Lexico-Semantic Collaborative Learning Framework

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Abstract – **In this paper an e-learning framework based the DSi semantic e-learning approach and aimed at providing a distributed collaborative e-learning environment is described. This framework builds on the previous versions of the DSi (Drag and Drop Semantic Interface) versions and is designed as a platform for user-generated semantic content building coupled with a peer-assessment approach, keeping the users' interaction with the system at the lexical level in order to maintain simplicity and usability. The fundamental DSi approach, as well as the projected learning scenarios are given too.**

Keywords – **E-learning, Semantic Web, Peer Assessment, Collaborative Learning.**

I. Introduction

A. E-Learning and Semantic Web

This paper describes a collaborative e-learning framework based on semantic markup and peer-reviewing elements, currently in development at the CIITLAB laboratory of the Computer Science Department at the Faculty of Electronic Engineering Niš. This framework is a follow-up to the previously developed versions of the DSi (Drag and Drop Semantic Interface) and builds up on their functionality and experience gained. As a tool aimed primarily at e-learning, the framework is developed with specific goals in mind: a readily available, dynamic learning material [1] with just-in-time availability of semantic resources for learning acceleration. Still vaguely defined, e-learning should include on-demand, real time delivery of custom-tailored and comprehensive, dynamically created learning material and should provide connection between learners and experts and encourage development of learning communities [2]. With this in mind, the collaborative upgrade to the DSi framework targets learning communities and aims at providing the framework for communication between community members in a formal (and semantic) way. Moreover, desired dynamic nature of e-learning systems requires granulation of learning material into smaller parts that enable aggregation. The proposed system follows this guideline by separation of textual and semantic learning material tiers.

The concept of learning material granulation and on-demand aggregation into individualized lessons and courses supports the ideas of cost-effective [2] accelerated dynamic e-learning scenarios, but requires means of learning objects annotation (markup) by means of metadata [3] and sequencing/aggregation rules. Through numerous initiatives such as IEEE-LOM [4], IMS [5] or ADL [6], a close relation of this approach with Semantic web surfaced. Furthermore, Semantic web offered numerous standardized tools for expressing semantics, such as ontologies [7] and ontology-expressing languages (RDF [8] and OWL [9] - powered with formal semantics and reasoning-ready). The reasoning power coupled with semantic markup allows for content granulation and aggregation in a standardized way, making the e-learning to Semantic Web coupling a natural outcome. Formal semantics also provided a framework for student modeling, while the concept of autonomous software agents enriched the tutoring systems with a new level of autonomy, using pedagogical agents to implement both required material sequencing and the chosen pedagogical approach. The specific modes of usage of Semantic Web tools in e-learning varies from semantic annotation of learning resources on the local learning platform [10] and representing various domains of knowledge in a semantically structured ways, [11] to automated reasoning on the learning material presentation and personalization [12] to the application of autonomous pedagogical agents. [13] The framework proposed in this paper uses Semantic Web technology to add a semantic layer to the textual learning material in order to make it active for querying, while the semantics are restricted to lexical level. This approach will be described in detail in the next chapter.

A. Collaborative Learning Paradigm

Further to the application of Semantic Web, the proposed system introduces elements of collaborative learning. This approach is somewhat difficult to define, as most learning scenarios, even if they include only using other learners' forum posts, can be viewed as collaborative. The main problem in this area is the "measurement" of each participant's quantitative role in the learning process. [14] Variables such as the number of participants must also be taken in account; while some authors focus on small numbers of learners [15], others consider various ranges, from classes to large communities of over a hundred participants. [14] The activities in collaborative learning are same as those in any standard one-person learning situations, so what differentiates collaborative from standard learning are the activities exclusive for groups, primarily interactions between participants. This interactions often include some group-specific forms of learning, such as disputes on the topic, giving arguments, explaining to others etc. An e-learning system can then be labelled as "collaborative" if it provides an infrastructure for such interactions in a guided way. Though putting too heavy restrictions on interactions and making them very formal can remove the "spontaneous" component of collaboration, [14] allowing too much freedom in interactions can cause an opposite effect: learners feel disoriented and "loose". [16] The system proposed in this paper tends to balance between these two extremes by providing a

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combination of well-defined structure for interactions, but within which a solid amount of freedom in expression is allowed. The negative result of this approach is that semantics are expressed only on a word-level (in the lexical domain), but this compromise was found acceptable given the aforementioned constraints.

II. DSi Evolution

A. DSi 1.0

In order to describe the proposed system, it is necessary to mention its predecessors, upon which the system is built. The initial idea of the DSi framework is providing a semantic layer, that contains relations between notions in the lesson text. These relations are defined manually and are expressed in the spoken language. The notions (the relations are between) are the words in the text – so this approach is on the lexical level. The relations in the semantic layer are expressed with the Semantic Web's RDF language and must be entered manually (preferably using some ontology-building tool such as Stanford Protégé) [17].

From the user's perspective, after logging in to the system the textual learning material is shown. The material can follow any sequencing algorithm and apart from the text any elements can be shown on the page – the DSi 1.0 framework is applicable only to the text/HTML, therefore the user experience will be described on a textual example (Fig. 1).

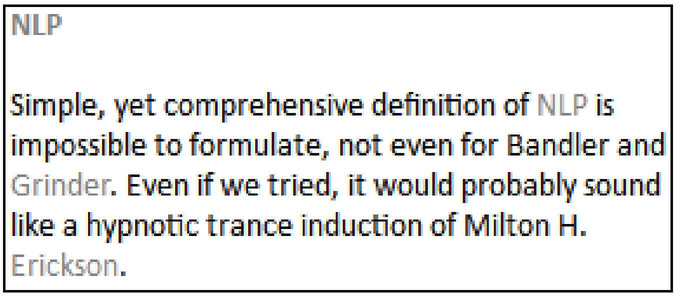

Fig. 1. The lesson loaded

In a general case, in the semantic layer relations will not be defined between all the words in the text, but rather between a subset of words. As a hint, words between which relations are defined are marked by color (gray). These words have the ability to be dragged and dropped on with a mouse. When the mouse pointer hovers above any of the grayed words it changes to the crosshair (drag) shape, indicating that the object beneath (the word) is draggable. In this example, it is the word "Grinder", which is dragged and dropped onto the heading "NLP", as shown in Fig. 2. When the word "Grinder" is released, the RDF layer, containing the relation(s) between "Grinder" and "NLP" is queried and all the relations found are shown to the learner. In this example, only one relation is found: "is_cofounder_of" (indicating that John Grinder is a cofounder of Neuro-Linguistic Programming. This is shown in Fig. 3.

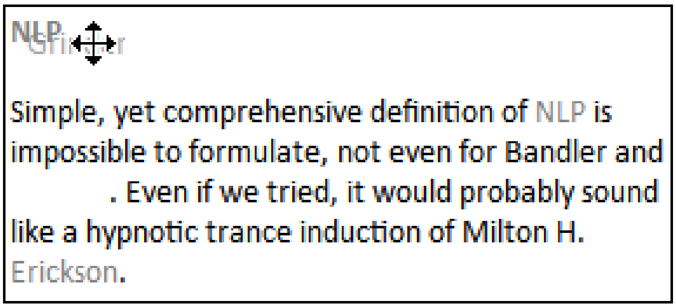

Fig. 2. Dragging and dropping the word

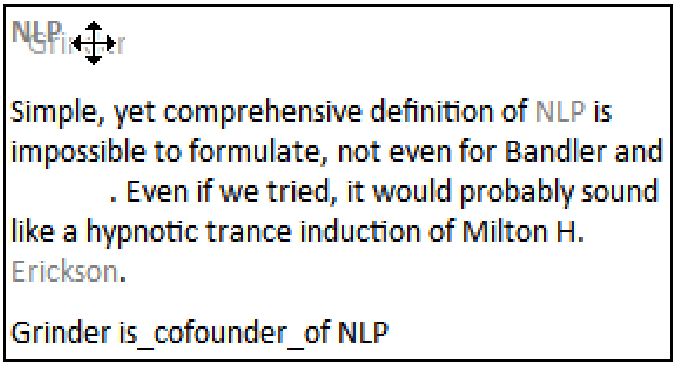

Fig. 3. The relation returned

Upon the page load, a JavaScript functions traverses the RDF and finds all the words that relations are defined for. Then it assigns the drag-drop capability to each of them in the text. Upon drop event, the pair of words (dragged and dropped-onto) are passed to the JavaScript function that traverses the RDF tree and returns any relations between these two words. This relation is then shown below the text. This initial DSi version was described in detail in [18].

B. DSi 1.5

Though functional, the version 1.0 suffered several design flaws. Firstly, the entire contents, both textual and semantic, was housed on the client. This was acceptable for a demo, proof-of-concept application, but was inappropriate for any real-world use, primarily due to no protection for the semantic data (which can be a corporate secret or a copyrighted material). Secondly, all the words that took part in RDF relations were marked (greyed out) as a hint to what is draggable. Nevertheless, there is no hint to which words the given word is related to. This can lead to multiple drag-misses, because dropping on another draggable word, in general, doesn't guarantee that the relations between the specific two words exist. Again, this is acceptable as a proof of concept, but can be discouraging for a real world learner.

These primary flaws have been corrected in the version 1.5. The front end is similar to the 1.0, as shown in Fig. 4. The only significant difference in the user experience is that when a word is chosen and dragged, the subset of droppable words that are related to this word is additionally marked (by underline, bold, color or any other emphasis). This way the learner knows where they can drop the dragged word without getting the "no relations" response from the system. This is shown in Fig. 5. Other than this, only the changes in color exist.

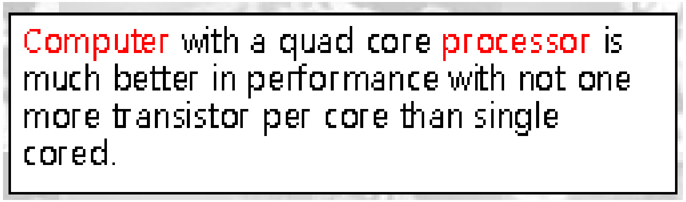

Fig. 4. DSi 1.5 frontend

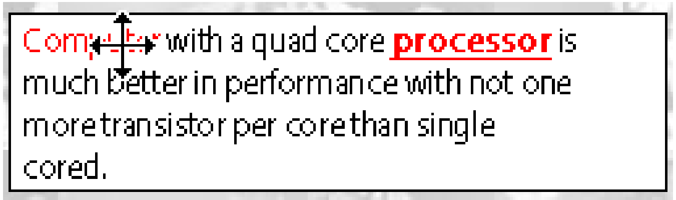

Fig. 5. DSi 1.5 drag action and additional highlighting

Under the hood, the main difference is that both the text and the RDF semantics are stored on the server. All the interactions are similar to 1.0, only instead of querying the client via JavaScript, the data is fetched from the server via AJAX. This way any sensitive information is kept on the server and only the portion needed for learning is pulled to the client.

C. DSi 2.0

The version 2.0 introduces a new dimension – a Web 2.0 component. [19] This is achieved by setting all words in the text draggable (and droppable). This way a learner can drag an arbitrary word, whether or not there are any relations defined for it. On the drop event, any found relations are displayed, but the user is presented with an option to enter their own relation. This turns the DSi 1 (which can be viewed as a semantic "reader") into what can be viewed as a semantic "editor". This is shown in Fig. 6.

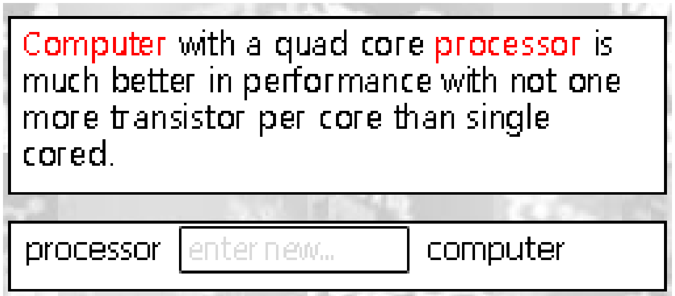

Fig. 6. DSi 2.0 – entering new relation

The primary benefit of this approach is the elimination of ontology editing tools or manual RDF editing. Up to the version 1.5 domain experts in charge of semantic layer needed to be IT savvy to edit it, which is a high expectation. With the version 2.0, anyone with the domain knowledge can build the semantic layer by virtue of dragging and dropping. This is not restricted to e-learning: such visual approach can be used as front end for building general-purpose ontologies. However, it opens the door for collaborative semantics building.

III. DSi 2.0 Collaborative

The DSi 2.0 Collaborative e-learning framework, currently in development at the CIITLAB laboratory of the Computer Science Department, Faculty of Electronic Engineering Niš, is a framework aimed at providing an infrastructure for collaborative and constructivist learning through collaborative building of the semantic layer.

The initial user experience is similar to one of the DSi 2.0, as shown in Figure 2.0. The crucial difference is the feature of assessment at the level of relations contributed by peers. Each student has the ability to, further than proposing their own relation between two notions (words), assess the relations proposed by their peers.

The user experience of this feature is designed as the ubiquitous 1 to 5 star rating, as shown in Fig. 7.

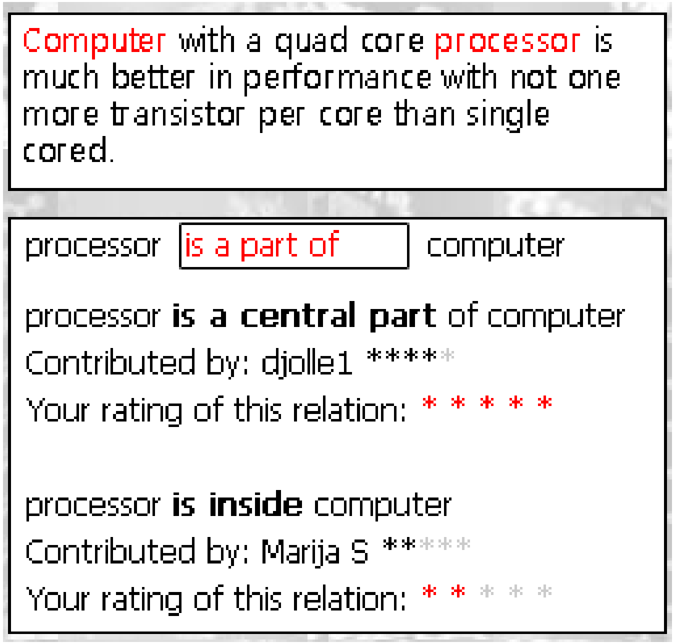

Fig. 7. DSi 2.0 Collaborative user experience

Along with every existing relations, the contributor's nickname is shown, as well as the relation's current rating – as rated by other peers. The first learner (djolle1) has a four-star rating for the "is a central part of" relations, while the second learner (Marija S) has a two-star rating for the relation "is inside". The current learner gives a five-star rating to the first one and two stars to the second, and contributes a new relation – "is a part of". This relation will further be rated by other peers. Enter a new relation is not mandatory – a learner can only assess relations entered by others.

The goal of this approach is a collaborative sorting of user-generated material, with best semantic elements surfacing to the top in an emergent fashion – as in any complex system. [20] In that sense, some changes must be introduced to the semantic document. A standard way of representing relations in the RDF document (from the version 1.0) has the following form:

```
<rdf:Description rdf:ID="processor">
    <is_a_part_of rdf:resource="computer" />
</rdf:Description>
```

When the learner adds a new relation, it will appear as a new statement. Alternatively, the predicate can be added to an existing statement:

```
<rdf:Description rdf:ID="processor">
   <is_a_part_of rdf:resource="computer" />
   <is_inside rdf:resource="computer" />
</rdf:Description>
```

Collaborative approach needs to keep track of three more parameters:

- relation contributor,
- current relation rating and
- current number of peer ratings of the relation.

Not only do these parameters need to be recorded, but also they must be tracked within the relation context; lexically same relation can occur between different pairs of words – and carry different semantics (this different relevance, accuracy and/or peer acceptance rate). Due to this restriction, in the framework proposed in this paper the accompanying data is stored within the predicate tag, in form of additional attributes (following the situation in Figure 8):

```
<rdf:Description rdf:ID="processor">
   <is_a_central_part_of
       rdf:resource="computer"
       dsi:contributor="djolle1"
       dsi:current_rate="4"
       dsi:current_peers="7"
   />
</rdf:Description>
```

Additional attributes are nested in the predicate's tag and assigned to the "dsi" namespace. This way they can not refer to any "is a central part of" relation between other two words.

IV. Conclusion

This paper describes a collaborative e-learning framework based on learner-generated and peer-assessed document semantics defined at the lexical (single-word) level. It is a follow-up to the existing semantic-based e-learning framework. Firstly, the previous versions of the system are described – as a foundation for the system proposed and the key differences from the previous versions are highlighted. On the completion of the system it will be tested in the university learning environment. Further research will include prompting peers on each new entered relation to increase involvement, finer granulation of assessment (accuracy, relevance...) and free-form commenting on peers' relations, while the current research branch heads towards semi-automated reasoning based on properties of relations (transitivity). [21]

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