Design Issues, in OER context, are:

- Use URIs as names for things, which can be unambiguously identified (e.g. OERs, courses, MOOCs, OER creators, OCW providers, knowledge areas,)
- Use HTTP URIs so that people can look up those names. With the aid of URIs, the corresponding OER data and relevant interlinked data can be dereferenced.
- When someone looks up a URI, provide useful information, using the standards (RDF, SPARQL) to describe linked OER data, which are machine-readable and repurposed to serve the proposed architecture to enhance integration with reused and interoperated OER data.
- Include links to other URIs, so that they can discover more entities. Linked Data—particularly data available using open licenses—has an important role to play on information systems and could be a key feature for Open Education based on OER data on the Web of Data.

D. *Quering heterogeneous datasets on the Linked Data Web*

Semantic Web technologies and, more precisely, Linked Open Data (LOD) are changing the way information is stored, published and exploited. The term "Linked Data" refers to a set of best practices for publishing and connecting structured data on the Web [19][18].

For OER providers to adopt and integrate RDF, a paradigm shift is required in the way that OER providers think about describing and cataloging open educational materials. OER providers and users might be familiar with the phrase "Things not Strings". This idea is fundamentally important in Linked Data but is diametrically opposed to the way that users have been creating and accessing metadata for the past years. In Linked Data, controlled strings are replaced by references to entities. In this way, transform current OER records based on textual descriptions; involve split records into separate entities.

Linked data is mainly about publishing structured data in RDF using URIs rather than focusing on the ontological level or inference. OER provided with Linked Data (Linked Open Educational Resources Data) supports the process of discovery, reuse, integration and interoperability of open educational materials.

E. *Ontology-Based Data Model*

Data models are a fundamental aspect of describing OER metadata. They define the overall structure of the data and serve as the basis for best practices in OER metadata development.

RDF is based upon the idea of making statements about resources (in particular web resources) in the form of subject-predicate-object expressions. These expressions are known as triples in RDF terminology. The subject denotes the resource, and the predicate denotes features or aspects of the resource and expresses a relationship between the subject and the object. Uniform Resource Identifiers (URIs) are used to identify these resources. RDF Schema (RDFS) is to represent the web resource and

SPARQL (Standard Protocol for RDF Query language) is to extract information from RDF graphs for machine understandable representation.

In [20], authors apply the Linked Data Design Issues to explore, visualize and use information that is semantically related to open educational resources that are accessible via the OCW Consortium. Serendipity initiative has begun to adopt models that are suitable for expressing OCW and OER metadata as Linked Data, in an attempt to provide OER users with well understood/recognizable RDF data models. Linked data has the potential of creating bridges between OCW data silos. The authors demonstrate that OCW resource metadata can be enriched using datasets hosted by the Linked Open Data cloud. Additionally, the Linked OER and OCW Data environment enabled us to discover and reuse open educational materials.

F. Process Layer

The data transformations include the generation and publication of OER metadata into Linked Open Data, to allow for better description of educational materials and the ongoing development of an OER data model.

The linked data provides a unique value to learning OER analytics approach that is now not possible. Linked Data suggests that the value and usefulness of data increases to the extent that these are related to other data. For this reason, Linked Data uses the Web to create different types of links between data from different sources. With this vision of the Web, data and relationships have fundamental roles. The availability of sources based on the principles of Linked Data enable new opportunities for exploiting knowledge representation techniques, information extraction and integration and multi-agent environments, among others.

G. Social Networks Analysis to understand and visualize the patterning of interactions betweem individuals in a quantitative manner.

Social network analysis (SNA) is a framework used to study the structure of social networks. The power of social networks analysis it is to assume that the attributes of individual nodes are less important than their relationships and ties with other nodes within the network. This approach has turned out to be useful for explaining many real-world situations, but leaves less space for individual action, the ability for nodes to influence their success, because so much of it rests within the structure of their network. Social networks analysis have also been used to examine how nodes interact with each other, characterizing the many informal connections that link members together, as well as associations and connections between individual nodes at different clusters of graph.

A social network, in its simplest form, is a set of social units (nodes) and the ties (edges) between them [21]. SNA encompasses a number of different graphical tools to visualize networks, as well as tools for mathematical modeling that allow the detection and quantification of patterns in social networks [22].

The graph theory is the mathematical approach to social network analysis. SNA views social relationships in terms of network theory, consisting of nodes, representing individual actors within the network, and ties -which represent relationships between the individuals.

Graphs are the basic subject studied by graph theory. Typically, a graph is depicted in diagrammatic form as a set of dots for the vertices, joined by lines or curves for the edges. Graphs are one of the objects of study in discrete mathematics.

In graph theory, a graph or network is a representation of a set of individuals where some pairs of objects are connected by links. A *graph* S consists of a set N(S) of elements called *nodes* (vertices or points) and a set M(S) of elements called *members* (edges or arcs) together with a relation of *incidence* which associates each member with a pair of nodes, called its *ends*. The edges may be undirected (e.g. an symmetric relationship) or directed.

There are some basic concepts of graph theory, which can help us understand and model social interactions, see Table I.

TABLE I. BASIC CONCEPT OF GRAPH THEORY

Concept	**Comment**
Size	The size of a graph is the number of its edges.
Adjacency	two nodes of a graph are called adjacent if these nodes are the end nodes of a member
Incidence	A nodo is called incident with a individual if it is an end node of that member. Two members are called incident if they have a common end node.

Degree	The degree (valency) of a node of a graph, is the number of members incident with that node.
Density	Density is the number of edges in the network expressed as a proportion of the number of all possible edges.
Handshaking	Handshaking lemma or the first theorem of graph theory, since each member has two end nodes, the sum of node-degrees of a graph is twice the number of its members.
Walks	Walks, a walk is a finite sequence whose terms are alternately nodes and members
Trail	Trail, a trail, is a walk in which no member of a graph appears more than once.
Path	Path, a path, is a trail in which no node appears more than once. The length of a path is taken as the number of its members.
Distance	Distance, the distance between two vertices is the minimum number of edges that it takes to go from one to another. This is also known as the geodesic distance.
Degree	Degree of vertex, in an undirected graph, the degree of a vertex is the number of edges that such a vertex has. In directed graphs, we have to distinguish between incoming edges (in-degree) and outgoing edges (out-degree).

H. Centrality, a structural characteristic of nodes in a graph.

Centrality, is a structural characteristic of individuals in the social network. Centrality refers to indicators, which identify the most important vertices within a graph. A centrality score means that individual fits within the network overall. Nodes with high centrality scores are often more likely to be leaders, key conduits of information, and be more likely to be early adopters of anything that spreads in a network. Low centrality individuals can be termed peripheral. Being peripheral can have advantages as well by protecting individuals from negative contagion and influence. Sometimes lower centrality is associated with less work overload in an organization.

There are several types of centrality measures that characterize slightly different aspects of structural positions in networks. The three of the most commonly used centrality measures recommended in the approach are: (1) closeness centrality, (2) betweenness centrality, and (3) eigenvector centrality.

Closeness centrality, this measure expresses the average social distance (e.g. six degrees) from each individual to every other individual in the network. One property of closeness centrality is that on individuals who are highly connected to others within their own cluster will have a high closeness centrality. High closeness centrality nodes tend to be important influencers within their own local cluster.

Betweenness centrality is another measure that is derived from the concept of counting the shortest paths between individuals in a network. This measure helps to find the individuals who are necessary conduits for information that must traverse disparate parts of the network. Those nodes who act as bridges between clusters in the network have high betweenness centrality, and are usually very different from those with high closeness. They are well positioned to perform brokering roles across these clusters in the sense that brokers connect otherwise disconnected individuals who yet may benefit from an exchange of information. In a graph, high betweenness individuals are often found at the intersections of more densely connected network communities.

Eigenvector centrality, this measure basically indicates the extent to which an individual is a node with many connections connected with others high-profile nodes. Individuals with high eigenvector scores have many connections, and are leaders of the network, and their connections have many connections, out to the end of the network. Highly connected individuals within highly interconnected clusters have high eigenvector centrality.

Measures for analyzing communities of OERs, from a networks perspective, the network of open educational resources harvesting as a whole:

- Central connectors, central node often have the most direct connections in a network and by virtue of this can have a substantial impact on a community of OERs or users.
- Brokers, network analysis also helps leaders find those who, based on where they stand in the network, are disproportionately important in holding the entire community together (e.g. Key OER providers).
- Peripheral players, network analysis can also help reveal loosely connect or isolated nodes that often represent under-utilized resources of a community, because their subject, skills, expertise, and unique perspectives are not leveraged efficiently.

- Fragmentation points, the idea is never that you want everyone connected to everyone else. Disconnections are the gaps to be solved, so they can keep a community as efficient as possible.
- External connectivity, while internal connectivity is important, it is also critical to consider the way a community is connected externally in order to understand how the entire network is learning and/or impacting the work of other.

To other measures that explain social interactions between nodes see Table II.

TABLE II. MEASURES THAT EXPLAIN SOCIAL INTERACTION BETWEEN INDIVIDUALS

Measures	Comment
Betweenness	Betweenness, extent to which an individual mediates, or falls between any other two individual on the shortest path between those two individuals.
Centrality	Centrality, extent to which an individual is central to a network or local cluster.
Closeness	Closeness, extents to which an individual is close to, or can easily reach all the others within the network.
Degree	Degree, number of direct links with other individuals.
Direction	Direction, extent to which linkage occurs from one actor to another.
Frequency	Frequency, how many times, or how often linkage occurs.
In-degree	In-degree, number of bidirectional links to one individual form others.
Indirect links	Indirect links, path between two nodes is mediated by one or more nodes.
Multiplixity	Multiplixity, extent to which two individuals are linked together by more than one relation.
Out-degree	Out-degree, number of directional links from one individual to other.
Prestige	Prestige, based on asymmetric relationships, prestigious individuals are the object rather than the source of relations.
Stability	Stability, existence of linkage over time.
Strength	Strength, amount of time, emotional intensity, intimacy or reciprocal services.
Symmetry	Symmetry, extent to which relation is bidirectional.

I. *Visualization Data*

An information visualization technique requires certain data structures to be present. When we can derive and generate these data structures automatically from reused vocabularies or semantic representations, we are able to realize a largely automatic visualization workflow. This will enable users to explore datasets even if the publisher of the data does not provide any exploration or visualization means.

Applying information visualization techniques to the OER data helps users to explore large amounts of data and interact with them. Visualizations are useful for obtaining an overview of the datasets, their main types, properties and the relationships between them. Compared to prior information visualization strategies, we have a unique opportunity on the Open OER Data environment generated by Linked Data and SNA. The unified RDF data model being prevalent on the Linked Data approach enables us to bind data to visualizations in an unforeseen and dynamic way.

The figure 2 is a visualization based on content analysis, which represents the relationships between OERs and subjects (branches of knowledge). The figure shows the uses of keywords in OERs, which are added by OER creators and describe the core content of material. The visualization help to investigate whether the creator used the proper concepts and terms in their resources, and use geographic information to show courses and form networks of collaboration and recommend related tags.

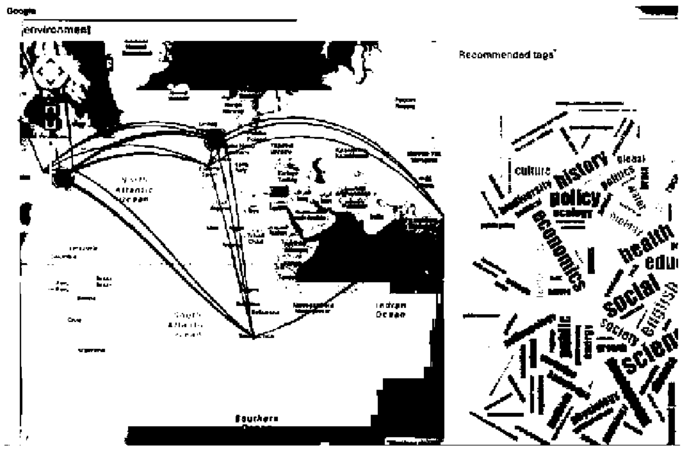

Fig. 2. Geo Data Visualization of OERs and relationated subjects

J. *Applications: Feedback, adaptation and personalization*

In this section, we describe applications for learning analytics, and for each, how the approach could be used. Each case of use show the use of linked data in combination with SNA to understanding and assessing learning process in OER context.

Recommendations and relationships between OER and OER creators based on their attention knowledge branches, or can also be clustered in categories based on how and when they submit. Users could have answers to questions such as: What next OER can be suggested for a teacher, student or selft-learner?: The approach can support recommendations by clustering users or by building a social network graph and then recommending resources among a cluster or network.

The approach could provide feedback to OER providers about the utility of their resources, about who reuses and adapts them. Users could have answers to questions such as: What actions should be suggested for the user? What groups do users cluster into? How should the user experience about discovery or reuse be changed for the next user?

Other application is OER knowledge modeling. The approach could be used to compute what a resource might be expected to successfully re-used or adapted.

IV. CONCLUSIONS AND FUTURE WORKS

In this work, we have presented the vision of an OER learning analytics approach, which can be used by all stakeholders involved in discovery and reuse of open educational resources.

The availability of Web-scale information in a structured and fine-grained representation could generate a paradigmatic shift in how applications and users consume and share data. Linked data provides a data layer on the Web that represents objects and relations.

This transition to Linked Data symbolizes a fundamental break from how OER providers have created and managed metadata. Linked data improve the ability to provide and share data. Although the development and implementation of RDF data models is vital in helping change the OER's technical infrastructure, another key idea is to gain wide support and use of Linked Data in the OER domain. The datasets information can be used to support different aspects of the open educational process; linked data within this schema can be analyzed and mined, and also used for formulating recommendations to the users; additionally, users can navigate, search and visualize this information, while personalization techniques are used to reduce information overload and facilitate users' tasks.

Our future work will focus on a next generation of interactive and social OpenCourseWare (Social-OCW) by providing an OER platform where self-learners and students can take an active role in the management of their personal learning environments, through self-organized dashboards and collaborative workspaces.

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REFERENCES

[1] Johnson, L., Adams Becker, S., Cummins, M., Estrada, V., Freeman, A., and Ludgate, H. "NMC Horizon Report: 2013 Higher Education Edition". Austin, Texas: The New Media Consortium. NMC Horizon Report: 2013 Higher Education Edition, 2013

[2] Siemens, G., & Baker, R. S. J. d. (2012). Learning analytics and educational data mining: Towards communication and collaboration. In Proceedings of the 2nd International Conference on Learning Analytics and Knowledge (LAK '12) (pp. 252–254).

[3] Campbell, J.P. et al. 2007. Academic Analytics: A New Tool for a New Era. Educause Review. 42, October (2007), 40-57.

[4] Campbell, J.P. and Oblinger, D.G. 2007. Academic Analytics. *EDUCAUSE Quarterly*. October (2007).

[5] Clow, Doug (2012). The learning analytics cycle: closing the loop effectively. In: LAK12: 2nd Inter- national Conference on Learning Analytics & Knowledge, 29 April - 2 May 2012, Vancouver, BC.

[6] Kloos, C.D.; Pardo, A. ; Munoz-Merino, P.J. ; Gutierrez, I. ; Leony, D Learning analytics @ UC3M. Global Engineering Education Conference (EDUCON), 2013 IEEE.

[7] Bienkowski, M., Brencht, J., Klo, J. The Learning Registry: Building a Foundation for learning resource Analytics. LAK'12 ACM. 2012.

[8] Amo Filva, D., García-Peñalvo, F., Alier Forment, M. Social Network Analysis Approaches for Social Learning Support. TEEM'14, Salamanca, Spain, 2014

[9] Piedra, N., Chicaiza, J., López, J., Tovar-Caro E.: Supporting openness of MOOCs contents through of an OER and OCW framework based on Linked Data technologies, Global Engineering Education Conference (EDUCON 2014), IEEE, Istanbul-Turkey, 3-5 April 2014, 1112 - 1117.

[10] Petrides, L., Nguyen, L., Jimes, C., Karaglani, A.: Open educational resources: inquiring into author use and reuse. International Journal of Technology Enhanced Learning, 1, (2008), 98 - 117.

[11] OpenCourseWare Consortium: OCWC User Feedback Survey Results » Announcements, Retrieved October 2013 from http://www.openedconsortium.org/news/2013/06/ocwc-user-feedback-survey-results/ (2013)

[12] Caswell, T., Henson, S., Jensen, M., Wiley, D.: Open Content and Open Educational Resources: Enabling universal education. The International Review Of Research In Open And Distance , 9, 1, (2008) 1-11.

[13] MIT, MIT to make nearly all course materials available free on the World Wide Web. 2001. http://web.mit.edu/newsoffice/2001/ocw.html

[14] UNESCO Promotes New Initiative for Free Educational Resources on the Internet. 2002. http://www.unesco.org/education/news_en/080702_free_edu_ress.shtml.

[15] Long, P., & Siemens, G. (2011). Penetrating the fog: Analytics in learning and education. Educause Review, 46(5), 31–40.

[16] The Dakar framework for action. Paris: UNESCO. 2000 http://www.unesco.org/education/wef/en-conf/dakframeng.shtm

[17] Berners-Lee, T.: Linked Data: Design Issues. W3C. 2006. http://www.w3.org/DesignIssues/LinkedData.html.

[18] Bizer, C., Cyganiak, R., Heath, T.: How to Publish Linked Data on the Web, 2007.

[19] Berners-Lee, T. Hendler, J. & Lassila, O.: The Semantic Web. Scientific American, 284, 5, (2001), 34- 42.

[20] Piedra, N., Tovar, E., Colomo-Palacios, R., López, J., Chicaiza, J.: Consuming and producing linked open data: the case of Opencourseware. Program: electronic library and information systems, 48, 1, (2014),16 - 40.

[21] Wasserman S, Faust K. In: Social Network Analysis: Methods and Applications. Granovetter M, editor. Cambridge: Cambridge University Press; 1994. p. 825.

[22] Freeman LC. The Development of Social Network Analysis. Vancouver, C: ΣP Empirical Press; 2004.