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SEMANTIC WEB 2.0 E-LEARNING FRAMEWORK – DSI 2.0

MARTIN JOVANOVIĆ
University of Niš, Faculty of Electronic Engineering, martin.jovanovic@elfak.ni.ac.rs

Abstract: *This paper describes a conceptual model of an e-learning framework designed for capturing semantic tier data from users. The model is based on the two-tier semantic e-learning framework (DSi), developed at the Faculty of Electronic Engineering, Niš. The existing framework expands textual e-learning material with a semantic layer, while providing intuitive drag-and-drop user interface for querying semantics. Proposed model allows both instructional designers and users (learners) to contribute to semantics using the same interface, thus creating documents' semantics collaboratively and in a Web 2.0 fashion, merging the concepts of Semantic Web and Web 2.0 with the collaborative approach to learning.*

Keywords: *E-Learning, Semantic Web, Web 2.0, Collaborative Learning, DSi*

1. INTRODUCTION

This paper discusses a conceptual model of an e-learning framework which couples an intersection of Semantic Web, Web 2.0 and collaborative learning with an intuitive and user-friendly interaction with the learning material. This blend shows potential for improvement of e-learning systems, as each of its components has field-proven positive impact on it.

E-learning, though hard to define, is about real-time delivery of individualized, comprehensive, dynamic learning material [1]; a *just-i-time* and *just-enough* type of education, integrated with value chains, [2] that revolves around the learner – contrary to traditional paradigm. Generalized learning material prepared in advance for reuse in unchanged form (*just-in-case*, material-centred type) is inapplicable in this approach. Instead, it requires on-demand aggregation of lessons and courses from repositories of fine-grained learning objects (LO). This, in turn, requires LO markup, a set of inference rules and, for effective personalization, a student model. Sole metadata is insufficient; formal semantics is needed to enable automatic reasoning [3], and at this point it is Semantic Web that provides what's necessary.

Intersection of e-learning and Semantic Web is not new, and benefits it brings revolve around following key points:

- new methods of structuring learning material (aggregation and reusability of LS),
- new and more intelligent semantic, context-sensitive search possibilities within the learning material,
- open and interoperable LO repositories,
- new possibilities for sequencing and navigation through the learning material, and, nonetheless
- possibility to use intelligent agents in any part of the e-learning scenario.

Comprehensive overview of Semantic Web applications in various aspects of e-learning is provided by [4], while several convergence points of research in these two areas are well articulated by [5]. Usual practical applications of Semantic Web in e-learning inclue ontologies that articulate LO in the file system, [6] multiple ontologies for multiple aspects, [7] automated reasoners, [8] use of pedagogical agents [9] etc. These trends are relatively stable in contemporary e-learning research. [10]

The DSi e-learning framework, developed at the Faculty of Electronic Engineering in Niš, applies semantic metadata to e-learning in an innovative way. [11] This framework is the foundation of the conceptual model proposed in this paper, and will be described in the following chapter.

2. THE DSI E-LEARNING FRAMEWORK

If we accept that theoretical learning means acquisition of facts and relations, and that (with exception of earliest age) defining facts and concepts means bringing them into relation with already familiar ones, nearly all theoretical learning resides on proper acquisition of relations between notions. In e-learning systems, any notion can be hyperlinked to a definition page, or equipped with a pop-up or tooltip on-hover definition. However, *establishing its relation to another specific notion*, which constitutes most of learning, is in this way impossible.

Typical scenario includes a student that reads about new notion, but forgets how it is related to the previously defined one. In classic approach, they need to rollback and search the material for earlier definition, then come back and continue reading. The DSi approach cuts this procedure short by providing immediate relation retreival for any two notions on the page. In DSi scenario, learner drags one notion (word) onto another and the framework returns all defined relations between these two notions. These relations are stored in a separate file and can be developed by separate instructional designers. Also, various relation-files can be applied to a single textual learning material in different contexts.

The DSi set of funcionalities is provided by two JavaScript frameworks: one for drag-and-drop user interface [12] and the other for accessing the relations file [13]. Relations are stored in RDF/XML syntax and form an RDF graph. On page load, relations file is parsed and each word in the lesson text, found in relations, is assigned with metadata refering appropriate relation. According to [3] this metadata can be considered semantic. One representative part of semantic (relations) file is shown in Image 1.

```
<?xml version="1.0"?>
<rdf:RDF
xmlns:eg="http://example.org/foovocab#"
xmlns:foaf="http://xmlns.com/foaf/0.1/"
xmlns:rdf="http://www.w3.org/1999/02/22-
rdf-syntax-ns#"
 <foaf:Person rdf:nodeID="Erickson">
<foaf:name>Erickson</foaf:name>
<eg:was_a_rolemodel_for rdf:nodeID="NLP"/>
<eg:was_modeled_by rdf:nodeID="Grinder"/>
</foaf:Person>
</rdf:RDF>
```

Image 1: One RDF n-tuple from the semantic layer file

User experience is best presented by screenshots of a typical interaction. All words found in relations file are highlighted (eg. by color - grey), as shown in Image 2.

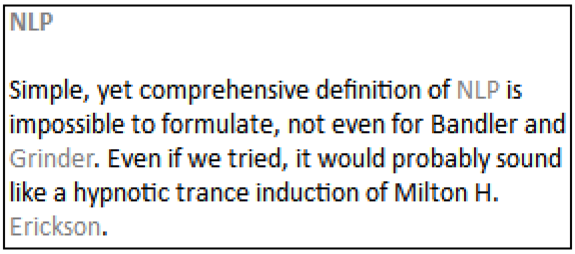

Image 2: Text ready to be semantically queried

The learner chooses one word and drags in onto another, as shown in Image 3.

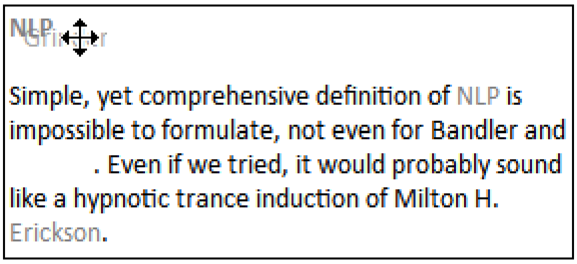

Image 3: Dragging the word

After dropping the word onto another, the framework queries the semantic file and returns all relations between chosent notions defined in it (Image 4).

The major limitation of DSi e-learning framework lays in the instructional design of the semantic layer. RDF can be edited using any text editor; however, instructional designer must be acquainted to basic principles of RDF and the syntax adds significant load to the workflow. The issue of syntax can partially be resolved with RDF editors such as Protégé [14] or Altova Semantic Works [15]. Nonetheless, non-IT domain experts can not be expected to know anything about RDF. The following chapter discusses one possible way to overcome this limitation, which, in turn, opens a new array of possibilities for integrating Web 2.0 and collaborative components to DSi framework.

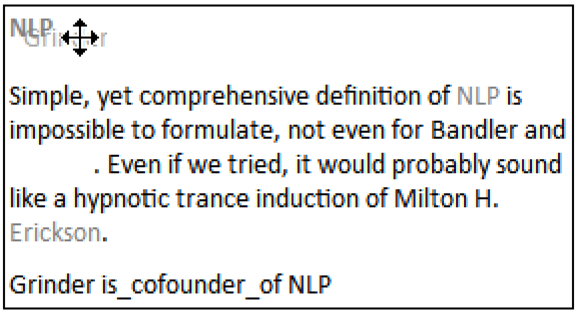

Image 4: Dropping the word and getting relation(s)

3. THE DSI 2.0 COLLABORATIVE MODEL

Even with aforementioned visual RDF editors, design of semantic layer still requires some knowledge about Semantic Web principles. Moreover, using those editors distances semantics designers from the actual textual document for which semantics is made; instructional design splits into two distinct and different environments. These issues highten simplicity treshold in design process above the acceptable level. In order to provide experts from various non-IT domains with usable semantics-building facility, level of abstraction of IT details needs to be as high as possible.

One possible solution is found in *reversing the DSi user interaction*. Instead of dragging and dropping in order to query semantics for possible relations between two words (notions), drag and drop functionality can be used in an opposite direction – to define (or add) relations between chosen two words. Since DSi, in its current version, supports only lexical relations (understandable solely to humans), adding new relation is straightforward. Adding this type of functionality transforms DSi e-learning viewer into a (semantics) editor, while keeping the exact same user interface learners will be exposed to. This approach brings editing semantics into the same environment where it is queried, keeping the design workflow in one setting and allowing WYSIWYG editing.

DSi 2.0 User Experience

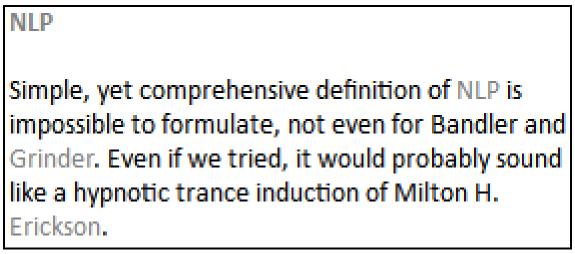

Image 5: Initial state of DSi 2.0

Expected user experience with DSi 2.0 editing begins with the lesson text where all words are draggable. Words that already have relations defined may be highlighted (as in existing DSi), as shown in Image 5.

If the learner chooses to drag and drop one highlighted word onto another, just like in the first version od DSi, system will respond with already defined relations between the two words, but with one additional option – adding a new relation (also enabling them to rate the existing relations, which will be explained ahead). This is shown in Image 6.

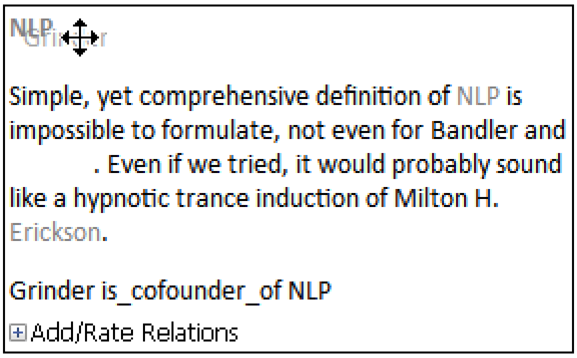

Image 6: Option to add/rate relations appears

User can also drag any non-highlighted word and drop it over any other (highlighted or not). If any of the words is not highlighted, no relations yet exist, and the user will be prompted to enter the first one, as shown in Image 7.

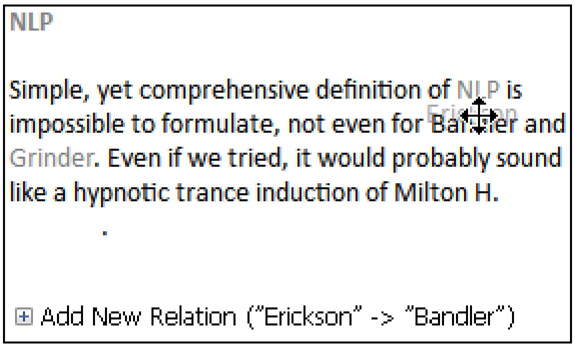

Image 7: Option to enter the first relation

If any relations already exist between the chosen two words, those will be exposed to the user, offering them to either add any new, or to concur with any existing. This way the user might just accept any of the already existing relations if finds appropriate. Moreover, they can rate existing relations with "concur" and "disagree" rating (Image 8).

If the learner concurs with specific relations, their weights are incremented. This way relations get sorted as various learners rate them.

This modality of editing semantics is extremly simple, user-friendly and intuitive. It requires no knowledge of formal representation of relations and abstracts the user from any technical knowledge related to the framework. This simplification of semantics design workflow opens up vast array of possibilities for various domain experts to contribute to semnatic layers of textual learning objects. Even more, adding to semantics can be open to *learners*, adding both Web 2.0 and collaborative value to the DSi framework.

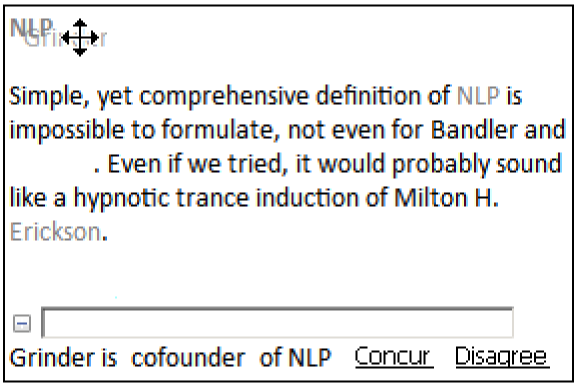

Image 8: Adding new or rating existing relation

Implementation details

Funcionality of DSi 2.0 is based on DSi, with few additional functions. On page load all words are given span tags with id, regardless of wheter or not they are found in the RDF document, in order for all of them to get drag and drop ability. Then only words that are found are highlighted and assigned to a class.

On drag and drop event, handler function examines wheter both words belong to the class of RDF present and, depending on that, returns any existing relations or only prompts for entering the first one. In case of entering a relation, it is added into the RDF n-tuple that belongs to the word dragged (not the one belonging to the word dropped). In case that symmetric relation needs to be entered, the user must drag words separately in both directions (automatic inverse relations are not supported).

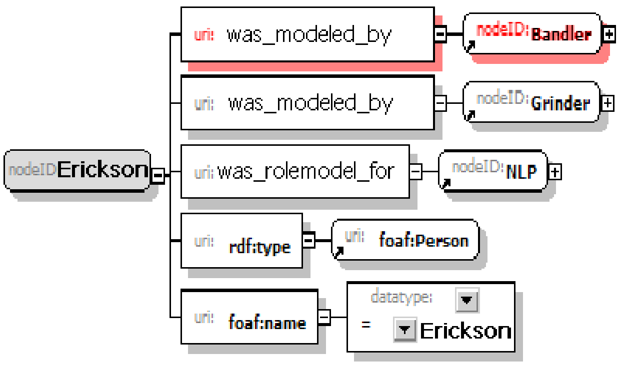

Image 9: Only single-direction relation is added at once

For example, if the user takes the word "Erickson" and drops it over the word "Bandler", the relation they enter will be added to the RDF n-tuple assigned to the word "Erickson", in the tag relating this word to the word "Bandler", as shown in Image 9.

4. VALUE ADDED

Web 2.0 in E-learning

Though it may seem chaotic and unstructured at first sight, community-generated web content (primarily through wikis and tagging) shows qualities of collective intelligence and competes with rigidly structured and controlled contents (the main example of this being the comparison between Wikipedia and the online edition of

Britannica [16]). At data level, one of the approaches is a two-tier structure (one tier being semantic markup, and conversion of obsolete markups, such as BibTeX to semantic; the other enabling users to tag). Another approach emphasizes intense communication between users, supporting it through semantics (ontologies) from three perspectives: personalized annotations, real-time discussions and semantic search [17]. More "outside" approach to semantics is taken by [18]: semantics are here used for collaborative group formation (instead of semantic support for interactions). This solution uses the student model to determine learner combinations with adjustable level of accuracy and inference of rules in case of uncertainties. One step forward towards Web 2.0 presents [19]. Instead of using ontologies for structuring learning material, author suggests using *folksonomies*, thus introducing user-generated content at an even deeper semantic level. Whatever approach applied, the intersection of semantic e-learning and Web 2.0 brings about the concept of collaborative learning (even if it meant collaboration between human learners and pedagogical agents [20]), along with all the previously mentioned considerations.

Collaborative Approach to E-learning

Similarly to the e-learning, the notion of collaborative learning escapes rigid definition. This makes sense, since it encompasses various human-dependent factors. In general, problem of collaborative learning definition can be broken down into two: nearly any learning situation can, to certain extent, be labeled as collaborative, and it is challenging to determine each author's own contribution to this definition [21]. It is also disputable whether collaborative learning can be considered a teaching method or learning mechanism. Just like in "solitary" learning, activities performed (reading, predicting, creating…) trigger certain learning mechanisms (induction, deduction…). In collaborative environment, both these actions and mechanisms occur. It is about additional activities (fostered by group interactions) that spark off additional learning mechanisms (explanation, disagreement…). In that sense, collaborative learning itself cannot be labeled a *single* mechanism, nor can it be labeled a *method*, due to inability to predict any specific interaction (unless make it obligatory, which can prove limiting in other ways [22]). Collaboration is rather a social contract, in which chances are that certain types of interaction will occur [21]. Furthermore, it is hard to distinguish between distributive natures of a group and an individual. Distributed cognition theories treat the group as one, distributed cognitive system [23]. On the other hand, Minsky's theory of a single person's distributive nature [24] puts a single learner in the frame of collaboration. Therefore, collaborative learning can only be viewed as a *situation*, and certain methods for invoking this situation can be applied. Collaborative situation, in this context, means symmetry of actions, knowledge and status), accompanied by high interactivity (with rather synchronous and negotiable interactions). Except learning, collaboration tends to develop other beneficial skills in learners, such as critical thinking [25]. However, caution is required on both sides of collaboration spectrum. Collaborative learning shows best results when, to some extent, emergent; a subculture of few that arose in an hour, with various levels of interaction (not limited to learning). Too much freedom of expression, especially in CSCL systems, may lead to confusion and a feeling of lack of structure [26]. On the other hand, if the interaction is too formalized and restricted, the element of 'freedom' (which seems to be one of the driving forces) can be significantly compromised [22].

DSi 2.0 - Web 2.0 and Collaborative Aspects

User-friendly straightforward semantics editor offered by the DSi 2.0 framework model encompasses both Web 2.0 and collaborative approach to e-learning in an unseparable way. User-editing of learning material semantics harnesses the creative force of community to contribute to material in an self-organizing, emergent fashion. Freeform community contribution to semantics is frequent through social tagging and folksonomies; however, this is limited to annotating and catogorazing content. DSi 2.0 model opens possibilities for users' contribution to somewhat deeper semantics (in form of RDF graph), possibly leading to social emergence of full ontologies – a tendency that, if comes to life, might be labeled *Semantic Web 2.0*.

On the other hand, any learner's contribution to learning material semantics is immediately available to all other peers. If annotated by contributor, those can spark off discussions among learners and engage them in critical thinking. Moreover, the option to concur or disagree with any of the existing relations introduces certain level of peer-grading; in case of multiple relations between terms, relations are sorted by learners' acceptance in an emergent way. Technical possibilities for learners to collaborate within the proposed framework are limited; however, complexity of offered interactions with the system trades off with the simplicity of use, latter being the ultimate requirement for any Web 2.0 based and/or collaborative e-learning system [22].

5. CONCLUSION

E-learning framework model proposed in this paper (DSi 2.0) is a follow-up to the existing DSi semantic e-learning framework which adds user-friendly semantics editor and opens up learners' contribution to semantics and certain level of collaborative learning. This model allows intuitive way of defining and grading lexically expressed relations between arbitrary notions (words) in a textual e-learning material. This way the DSi 2.0 framework model introduces Web 2.0 and collaboration principles to e-learning in an intermingled way.

Usability and drawbacks of the model will be established after its testing on live subjects. However, certain limitations of the proposed model are noticeable.

Firstly, relations that build semantic layer are purely lexical and not machine-understandable; moreover, they cannot be assigned with qualities such as transitivity, symmetry etc, which would enable certain level of automated reasoning and inference in relations space. Evolving the DSi concept towards richer semantics, including expression in the OWL language, seems like the next logical step in its development.

Secondly, the free form of learner's contribution to semantics may need to be limited to minimize noise. This can be achieved through an option to delete inappropriate relations, given to course teachers. Another way to minimize noise may be assigning different weights to relations added by different roles in the system (student, teaching assistant, teacher, supervisor etc).

Finally, unpredictable, emergent directions of research are expected in the testing phase of the framework.

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