SEMANTIC ANNOTATION OF RESOURCES TO LEARN WITH CONNECTED THINGS

Aymeric Bouchereau and Ioan Roxin
ELLIADD laboratory, Franche-Comté University, France

ABSTRACT

Computer systems tend to be ubiquitous as they become more integrated in our everyday activities, embedded in tables, shoes, watch and plenty of others connected things (CT). In the e-learning field, the transformations induced by the Internet of Things (IoT) allow individuals to learn whenever they want, accessing a quantity of diverse digital learning resources (DLR) and experiencing new interaction modes paired with innovative pedagogical methods. In the perspective of ubiquitous learning in line with the IoT paradigm, accessibility and interoperability of the DLRs became critical for accessing knowledge. The growing volume of online data scattered in heterogeneous repositories restrains these DLR characteristics. In these conditions, we think semantic Web technologies can be used to face these challenging issues enhance DLR accessibility and interoperability to sustain ubiquitous learning.

KEYWORDS

Digital learning resource, Internet of Things, Linked Open Data, semantic web, ubiquitous learning

1. INTRODUCTION

The pervasiveness of connected things (CT) and the ubiquity of communication networks have given rise to the ubiquitous computing (Weiser, 1999) and contribute to the Internet of Things (IoT) development. In education, the digital convergence—i.e. the digitalization and integration of various media (e.g. voice, picture, video, text) into one architecture—and the explosion of Internet-based services have stimulated new ways of learning and teaching. The IoT paradigm tends to continue and emphasise these transformations, leading to ubiquitous learning (u-learning): individuals can learn throughout everyday activities (Yahya et al., 2010). The ATAWADAC acronym (AnyTime, AnyWhere, AnyDevice, AnyContent)[1] illustrates the fact that learning activities can occur without constraints of time, space, device and content (Derycke, 2006). The CT multiplication is combined with a diversification of presentation forms, interaction modes (provided by ubiquitous user interfaces (Krumm, 2010)) and pedagogical methods (e.g. flipped classroom, blended learning). These elements echo with learning theories like constructivism (Piaget, 1969) and socio-constructivism (Vygotski, 1997), suggesting that learners construct knowledge by means of involvement, social interaction and collaboration.

Beyond the implementation of u-learning in relation to the IoT, the main issues are accessibility and interoperability of Digital Learning Resources (DLR, like books, videos, pictures, Open Educational Resources (OER) and Massive Open Online Courses (MOOC)). These DLR characteristics are critical to access knowledge, to the design of learning platforms and to the Open Learning movement (Barker and Campbell, 2016). Nonetheless, obstacles are reducing access to relevant DLRs and are negatively impacting the e- learning sector.

The aim of this paper is to give an overview on DLR accessibility and interoperability issues and solutions regarding to the IoT development. In section 2, we highlight obstacles to u-learning generated by evolution's intrinsic effects of technologies and by the adopted model of e-learning actors. In section 3, we will describe semantic Web technologies as a possible solution to face these challenging issues and their potential to sustain u-learning.

[1] Extension of ATAWAD, a term registered by Xavier Dalloz in 2003.

2. LEARNING HINDRANCES

In an "everything's connected" world individuals are bombarded with a mass of information that exceeds individuals' capacity to treat all. When it comes to learning the phenomenon becomes problematic because individuals are facing a growing volume of DLRs scattered in distinct silos that tend to isolate resources from each other.

2.1 Data Volume

In the form of dictionaries, encyclopaedias, MOOCs, learning systems, videos, blogs, records, video games, and interactive devices, individuals have access to a vast amount of DLRs. Like (IDC, 2014; Kanellos, 2016) numerous studies demonstrated the gigantism of the data volume produced and its exponential growth. The digital convergence and the explosion of the Internet have initiated a systematic process of knowledge dematerialization and publication on the Web. In so doing, the World Wide Web (WWW) has evolved into a virtual library hosting countless books. Learner's questions are no longer about the existence of a specific DLR, but about the localization. The Web looks like a library in which finding the corresponding book to a specific need becomes complex and requires the support of specialized tools (e.g. vertical search engines, MOOC platforms, databases, Virtual Learning Environments (VLE)). In these conditions, the identification of relevant DLR becomes time-consuming and the success may depend on variables such as time spent on the task, search channels used, and the ability to discern what is appropriate and what is not. In other words, the volume limits the effectiveness of DLR searching activities and restraints DLR accessibility.

2.2 Data Silos

The limited accessibility of the DLRs is also amplified by their dissemination in different repositories (e.g. OER repository, VLE, MOOC platform) (Dietze et al., 2013); which engenders DLR isolation. The plurality and heterogeneity of repositories make critical the interoperability characteristic of DLR as formats and structures vary from one repository to another. Plus, within the Web 2.0, learning platforms have been built upon closed environment using proprietary technologies and architectures (Christian Bizer et al., 2009; Piedra et al., 2017). As a consequence, the visibility and discovery of the DLRs are lessened (Piedra et al., 2017) and learners have no choice but to adapt and adopt specific strategies to find relevant DLR (e.g. using vertical search engine, repeating investigation on each repository). To improve interoperability, standards have been developed to provide a common and structured description of DLR: Dublin Core (DC), Learning Object Metadata (LOM), Tin Can API (the successor of Sharable Content Object Reference Model (SCORM)) (Abdullah and Abdel Aziz Ali, 2016; Klašnja-Milićević et al., 2017). Nevertheless difficulties are persisting to express all possible contexts, use cases and DLRs (Allert, 2004). The coexistence of standards sharing the same purpose limits the interoperability because learning platforms are implementing different one. Despite this, several projects aim to enhance the DLR visibility and discovery by manually indexing and listing them into a single repository. For example, the "search engine for pedagogical resources" set up by the French government is indexing DLR according to the SupLOMFR standard (Sup-Numérique, 2017). More widely with the Open Learning movement where several repositories and resource aggregators have been created to index and list OERs (Barker and Campbell, 2016). Yet, operation modes and standards used to describe DLR differ from one project to another (Dietze et al., 2013). In a general way, we can state that the visibility and the discovery of the DLRs are limited by the lack of interoperability among platforms and resources.

3. RESOURCE INTERCONNECTION

DLR accessibility and interoperability needs to be improved so individuals can easily find relevant resources without searching in a quantity of information and multiple repositories. In this context, we think semantic Web technologies and more specifically the Linked Open Data (LOD) can enhance the visibility and discovery of the DLRs and, therefore, can support u-learning.

3.1 Semantic Web and Linked Open Data (LOD)

Initiated by Tim Berners-Lee and the World Wide Web Consortium (W3C), the semantic Web (also called Web of data, which is sometimes used in reference to the Web 3.0) is an extension of the Web of documents designed for data (Berners-Lee et al., 2001). More precisely, the semantic Web gives computer systems the capacity to understand the "meaning" of data and make them searchable like current Web documents. This can be achieved thanks to the description of knowledge and relationships between data in accordance with a structured language. In order to undertake the semantic Web goals, the LOD concept (called Linked Data without the notion of openness) aims at formally describing data, creating connections among themselves and enabling readability as if it was web documents. When publishing data on the Web, the following principles should be applied to be compliant with LOD: formal description of data using the Resource Description Framework (RDF) language, unique identification via the Uniform Resource Identifier (URI) protocol, linking with existing online data, and open exploitation of data with the HyperText Transfer Protocol (HTTP) (Christian Bizer et al., 2009). The semantic description and the creation of connections among data and datasets lead to the creation of a global graph, composed of data (respecting the LOD principles) across the Web. From the point of view of learning, the LOD principles are promoting an open access to DLR from any computer without the need of specific and proprietary programs. The use of a common description language and the DLR interconnection ensure their interoperability so that learners can easily access to a DLR and navigate from one to another (d'Aquin, 2012).

3.2 Exploitation of Semantic Resources

In addition to technologies for describing, identifying and accessing DLR, the W3C also standardized tools to query and handle resources with semantic annotation. Thus, thanks to the SPARQL Protocol and RDF Query Language (SPARQL), it is possible to build and execute complex queries on a graph of RDF described resources: to select, modify, update, or delete information[2]. Besides SPARQL, the standard Linked Data Platform (LDP) achieves the same goals but with an approach turned towards Web services production (Nandana Mihindukulasooriya, 2016). LDP behaves like an extension of HTTP and defines an architecture to read and write data on the Web. The LDP operationalization is close to the REpresentational State Transfer (REST) architecture on which are based numerous Web services. These standards can be used as a basis for the design of tools to speed up the identification of relevant DLR and recommendation systems can enhance their suggestions to the learners. The creation of a resource graph reduces silos negative effects and fosters the accessibility and interoperability of the DLRs. The implementation of systems able to correlate the meaning of the resource and the meaning of the query ensures efficient DLR identification. Moreover, the identification process can also be fine-tuned by considering the learner's profile (e.g. age, knowledge level, learning style) and contextual information (e.g. localisation, time, device). The development of semantic learning tools allowing relevant DLR identification can sustain learning activities within the IoT paradigm outlined in the introduction. On the one hand, CT supports mobility, interactivity and peer collaboration and, on the other hand, visibility and discovery of suitable DLR are ensured by semantic Web Technologies. We think these conditions make possible the operationalization of opportunities offered by the IoT and can support the advancement of u-learning—i.e. providing the right DLR, at the right time and the right place.

4. CONCLUSION

Transformations involve by the IoT progress are changing practices and tools for learning and teaching. The increasing number of CT and the ubiquitous aspect of communication networks contribute to the diversification and multiplication of DLRs. Perspectives brought by the IoT suggest u-learning whose main features are ubiquity, the diversity of presentation forms, new interaction modes, the application of innovative pedagogy, and personalization. However, the progress of IoT adapted learning is hampered by a limited DLR accessibility and interoperability. Individuals are searching DLRs in a large volume of resources in which the most relevant DLRs are drowned. DLR visibility and discovery are also reduced by a silos

[2] https://www.w3.org/TR/rdf-sparql-query/

model created both by proprietary platforms, and by the heterogeneity of standards and repositories. In these circumstances, we proposed to use semantic Web technologies, which are endowed with properties that allow answering DLR accessibility and interoperability issues. On one side, computer systems became able to understand the meaning of data they handle due to the semantic annotation of DLR in line with a structured description language. On the other side, the creation of a link between a DLR and an existing online data leads to the development of a global graph that can be explored like we used to with documents on the Web. Both mechanisms improve the accessibility and interoperability of resources by implementing a more efficient DLR organization and by providing effective tools to query and identify relevant DLR. Therefore, we think u-learning can be sustained by semantic Web-based systems that enable to relevant identification and provide rapid access to a DLR in relation to a context. Our future works should focus on modelling such a system and reflecting on these following concerns: means for semantically annotated DLR in distributed repositories, DLR indexation, semantic kernel for querying resources, and management of contextual data and learner's profile.

REFERENCES

Abdullah, M. and Abdel Aziz Ali, N., 2016. E-learning standards. *Proceedings of the International Conference on Communication (ICCMIT 2016)*. Cosenza, Italy, pp. 639–648.

Allert, H., 2004. Coherent Social Systems for Learning: An Approach for Contextualized and Community-Centred Metadata. *Journal of Interactive Media in Education*. Vol. 2004, No. 1, p.Art.7.

Barker, P. and Campbell, L.M., 2016. 3. Technology Strategies for Open Educational Resource Dissemination. *Open Education: International Perspectives in Higher Education*. Open Book Publishers, pp. 51–72.

Berners-Lee, T., Hendler, J. and Lassila, O., 2001. The Semantic Web. *Scientific American*. May 2001, pp. 28–37.

Bizer, C., Heath, T. and Berners-Lee, T., 2009. Linked Data - The Story So Far. *International Journal on Semantic Web and Information Systems (IJSWIS)*. Special Issue on Linked Data.

d'Aquin, M., 2012. *Linked data for open and distance learning*. Commonwealth of Learning, Burnaby, Canada.

Derycke, A., 2006. Du E-Learning au Pervasive-Learning: Concepts, Exemples et Questions de Recherche. *Conférence UBIMOB'06*. Paris, France.

Dietze, S., Sanchez-Alonso, S., Ebner, H., Qing Yu, H., Giordano, D., Marenzi, I. and Pereira Nunes, B., 2013. Interlinking educational resources and the web of data: A survey of challenges and approaches. *Program*. Vol. 47, No. 1, pp. 60–91.

IDC, 2014. The Digital Universe of Opportunities: Rich Data and the Increasing Value of the Internet of Things. *EMC*.

Kanellos, M., 2016. 152,000 Smart Devices Every Minute In 2025: IDC Outlines The Future of Smart Things. *Forbes*.

Klašnja-Milićević, A., Vesin, B., Ivanović, M., Budimac, Z. and Jain, L.C., 2017. *E-Learning Systems*. Springer International Publishing, Switzerland.

Krumm, J. (Ed.), 2010. *Ubiquitous computing fundamentals*. Chapman & Hall/CRC Press, Boca Ragon.

Nandana Mihindukulasooriya, 2016. Introduction to W3C Linked Data Platform (LDP). 4th Linked Data in Architecture and Construction Workshop. Madrid, Spain.

Piaget, J., 1969. *Psychologie et pédagogie*, Denoël ed., Paris, France.

Piedra, N., Chicaiza, J., Atenas, J., Lopez-Vargas, J. and Tovar, E., 2017. Using Linked Data to Blended Educational Materials With OER—A General Context of Synergy: Linked Data for Describe, Discovery and Retrieve OER and Human Beings Knowledge to Provide Context. *Open Education: From OERs to MOOCs*. Springer, Berlin, Heidelberg, pp. 283–313.

Sup-Numérique, 2017. Moteur des ressources pédagogiques - sup-numerique.gouv.fr. Ministère de l'éducation nationale, de l'enseignement supérieur et de la recherche.

Vygotski, L.S., 1997. *Pensée et langage*, La Dispute ed., Paris, France.

Weiser, M., 1999. The Computer for the 21st Century. *SIGMOBILE Mobile Computing and Communications Review*. Vol. 3, No. 3, pp. 3-11.

Yahya, S., Arniza Ahmad, E. and Abd Jalil, K., 2010. The definition and characteristics of ubiquitous learning: A discussion. *International Journal of Education and Development using Information and Communication Technology (IJEDICT)*. Vol. 6, No. 1, pp. 117–127.