Argumentation Map Generation with Conceptual Graphs: the Case for ESSENCE

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Abstract. Argumentation maps are visual representations of argumentation structures, making it possible to efficiently examine the cumulative results of protracted, distributed, and complex argumentation processes. Such visualizations can be useful to, for example, informally assess the status of public debates. Although the elicitation of argumentation maps is well supported, the support for the (1) analysis, (2) comparison, and (3) generation of maps relevant to particular stakeholders is still an open research problem. To develop such services, conceptual graph theory and tools can prove to be very useful. We analyze the argumentation needs of the ESSENCE (E-Science/Sensemaking/Climate Change) project, which aims to create useful argument maps to assess the current state of the global debate on climate change. We outline a public investigator service, which would allow policy makers, journalists, etc. to quickly zoom in on only those stakeholders, positions, and arguments they are interested in.

Key words: argumentation maps, conceptual graphs, services

1 Introduction

Argumentation maps are visual representations of argumentation structures, making it possible to efficiently examine the cumulative results of often protracted, distributed, and complex argumentation processes. Such visualizations can be very useful to, for example, informally assess the status of public debates. They help give an overview of the issues, positions, arguments pro and contra positions and other arguments of the stakeholders involved.

Although the elicitation of argumentation maps is well supported, support for the analysis, comparison, and generation of maps relevant to particular stakeholders is still an open research problem. Indeed, on the one hand the users of arguments are not necessarily the same as their creators. It is also very easy to get lost in the argument map space, especially when the maps grow in size, number, contributing authors, etc. Addressing such issues requires a careful pragmatic evaluation of collaborative technologies in their context of use, focusing on their *relevance* to the user community [5, 7]. Fig. 1 outlines a conceptual model of this pragmatic evaluation of argumentation maps.

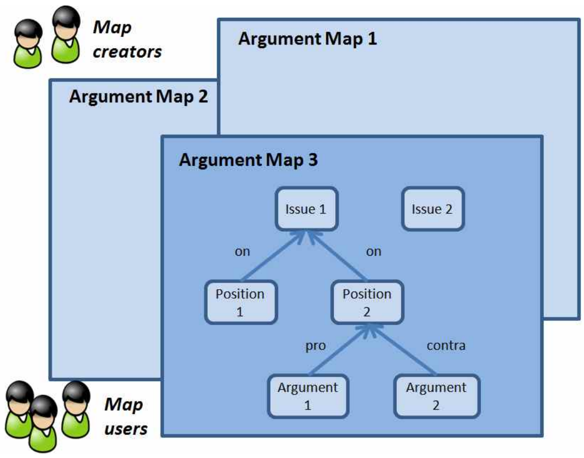

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Fig. 1. Argumentation maps in their context of creation and use

For instance, a policy maker in national government who is preparing new legislation about stricter carbon emission measures, may be especially interested in controversial issues, which are defined as those positions that business / environmental organizations have opposing arguments for / against. An argumentation map-based service should be able to present those parts of the overall climate change map which directly address this particular interest. Please note that the term “directly” is interpreted here in a somehow restrictive manner. In a first step we are interested in the **immediate** consequences and support arguments for a given issue that concerns the user. Once this service in place, it could be extended in order to include the **transitive closure** of pro / con arguments etc.

To improve the relevance of argument maps, automated semantic analysis can be useful. Argumentation maps are in fact semantic networks of argument nodes connected by meaningful relations. To analyze dependencies between map parts and answer queries, this basic semantic network structure can provide a useful starting point. Please note that in this paper we will not analyze the “semantics” of the relations or how they interact amongst each other (transitive closure of the same type of relation, what a “contradictory” relation means etc.). Instead, we will regard the relations as binary relations with a given pre-defined order.

Conceptual graph theory is a powerful formalism for knowledge representation and reasoning. Theory and tools can provide essential support especially in this application context. Intuitively this is due to the fact that Conceptual Graphs use graphs (a visual paradigm) for both representation and reasoning. This means that not only the main representational constructs of the language are graphs, but also that the operations that allow for reasoning (expressed in a subset of first order logic operations) are done via graph based operations. Of course, the type of inference needed in the context of argumentation maps and first order logic subsumption provided by Conceptual Graphs have to be accordingly joined together.

To show how the worlds of argumentation maps and conceptual graphs can meet, we focus on addressing the argumentation needs of the ESSENCE (E-Science / Sensemaking / Climate Change) project[4]. This project aims to create argument maps to help stakeholders assess the current state of the global debate on climate change. In order to do so, stakeholders must be able to view highly customized maps which are those selections from the overall map which should most directly relate to their current information needs. To this purpose, we propose an architecture of a service based on a system of interoperating argument mapping and conceptual graph tools that allow such stakeholder-relevant maps to be dynamically generated from the overall argument map having been created at a particular moment in time. This service can be the basis for a range of stakeholder-specific services such as for policy makers or investigative journalists.

In Sect. 2, we explain the intuitive process behind the generation of relevant argumentation maps. Sect. 3 describes the role of conceptual graphs in providing the required service. Sect. 4 outlines an architecture of the ESSENCE argumentation map generator. We conclude the paper with a discussion and future directions of work.

2 Argumentation Mapping Support: From Elicitation to Generation

In this section, we introduce the ESSENCE case as a testbed for argumentation mapping support evaluation, and give a concrete example of the generation of relevant argumentation maps.

2.1 The ESSENCE Case

The ESSENCE project is the first major project that emerged out of the GlobalSensemaking Network[5]. It has a range of ambitious, but very important and interlinked goals [4]:

- **pilot software tools designed to help facilitate structured analysis and dialogue**. Map, summarise and navigate science and policy arguments underpinning the issues that people care about and collaborate with the development teams who are shaping these tools to meet the complex, systemic challenges of the 21st Century.
- develop a **comprehensive, distilled, visual map of the issues, evidence, arguments and options** facing the UN Climate Change Conference in Copenhagen, and being tackled by many other networks, which will be available for all to explore and enrich across the web.
- build a **definitive, public collective intelligence resource** on the climate change debate.

[4] `http://globalsensemaking.wik.is/ESSENCE`
[5] `http://www.globalsensemaking.net/`

– **support dialogue** that builds common ground, resolves conflict, and re-establishes trust

In May 2009, a kickoff workshop was held at the Knowledge Media Institute of the Open University in Milton Keynes, UK[6]. It was decided that a demonstrator will be built to show proof of concept of the usefulness of the argumentation mapping tools for helping make sense of the global climate change debate. These tools, however, will not be applied in isolation, but as part of a system of tools in a well-defined usage context. This socio-technical system is to provide a useful service to stakeholders involved in the debate.

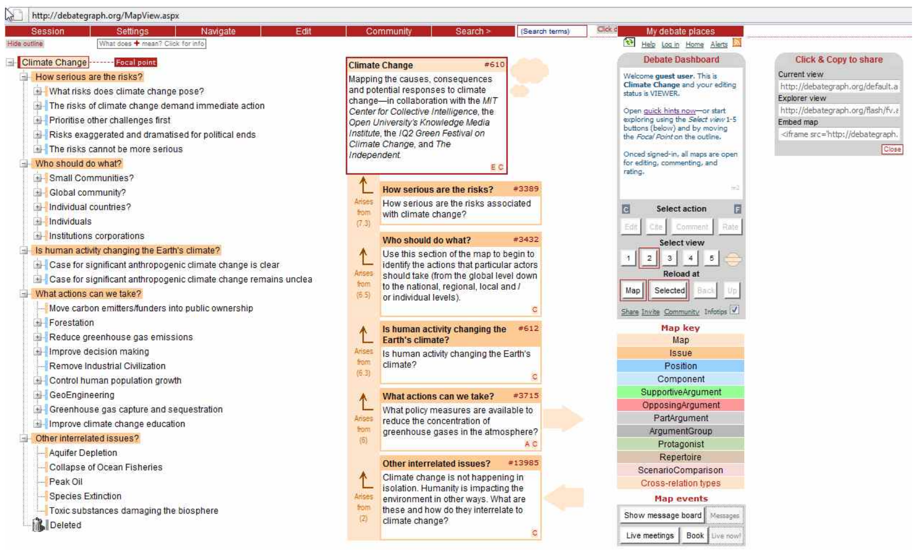

Fig. 2. The DebateGraph Climate Change argumentation map

To construct such a service, the initial focus is on the DebateGraph tool[7], as using this tool already quite a comprehensive map of the most important risks, causes, and effects is being produced[8], see Fig. 2. Furthermore, this map has already achieved considerable public visibility, as it has been embedded in the website of the UK quality newspaper The Independent [9] and as the DebateGraph tool has already been considered useful by the White House to map policy options relevant to the new U.S. administra-

[6] `http://globalsensemaking.wik.is/ESSENCE/EVENTS/ESSENCE09_Workshop`
[7] `http://debategraph.org/`
[8] `http://debategraph.org/default.aspx?sig=610-610-2-0`
[9] `http://www.independent.co.uk/environment/climate-change/mapping-the-contours-of-climate-change-1640886.html`

tion[10]. As such, the maps produced through this tool are prime candidates for exploring relevant argumentation mapping functionalities in a realistic context of creation and use.

2.2 Relevant Argument Map Generation: A Public Investigator Service

Assuming that using Debategraph, over time many climate change-related maps are being created. These would comprise the ”reference map” currently being hosted at Debategraph and a number of related maps of particular interest to specific stakeholders. For example, one could be created by a EU policy making institute, one by the US government, one by a network of corporations interested in investigation carbon credit schemes, and so on. To be interoperable to at least some extent, all of these maps could be manually linked to relevant nodes of the reference map. However, to truly realize the policy making potential of these maps, relevant views need to be defined for *map users*.

When generating these views, rather than interpreting the content of the nodes, we could automatically interpret the argumentation *structure*, which has a restricted, yet well-defined and powerful semantics. When defining this restricted semantics and the knowledge operations based on them, the focus would be on the stakeholders, as this is what interests policy makers: what are the relative positions of organizations X, Y, and Z on the web of issues, positions, and arguments?

To illustrate what we mean, we introduce a ”Public Investigator” service. Assume there is an investigative journalist who is interested in being kept up to date about controversial issues, which in our argumentation structure semantics could be defined as:

> “all the immediate *positions* on *issues* of which there is at least one *stakeholder* (”protagonist” in Debategraph terms) of a business-type that gives either a pro or a con *argument* and at least one *stakeholder* of the NGO-type who gives an *argument* with the _opposite_ *argument-relation* type (so, if the business stakeholder gives a pro-argument and the NGO-stakeholder a con-argument then we have a match, and thus a controversy, and vice versa).”

The resulting positions plus the relevant argumentation parts with their associated stakeholders could then be presented in a simple web page, with clickable links to supporting contact information and documentation. An example of an argument map that should match with this query is given in Fig. 3.

In the rest of the paper, we outline in broad strokes the theory behind and implementation of a service that could deliver such matches.

3 Using Conceptual Graphs to Analyze Argumentation Map Semantics

3.1 The IBIS formalism

At the core of our argumentation semantics is the Issue-Based Information Systems (IBIS) paradigm. The IBIS formalism [6, 8] has been reduced to practice by Jeff Con-

[10] `http://www.whitehouse.gov/blog/Open-Government-Brainstorm-Collaboration-in-Action/`

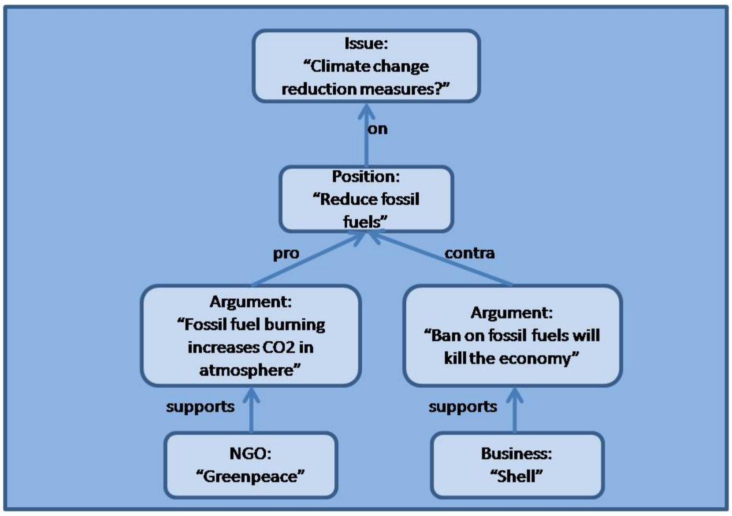

Fig. 3. An example of a matching argument map

klin [3]; a small ontology that defines node types and inter-node relationships is available and used in ESSENCE platforms such as Compendium[11], DebateGraph, and Deliberatorium[12]. The principal nodes of interest are as follows:

– *Map* - serves as an envelope that lends context to the other nodes, including map nodes.
– *Issue* - provides a container to ask a question and to explain the question with further details. These nodes can be answered by issue nodes that refine the question, or by Position nodes which provide answers.
– *Position* - provides a container to respond to a question with an answer, or to refine an earlier position.
– *Pro* Argument - a node that presents an argument that supports a position, together with details that explain the argument.
– *Con* Argument - a node that presents an argument that refutes a position, together with details that explain the argument.

The node types we present represent an IBIS ontology that has been found to be common among the three IBIS platforms mentioned above. Each platform is capable of providing other node types, some of which may enter the common ontology. For instance, a Reference node is useful in documenting a position or argument, though citations can presently be included in the details.

[11] `http://compendium.open.ac.uk/institute/`
[12] `http://18.36.1.44:8000/ci/login`

A typical IBIS conversation can begin with either an issue declaration, an opening question that sets the context for the remainder of the conversation, or the conversation can be opened with a topic for discussion, typically represented as a position node. An opening topic invites multiple issues to be raised. For instance, a conversation could begin with an issue such as "What is the role of carbon dioxide in climate change?", which defines a narrow context; a different conversation could simply begin by stating that "Climate Change" is the topic of the conversation, which would invite questions along the lines of causes, consequences, and so forth.

In a typical IBIS conversation in DebateGraph, IBIS statements take the form of short natural language sentences. The IBIS formalism adds context to those statements through the structure the conversation takes.

3.2 The CG formalism

Conceptual Graphs were introduced by Sowa (cf. [9, 10]) as a diagrammatic system of logic with the purpose "to express meaning in a form that is logically precise, humanly readable, and computationally tractable". In this paper we use the term "Conceptual Graphs" to denote the *family of formalisms* rooted in Sowa's work and then enriched and further developed with a graph-based approach in [2].

Conceptual Graphs encoded knowledge as graphs and thus can be visualized in a natural way:

- The vocabulary, which can be seen as a basic ontology, is composed of hierarchies of concepts and relations. These hierarchies can be visualized by their Hasse diagram, the usual way of drawing a partial order.
- All other kinds of knowledge are based on the representation of entities and their relationships. This representation is encoded by a labeled graph, with two kinds of nodes, respectively corresponding to entities and relations. Edges link an entity node to a relation node. These nodes are labeled by elements of the vocabulary.

The **vocabulary** is composed of two partially ordered sets: a set of concepts and a set of relations of any arity (the arity is the number of arguments of the relation). The partial order represents a specialization relation: $t' \leq t$ is read as "t' is a specialization of t". If t and t' are concepts, $t' \leq t$ means that "every instance of the concept t' is also an instance of the concept t". If t and t' are relations, then these relations have the same arity, say k, and $t' \leq t$ means that "if t' holds between k entities, then t also holds between these k entities").

A **basic graph** (BG) is a bipartite graph: one class of nodes, called *concept* nodes, represents entities and the other, called *relation* nodes represents relationships between these entities or properties of them. A concept node is labeled by a couple $t : m$ where t is a concept (and more generally, a list of concepts) and m is called the marker of this node: this marker is either the generic marker, denoted by $*$, if the node refers to an unspecified entity, otherwise this marker is a specific individual name. BGs are used to represent assertions called *facts*. They are also building blocks for more complex kinds of knowledge (such as rules, or nested graphs). In this paper we only detail rules as they are of direct interest to the framework we are proposing.

A **rule** expresses implicit knowledge of form "if *hypothesis* then *conclusion*", where hypothesis and conclusion are both basic graphs. Using such a rule consists of adding the conclusion graph (to some fact) when the hypothesis graph is present (in this fact). There is a one to one correspondence between some concept nodes of the hypothesis with concept nodes of the conclusion. Two nodes in correspondence refer to the same entity. These nodes are said to be *connection nodes*. The knowledge encoded in rules can be made explicit by applying the rules to specific facts.

These graphical objects are provided with a **semantics in first-order-logic**, defined by a mapping classically denoted by Φ in conceptual graphs [10]. First, a FOL language corresponding to the elements of a vocabulary $\mathcal{V}$ is defined: concepts are translated into unary predicates and relations of arity k into predicates of arity k. Individual names become constants. Then, a set of formulas $\Phi(\mathcal{V})$ is assigned to the vocabulary. These formulas translate the partial orders on concepts and relations: if t and t' are concepts, with $t' < t$, one has the formula $\forall x(t'(x) \rightarrow t(x))$; similarly, if r and r' are k-ary relations, with $r' < r$, one has the formula $\forall x_1 \ldots x_k(r'(x_1 \ldots x_k) \rightarrow r(x_1 \ldots x_k))$. A fact G is naturally translated into a positive, conjunctive and existentially closed formula $\Phi(G)$, with each concept node being translated into a variable or a constant: a new variable if it is a generic node, and otherwise the constant assigned to its individual marker. The logical formula assigned to a rule R is of form $\Phi(R) = \forall x_1 \ldots x_p \; ((hyp) \rightarrow \exists y_1 \ldots y_q \; (conc))$, where: hyp et $conc$ are conjunctions of atoms respectively translating the hypothesis and the conclusion, with the same variable being assigned to corresponding connection nodes; $x_1 \ldots x_p$ are the variables assigned to the concept nodes of the hypothesis; $y_1 \ldots y_q$ are the variables assigned to the concept nodes of the conclusion except for the connection nodes.

More importantly, first order logic subsumption can also be translated in a graphical operation: homomorphism. A homomorphism from G to H is a mapping between the node sets of G to the node sets of H, which preserves the adjacency between nodes of G and can decrease the node labels. If there is a homomorphism (say π) from G to H, we say that G *maps* to H (by π).

3.3 Linking IBIS and CGs

In this section we present the advantages of using Conceptual Graphs to complement the IBIS architecture. Intuitively speaking, the semantic network generated by IBIS does not differentiate amongst any of its nodes / relations. We will try to address this shortcoming by using Conceptual Graphs. However, this is not a trivial problem given the nature of "inference" (where by inference we mean making implicit facts explicit in the domain of interest) used by argumentation maps and by Conceptual Graphs.

Conceptual Graphs, in a first step, will provide a vocabulary for the types of nodes / relations of this semantic network. Indeed, what we propose is to organise the principal nodes of interest in a concept hierarchy as follows: the *Map, Issue, Position* and *Argument* nodes will be direct subconcepts of the node *Top*, while *Pro Argument* and *Con Argument* will be subconcepts of *Argument*. While debatably, on a first glance, this can only provide us with a quicker indexing method, these concept types will also be taken in consideration by relation signatures. For instance, the relation *argumentPro* will have *(Pro Argument, Position)* as signature. Furthermore, this pre order is easily extended with different types of concepts / relations as need may be. In the context of a specific domain the concept hierarchy will also be enriched with the different roles that the "actors" participating at the debate will play (e.g. non- profit organisation, company, etc.)

Second, the projection will provide us with a basic mechanism for performing reasoning. As already mentioned in the previous section we can search for:

> "all the immediate *positions* on *issues* of which there is at least one *stakeholder* ("protagonist" in Debategraph terms) of a business-type that gives either a pro or a con *argument* and at least one *stakeholder* of the NGO-type who gives an *argument* with the _opposite_ *argument-relation* type (so, if the business stakeholder gives a pro-argument and the NGO-stakeholder a con-argument then we have a match, and thus a controversy, and vice versa)."

Please note the use of "immediate" in the context of the previous query. The rationale for using "imediate" is the fact that if we have a long chain of arguments which are pro each other (p_1 *supports* p_2 ... *supports* p_n) we can deduce the transitive closure of all these arguments. This is no longer true for instance when the relation between arguments is *"contradicts"*. Moreover, if we have p_1 *supports* p_2 which *contradicts* p_3, or we p_1 *contradicts* p_2 which *supports* p_3 we cannot deduce anything using Conceptual Graphs projection either. However, potentially, all these arguments could be useful in the context of the query mentioned above. This is why, in a first step we will only address immediate positions on issues. Heuristics are to be developed that will integrate first order logic subsumption with argumentation scheme manipulation.

4 A Proposal for the ESSENCE Argumentation Map Generator

As already explained, a missing piece of the puzzle so far has been a sophisticated semantic analysis service within and across these maps. This service could be based on, for instance, the Debategraph node/link primitives and possibly (within bounds) an analysis of the content of such nodes. The LIRMM conceptual graphs tools, in particular the reasoning engine Cogitant[13], would be perfectly capable of doing this. The problem is that so far, no hosted web service is available for manipulating (representation and / or reasoning with) conceptual graphs, but this could be realized at a relatively short notice.

4.1 Objectives

What we envision is using:

1. Debategraph to host a collection of growing argumentation maps
2. A well-designed service in which these argumentation maps are created and used by relevant stakeholders such as policy makers
3. CG analysis to generate new maps (subsets of original maps) based on user queries

[13] Available at: `http://cogitant.sourceforge.net/`

4. The results of these queries to be presented in a useful (Web page) format so that users can benefit best from the results.

This could be operationalized by having Debategraph send a set of queries with relevant parts of its argument maps to the Cogitant engine. This CG engine would process those queries, and return the results to Debategraph, which could then render the new, customized maps that are partial views highly relevant to *particular* stakeholders. Depending on their preference, the stakeholders would never even know that CGs have been used to help generate relevant views on the knowledge contained in the potentially many and very large maps having been created. With CGs, it is possible to create the highly customized and relevant map views, which can then be displayed in various formats.

4.2 The Argumentation-Conceptual Graph Converter

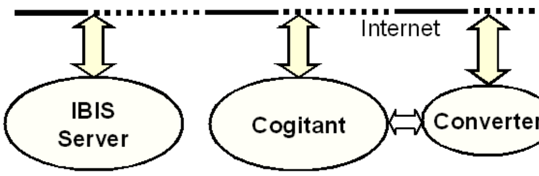

Fig. 4. IBIS Converter Extension to Cogitant

The prototype converter is planned to be a plug in agent for Cogitant as illustrated in Figure 4. In another ESSENCE-related project one of the authors is creating an IBIS serialization format that allows IBIS conversation platforms, including Compendium, DebateGraph, Deliberatorium, and Cohere from the Knowledge Media Institute's hypermedia discourse research [1], to share IBIS documents (conversations) with each other. It is that serialization format that will be read by the converter. The serialization format represents a subset of the XML Document Type Definition (DTD) used by Compendium. The serialized nodes are those listed in the Section above. All IBIS conversations persisted by the IBIS Server are thus available to the converter agent. The Converter serves as an agent to interact through Web services calls to the IBIS Server; fetching new IBIS conversations as they appear, and converting them to CG documents internal to Cogitant. The IBIS server provides an XML serialization that represents nodes and links from the IBIS conversation. As a simple example, a fragment of a serialization of the IBIS graph illustrated in the fragment below, where protagonist relations are modeled in the link structure:

```
<nodes>
<node id="1000" type="question" label="Climate change reduction measures?" />
<node id="1001" type="answer" label="Reduce fossil fuels" />
<node id="1002" type="pro" label="Fossil fuel burning increases CO2 in
 atmosphere" />
<node id="1003" type = "con" label="Ban on fossil fuels will kill the economy" />
<node id="1004" type="answer" label="NGO: Greenpeace" />
```

```
&lt;node id="1005" type="answer" label="Business: Shell" /&gt;
&lt;/nodes&gt;
&lt;links&gt;
<link id="2100" type="answers" label="Responds To" fromId="1001"
 toId="1000" />
<link id="2101" type="pro" label="Argues For" fromId="1002"
toId="1001" />
<link id="2102" type="con" label="Argues Against" fromId="1003"
toId="1001" />
<link id="2103" type="protagonist" label = "Supports" fromId="1004"
toId="1002" />
<link id="2104" type="protagonist" label="Supports" fromId="1005"
toId="1003" />
&lt;/links&gt;
```

Operational steps presume that the IBIS Server is aggregating IBIS conversations from a variety of sources:

- Cogitant, through its IBIS Converter, acquires IBIS conversations through Web services calls to IBIS Server, and builds a CG database from those maps. Conversations are acquired in the XML form as illustrated above, and are then mapped to conceptual graphs.
- Cogitant receives queries submitted by Web services calls to the IBIS Converter and processes them as described below in Section 4.2

4.3 The Argumentation Map Generator Service

The envisaged functionality for Cogitant is to act as a stand alone web service. Once this is accomplished the query obtained from the IBIS Web Server will be run against the knowledge base and relevant projections will be retrieved. From an expressivity view point the query answers will allow for the users to retrieve certain parts of the maps they are interested in. These projections will be mapped into relevant subsets of the IBIS map and then rendered, for example in Debategraph, to the user.

As mentioned before if we are searching for issues and positions which are not “immediate” one to another certain manipulations should be performed in order to integrate the argumentation scheme with first order logic subsumption. These heuristics will also be implemented at this level, leaving projection to act on its own as a basic CG operation.

5 Discussion and Conclusions

Argumentation maps are visual representations of argumentation structures, making it possible to efficiently examine the cumulative results of protracted, distributed, and complex argumentation processes. Argumentation mapping tools could play an important role in improving the quality of societal debate and policy making processes, for example in the key domain of climate change. By generating relevant views on large argumentation maps, stakeholders can be helped in making better sense of new issues, positions, and arguments that pertain to their interests. The ESSENCE project investigates how such systems of tools in realistic contexts of use can be applied.

Conceptual graphs tools can be instrumental in performing the semantic analysis and reasoning needed for producing such relevant argumentation maps out of large argumentation knowledge bases. To show proof of concept, we outlined an architecture of a Public Investigator service built on a combination of DebateGraph, an argumentation support tool, and Cogitant, a concepual graphs engine.

What we propose is only a small step on a long road of research and development. Some directions for improvement:

- In our example, we only used a few argumentation semantics primitives: maps, issues, positions, arguments, and stakeholders. However, there are many more primitives, some only supported by specific tools. By including richer sets of argumentation primitives, more advanced services can be developed.
- Most argumentation supprort focuses on a single map at a time. However, in realistic usage scenarios, hundreds or thousands of related maps may need to be combined. How to classify the maps and their linkages is still very much an open question.
- In this paper, we only looked at the semantics of the argumentation structure, considering the semantics of the node contents a black box. Using the meaning of these nodes as well, would allow for more advanced argumentation support services. However, the natural language processing issues involved are still daunting and would require much more research.
- Many argumentation support tools are often considered in isolation. Still, in the real world, such tools are parts of much larger tool systems, including wikis, blogs, and social network sites such as Facebook. We are still only at the beginning of understanding technical, semantic, and pragmatic interoperability issues of such tool systems in their many different usage contexts
- We gave an example of one possible service, a ”Public Investigator”-service. Many other (types of services) are conceivable. However, before we can implement these, basic argumentation semantics interoperability issues such as alluded to in this paper need to be resolved first.

Both argumentation mapping and conceptual structures tools are coming of age. The need for sophisticated semantics-based argumentation support is greater than ever with the many wicked problems threatening our global society. The ESSENCE project can be a testbed for their alignment and integration. We start with only one tool from each class, providing a relatively simple argumentation map generation service. In future work, this proof of concept will be expanded in many different directions. Through their combined forces, argumentation tools meeting semantic analysis tools can at last start delivering their fascinating potential on a very large scale.

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