Enacting Argumentative Web in Semantic Wikipedia

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***Abstract*—This research advocates the idea of combining argumentation theory with the social web technology, aiming to enact large scale or mass argumentation. The proposed framework allows mass-collaborative editing of structured arguments in the style of semantic wikipedia. The long term goal is to apply the abstract machinery of argumentation theory to more practical applications based on human generated arguments, such as deliberative democracy, business negotiation, or self-care.**

Keywords - argumentation theory; semantic web; semantic wikis.

I. Introduction

Argumentative Web [2] is a large scale network of interconnected arguments created by human agents in a structured manner. The vision is to create an infrastructure for mass-collaborative editing of structured arguments. One desiderata is that Argumentative Web employs a unified extendable argumentation ontology.

Building argumentation corpora is an active line of research, aiming to facilitate the use of argumentation theory in practical applications. The arguments are extracted either by i) automatic means, leading to the field of *argumentation mining* which processes free-text to detect natural occurring arguments, or ii) human based annotation, in which experts are employed to identify arguments and categorize them based on a set of argumentation schemes. At the moment few such argumentation corpora exist and they are limited in size. Two examples are Araucariawith 641 arguments and ECHR (European Court of Human Rights) corpus with 257 arguments [9]. In this paper, we advocate the idea of combining argumentation theory with the social web technology, aiming to enact large scale or mass argumentation.

Due to the large popularity of the well known Wikipedia, a free web-based, collaborative encyclopedia, efforts were made to recreate that community spirit and propagate it to the Web 3.0. Semantic Wikis are a subset of the participants of this movement, adding underneath the Wikipedia core a knowledge model capable of query and reasoning. In this paper, we implement a multi-user argumentation framework in Semantic MediaWiki based on the state of the art model, the Argument Interchange Format (AIF) ontology [2].

II. Technical Instrumentation

A. Argumentation Schemes

For the abstractization of the debate, we use the theoretical model of Walton based on argumentation schemes [1].

Argument from expert opinion $\doteqdot$ *AS_EO*

A_1 : *E asserts that A is known to be true.*

A_2 : *E is an expert in domain D.*

C : *A may (plausibly) be taken to be true.*

CQ_1 : *Expertise Question — How credible is expert E as an expert source?*

CQ_2 : *Field Question — Is E an expert in the field that the assertion, A, is in?*

CQ_3 : *Opinion Question — Does E's testimony implyA?*

CQ_4 : *Trustworthiness Question — Is E reliable?*

CQ_5 : *Consistency Question — Is A consistent with the testimony of other experts?*

CQ_6 : *Backup Evidence Question — Is A supported by evidence?*

Fig. 1. Critical questions block the derivation of the conclusion.

Argument schemes encapsulate common patterns of human reasoning such as: *argument from position to know, argument from evidence, argument from sign, etc.* Argumentation schemes are defined by the following items: a name, a set of premises (A_i), a conclusion (C) and a set of critical questions (CQ_i). Figure 1 details these attributes of *Argument from expert opinion* scheme. When a critical question is conveyed the conclusion is blocked until the issue risen by the CQ is clarified. CQs have the role to guide the argumentation process by providing the parties a subset from the most encountered possible counter-arguments.

B. Argument Ontology

To model the interaction between arguments, the AIF ontology is used. Defined originally by Chesñevar [3], the AIF represents a core ontology of argument-related concepts. There is a hierarchy of class nodes defined, where the two most important types are I-nodes which contain pieces of information, and S-nodes which represent a type of inference act. An information node $I-node \in N_I$ represents passive information of an argument such as: claim, premise, data, locution, etc. A scheme node $S-node \in N_S$ captures active information or domain-independent patterns of reasoning. The schemes are split in three disjoint sets, whose elements are: rule of inference schemes ($RA-node$), conflict application node ($CA-node$), preference application node ($PA-node$). $RA-nodes$ are used to represent logical rules of inference such as modus ponens, defeasible modus ponens, modus tollens. $CA-nodes$ represent declarative specifications of possible conflicts. $PA-nodes$ allow to declaratively specify preferences among evaluated nodes.

An extension to the core AIF ontology is presented in [2] that would ease the representation of argument schemes. The schemes are provided with detailed descriptions (premise, conclusion and critical question descriptors) that must (or can in the case of critical questions) be fulfilled.

III. Computational Model of Arguments

A. Argument Annotation

For the semantic annotation of arguments we use the semantic templates. of the Semantic Media Wiki (SMW) framework. SMW is an extension to the popular MediaWiki software package. Templates are a simple way of reusing content or parameterizable structures. The advantage that SMW brings is that semantic annotations can be used inside templates, thus allowing consistent annotation without having to learn specific syntax.

In order to exploit the AIF ontology in the SMW, we used a mapping process [4] between the concepts and roles from the ontology, to the internal structuring mechanisms available in the semantic media wiki. Thus, the class hierarchy, as well as class membership, are employed through the use of categories, object and datatype properties are defined through the use of the *property namespace*, whilst attribute values are inserted using semantic annotations.

We present an example of how the S-node hierarchy is created. In the Scheme Node category we type

$$[[imported\ from :: aif : S - node]][[category : Node]]$$

which indicates that $S - node$ is an element from the AIF vocabulary and that it is a subclass of *Node*. For creating a new conflict between arguments, in the Conflict Node category one has to enter:

$$[[imported\ from :: aif : CA - node]][[category : SchemeNode]]$$

After creating the two remaining top level subclasses of S-node, the scheme node hierarchy is complete.

The concept of information in argumentation domain is defined by I-node. In this wiki implementation, the pieces of information will be created as articles belonging to the I-node category. The I-node semantic template can be used with the syntax described in figure 2. Here, in order to create an argument the user can populate the following fields: *summary*, representing a short description of the argument, *certainty* representing the degree of belief the user would grant to the statement, *text*, theoretically unlimited text from a wiki article that encapsulates the content of the argument, *supportURL*, a link to the source of the information, and the *context*, represented as a list of terms from the imported ontologies (the *cyc* ontology and the *foaf* vocabulary are used in the example).

S-nodes are a way of logically linking I-nodes. Regardless of the type of scheme used to build an argument, the structure can be summarized as a list of premises and a conclusion. A sample usage of the S-node template is displayed in figure 3. Here, the *premises* of the scheme are represented as a list of I-nodes, the *conclusion* as a type of Node, *scheme* attribute encapsulates the type of the argumentation scheme used (i.e. argument from expert opinion). The *default form* is used internally for the graphical representation of the argument chains, whilst the *topic* field, representing the subject of the debate, is also defined as a list of terms provided by the imported ontologies.

```
{{I-node
   |summary    = John said that it would rain tomorrow.
   |certainty  = High
   |text       = John, a weather man, carefully read ...
   |supportURL = http://www.theweathernetwork.com/weather
   |context    = [cyc:weather,foaf:topic]
}}
```

Fig. 2. Semantic template for I-node annotation.

```
{{S-node
  |summary      = Considering the John's occupation and the
                  fact that he said it, proves it will rain.
  |certainty    = Very high
  |premises     = John's occupation, John said it would rain
  |conclusion   = On Friday (18.02.2010) it will rain.
  |supportURL   = http://en.wikipedia.org/wiki/Inference
  |scheme       = Argument from position to know
  |topic        = Rain on Friday (18.02.2010)
  |default form = Argument from position to know
}}
```

Fig. 3. Semantic template for S-node annotation.

The prototype system will aid the argument creation process by providing users with the option of selecting existing argument schemes. However, to encourage further project growth, users will have the ability to create new argument schemes. Figure 4 shows the usage of the template. The template necessary for scheme creation needs three attributes: a set of premise descriptions, a conclusion description and a set of critical questions.

Having this argument model, arguments can be annotated by selecting a descendant of S-node using an appropriate template, selecting the existing Node types for premise and conclusion, and choosing a descendant specific argument scheme. The existing arguments are linked in argument networks based on the following actions: i) *creation*, ii) *infer*, using *RA-node*, iii) *support*, using *PA-node*, and iv) *attack*, based on *CA-node*.

B. Argument Reasoning

In order to allow reasoning on the argument base contained in MediaWiki, we make use of the ExportRDF feature provided by the semantic extension. With the help of

```
{{New Scheme
  |Ai  = E asserts that A is known to be true.
          E is an expert in domain D.
  |C   = A may (plausibly) be taken to be true.
  |CQs = How credible is expert E as an expert source?
         Is E an expert in the field that the assertion A is in?
         ...
}}
```

Fig. 4. Semantic template for Argument Scheme annotation.

SMW_dumpRDF.php, a maintenance PHP script in SMW, we can export the entire wiki knowledge base in RDF[1] format. Jena tool, due to its maturity and stability, was chosen to perform the following reasoning tasks:

- *argument validity*: the state of the argument is computed from its credibility value;
- *argument explanation*: chaining of argument content;
- *degree of contradiction*: measure of argument subnetwork inconsistency or disapproval.

The illustration of the above tasks appears in section IV-B). The first step in achieving these goals is creating an internal model capable of being easily processed. Using the Jena framework we create an ontology model from the RDF file which will serve as data for building an argument tree having the query argument as root. This tree will contain all interaction with the query argument: argument components and all arguments inferring, supporting or attacking the argument or its descendants in the tree.

In order to establish concepts like argument validity and explanation we need to define factors for evaluating the degree of supports for the arguments. The set of parameters is not a stable one and some may be domain dependent, but in our multi-user, domain-independent argumentation system, we defined the following attributes:

- *User defined certainty* (γ): a numeric value selected by the user, symbolizing the certainty attached to the current *I-node*;
- *Node usage* (υ): counts the number of argument networks in which the current I-node is included;
- *PA-nodes* (ψ): number of preference nodes and their credibility;
- *CA-nodes* (α): number of conflict nodes and their credibility;
- *Minimum support* (μ): the minimum value of premise credibility in order to be accepted in the current dispute;
- *Scheme* (σ): the relevance of the type of the argument scheme for the current debate.

By creating an extensible Java model that lets developers write simple classes that modify the credibility function and allowing users to specify the weight of each factor, we maintain a flexible method of evaluating arguments. Argument validity is defined as good credibility, thus determining validity can be summed up calculating a node's credibility and deciding whether it is above or below a balance point. In case the credibility is an integer, the balance point can be zero and the validity defined as a positive or negative number.

Explanation generation for accepting or defeating an argument rests on the computation of element credibility. If one wishes to obtain the explanation of an argument, the system must evaluate all nodes in the argument tree with the requested argument as root and select the most credible path from the root to a descendant.

The degree of contradiction *dc* in a topic or in the related arguments network can be stated in two ways. A simpler choice would be $dc(c,r,p) = c/(r+p)$ (1), where c is the number of conflict nodes, r is the number of rule nodes and p is the number of preference nodes. However, this method does not take into consideration the credibility values of each argument, therefore a more precise equation would be

$$dc(c,r,p) = \frac{\sum_{i=1}^{n_c} credibility(c_i)}{\sum_{i=1}^{n_r} credibility(r_i) + \sum_{i=1}^{n_p} credibility(p_i)} \quad (1)$$

where c, r and p are vectors of conflict, rule and preference nodes, and n_c, n_r and n_p are the vector sizes.

C. Querying the Argument Corpus

We extend the querying capabilities provided by the Semantic MediaWiki with specific argument related capabilities. To identify the most adequate argumentation chain, both sources of annotations are exploited: i) argument annotations based on the AIF ontology and its argumentation schemes and ii) term annotations based on the ontologies and vocabularies imported into the Semantic Media Wiki framework. The following specific queries are considered:

- *Search by AIF nodes*: The user can search the arguments created based on specific nodes in the AIF ontology. For instance, given the *Implication* node as a subclass of the *Scheme* application node:

  $$[[importedfrom :: aif : Implication]][[category : S\!-\!node]]$$

  one query might be: $\prec$ *Give all the implications of accepting argument X* $\succ$.
- *Search by scheme*: For this case, only specific patterns of arguments are accepted to contribute to the conclusion: $\prec$ *Give only the arguments from expert opinion for supporting the argument "undercooked food is not recommended for pregnant women"* $\succ$ or $\prec$ *List all the consequences based on practical reasoning scheme for the argument "use Linux on Servers"* $\succ$. In the first query the argument from expert opinion was used as filter, whilst for the second query, the argument from practical reasoning was employed.
- *Search by wikipedia metadata*: Specific wiki-related terms can be used to limit or refine the searching domain, such as i) user: $\prec$ *Give all the arguments from the user Y against argument X* $\succ$, ii) data: $\prec$ *Give all the arguments posted from yesterday against "pollution"* $\succ$, or iii) location: $\prec$ *Give all the arguments of the users from Haiti against "ONU support"* $\succ$.
- *Search by domain*: This search implies reasoning on domain ontologies. Each semantic wiki page can be annotated with the domain to which belongs. Suppose that an argument against using doping substances in football exists. Based on the terminological box *Football* $\sqsubseteq$ *Sport* the system is able to include this argument in the answers list to the more general query $\prec$ *Give me all the arguments against the argument "doping in sport"* $\succ$.

[1] http://www.w3.org/TR/rdf-concepts/

```
[ Premise1 ], [ Premise2 ]
 --> { end: back,0; } [ S-node ]
    --> [ Conclusion ]
```

Fig. 5. Graphical description language of a simple argument.

- *Search by degree of support*: Each dispute is characterized by a specific standard of proof, representing the willingness of the parties to accept unreliable arguments. Only the arguments whose degree of support satisfies the minimum threshold of the current dispute will be considered.
- *Filter by context*: The acceptance of an argument is a combination of intrinsic and extrinsic factors. A successful argument in a context might have no relevance in another. In order to effectively support a consequent, flexible control must be exercised over the extrinsic factors of argumentation by providing a context [8]. The context is encapsulated as a list of terms from the ontologies imported in the Semantic Media Wiki. Thus, reasoning on context is similar to reasoning on the domain ontologies. One advantage is that the context helps agents to discover the available means of persuasion for the current debate.

The context of an argument can be seen as representing subjective perspectives on the argument. Several contextual dimensions can be formalized for a general argument such as dialectical context, intentional context or social context. By making use of wikipedia technology, the social context is of particular interest here. It encapsulates the human factors related to the context, which might refer to: information on the user (knowledge of habits, emotional state), social environment (co-location of friends, social interaction), cultural issues (e.g. acquisition of context), relationship between the specific arguments and the plans of the arguers.

D. Graphical Representation

This internal structure allows the construction of a graphic module that will use the Graph[2] MediaWiki extension. This visual plugin defines a complex graph description language through which it can render graphical representations in different formats such as ASCII, HTML, SVG or Graphviz compatible formats. An example of how a simple argument would be described using this extension is shown is figure 5, where 2 nodes will be created for representing the *premise*1 and *premise*2, linked with support-like arrows ($--\ >$) with the conclusion *Conclusion*, based on an S-node scheme.

IV. Running Scenario

This section presents a simple usage scenario and shows the application results. The discussion is based on the network of arguments displayed in figure 6. Here, the information nodes are white, rule nodes are green, conflict nodes depicted with red, and preference nodes with blue. Each node type has its user defined certainty between parentheses, and argument scheme names were shortened from *Argument from position to know* to *position*, from *Argument from example* to *example* and from *Argument from sign* to *sign*.

[2]http://bloodgate.com/perl/graph/

TABLE I
Default weights of argument schemes.

Scheme name	Weight
Argument from example	2
Argument from sign	3
Argument from position to know	4
Preference	3
Conflict	3

TABLE II
Default weights of the credibility factors.

Factor	Weight
User defined certainty (γ)	0.02
Node usage (υ)	0.7
PA-nodes (ψ)	1.5
CA-nodes (α)	-1.5
Minimum support (μ)	0.18
Argument scheme (σ)	0.1

A. Network construction

Suppose that Jim wishes to create an argument about the fact that good software costs more. He decides on what argument scheme fits best and chooses *Argument from position to know*. He builds the appropriate premises, conclusion and rule node (argument 1, where the credibility *high* is attached to the I-node $\prec$ *Good software costs more* $\succ$). Another argument is provided by Sally based on the *Argument from sign* scheme, stating that $\prec$ *Protege is developed in Java* $\succ$ and considering that $\prec$ *Java applications are usually free* $\succ$, so is Protege (argument 2). Consider the Sally sees on the wikipedia the claim that $\prec$ *Good software costs* $\succ$ and the fact that $\prec$ *Protege is a good and free piece of software* $\succ$. Considering the fact that the claim is also true she creates a *CA-node*, attacking the *RA-node* of the argument 1 instead of its conclusion. Steve thinks $\prec$ *Protege is typical of good Java software* $\succ$ and builds argument 4 by re-using the conclusion of the argument 2. Lastly, Tom, a Java passionate, adds a *PA-node* (argument 5) on the argument that $\prec$ *Java applications are good* $\succ$, using one of the premises of the argument 2.

B. Network processing

Before we begin any processing we must establish certain parameters needed for calculating node credibility. The values used are the default ones, users will have the opportunity to set them according to their preferences. Default user defined certainty weights are 1 for *very low*, 2 for *low*, 5 for *average*, 7 for *high*, and 9 for *very high*. The argument scheme weights are defined in table I, and the credibility factors weights in table II.

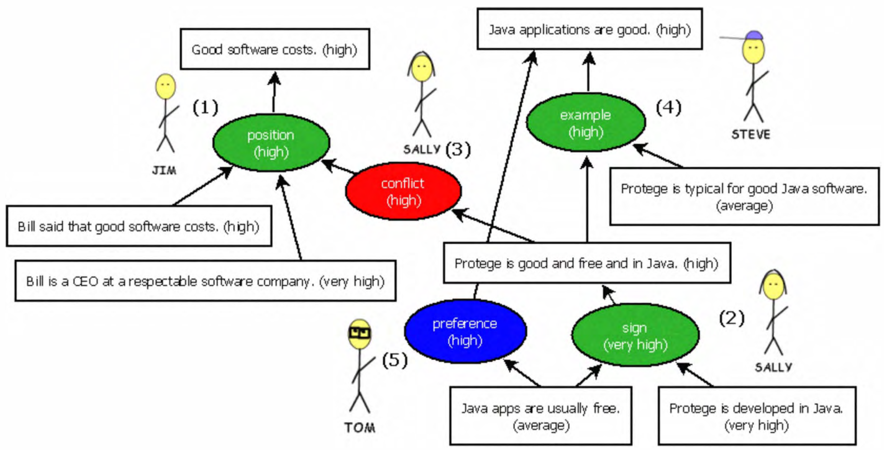

Fig. 6. A sample argumentation scenario.

```
Argument   : Good software costs.
Status     : The fact that Good software costs is not
             sufficiently supported.
Explanation: The facts that Java apps are usually free and
             that Protege is developed in Java indicate that
             Protege is good and free and in Java, which is
             in conflict with the current claim.
```

Fig. 7. Argument explanation.

1) Argument validity: To be able to determine argument validity we must define a function for calculating credibility. As we mentioned earlier, this implementation will be a default one and the addition of others will be facilitated. The standard credibility function is

$$credibility(node) = \gamma c + \upsilon u + \mu m + \alpha a + \psi p + \sigma s \qquad (2)$$

where γ, υ, μ, α, ψ and σ are the weighted factors from table II, and c, u, m, a, p and s are the certainty, usage, minimum support, conflict attacks, preference supports and scheme type of the targeted node.

If one would ask the validity of the argument 1 from figure 6, we would have to calculate all credibility values from the claim to its descendants. After evaluating all credibilities, the claim's validity fails with a value of -1.08407. The conclusion fails mainly because of the strong conflict node (credibility = 1.59018), supported by reusable information (reusability being a heavily weighed factor).

2) Explanation: The generation of explanation also depends on credibility values. In order to build an explanation, the system connects argument components found on the most credible chain of arguments from the claim to one of its descendants. In this case the explanation for the argument $\prec$ *Good software costs* $\succ$ would be constructed from the premise of the argument 3 and from the antecedents of the argument 2 (see figure 7).

3) Contradiction Degree: This degree will be computed with the help of equation (1) and equation 1. Using the first one we count one conflict node, three rule nodes and one preference node, thus $cd(c,r,p) = 0.25$. By making use of the second equation we obtain the result $cd(c,r,p) = 0.537236$.

V. Estimated Impact

The benefits of enacting large scale argumentation are related to: i) augmenting human collaboration and argumentation by appropriate technologies; ii) extending the argumentative web towards a Pragmatic Web infrastructure for collaborative human-computer argument networks; iii) enhancing an individual's reasoning capabilities by increasing visibility, handle information overload, and providing users with re-usable patterns of argumentation. The current trend of forums, blogging, on-line debates is a positive social factor in the spirit of the current research. The technology is seen as an important part in the argumentation process [7], with an exciting impact on several domains such as:

Deliberative democracy (e-Government, e-Administration). It involves dialog with the public and it requires many feedbacks, which must present themselves in a structured manner in order to be effectively processed and taken into consideration by the decision factors. The opposite direction, in which the local leaders justify their decision, is important for increasing transparency in e-democracy. The system helps when building multiple views of problems and resources among the following key actors: government and institutions, planners and technical experts, community. Services supporting structured argumentation impact e-government in: i) increasing transparency by providing structured and more clear justifications of decisions; ii) collecting relevant and motivated ideas from citizens in the form of structured public opinions; iii) supporting multiple views representation on an issue and public debates before norms adaptation. We anticipate the emergence of clusters of structured debates, in the context in which the technology for deploying structured government data in wikipedia is an intense research area.

E-commerce. The consumers can obtain more accurate information related to specific items. For instance, when one wants to buy a specific car, arguments pro and against can be browsed. In this line, our approach is complementary to field of "opinion mining", with the supplementary advantage of fetching the framework with more structured data.

Self-care. A lot of research centered on applications of argumentation in medicine (such as risk assessment or treatment planning) has led to a comprehensive view of argumentation as a form of evidential reasoning. By accessing arguments provided by related patients, one benefit is that the patient is helped to understand his or her health state.

VI. Discussions and Related Work

At the moment, there exists a primordial soup of prototype systems that support argumentation: The current trend consists in developing hybrid approaches that combine the advantages of formal (logic-based) and informal (argumentation scheme-based, diagramming reasoning) ideas [5]. Among the variety of prototype systems that support argumentation: Rationale [12], Araucaria [10], Carneades [6], Reasonable, Magtalo (MultiAgent Argumentation, Logic and Opinion), Aver (Argument visualization for evidential reasoning), Compendium,none seem to overcome a minimum number of users. In our view, argumentation frameworks should have the ability to integrate the domain oriented aspect with the capability of re-using arguments in different contexts. The domain oriented characteristic of the argumentative debates is supported by the following reasons: i) usually the participants of a debate share common interests; ii) standards of evaluating arguments are also domain dependent [11]. One benefit of re-using existing arguments in different contexts is that it provides a bottom-up approach for developing large networks of interconnected arguments. We advocate the idea of combining argumentation theory with the social web technology aiming to enact large scale or mass argumentation.

Debatepediais a new wiki encyclopedia of arguments and debate related materials, including domains such as critical thinking, education, deliberative democracy. It provides a searchable repository of debates and the corresponding arguments supporting them, but without any formalization. We address the issue of large scale argumentation from a more structured viewpoint, exploiting the benefits of semantic technologies for enhancing query capabilities of the system.

Araucaria analyzes arguments based on diagrammatic reasoning, which also deploys a repository of debates. It provides a user-customizable set of schemes with which the human agent can analyze arguments and save them in the Argument Markup Language format. One output of the proposed framework is a large scale argumentation corpus semantically annotated. One difference is that both Araucaria and ECHR corpus are annotated by experts, which is not necessarily the case in our framework. The existence of such large size argument base will trigger the use of machine learning techniques in the argumentation field. We make use of the AIF ontology, which represents the state of the art standard at the moment when formalizing arguments and we exploits the Jena reasoning capabilities to provide more accurate answers when searching within the argument base.

Inference engines for computing the acceptability of arguments have been developed under the ASPIC project. To prove the AIF concepts in this prototype, each node has a degree of support ($dos \in [0, 1]$) attribute. Also, the computation of the *dos* of a conclusion based on the *dos* of its premises is based on the weakest link principle, according to which the *dos* of the consequent equals the minimum degree of support of its antecedents. In the large-scale, open context of WWAW, these attributes might not suffice due to: i) standards of evaluating arguments are domain dependent; ii) the applicable principle of inference for computing the reliance on an argument may change during the course of argumentation. iii) the applicable principle of inference depends on the current context; iv) different principles require different attributes attached to the premises instead of the degree of support, such as fuzzy numbers or rough intervals. Therefore, we designed a flexible framework in which the users can choose from a set of possible argument evaluation strategies, aiming to map the standard of proof with the current domain of the dispute.

VII. Conclusion

In this paper we have shown that using a prolific environment such as SMW as an argumentation platform could have numerous benefits and present a stable, yet flexible foundation for further development. Among the above presented features, this ontology provides the opportunity of integrating software agents within argumentative web, where the agents use the argument reasoning capabilities of our framework and structured facts extracted from DBpedia.

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