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Proceedings of the 2nd International Conference on the

Pragmatic Web

"Building Common Ground on the Web"

Tilburg, The Netherlands, 22–23 October 2007

Editors:
Simon Buckingham Shum, Mikael Lind and Hans Weigand

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Proceedings of the 2nd International Conference on the Pragmatic Web

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From the Conference Chairs

Welcome to Tilburg, and to ICPW 2007!

We're delighted to welcome you to the *2nd International Conference on the Pragmatic Web*. Following last year's inaugural meeting, it is exciting to see continued interest in this fascinating concept.

At last year's conference, almost every speaker seemed to open with the words *"I'm not sure what the Pragmatic Web is, but here's my take on it…"* Clearly, the concept resonates in different ways with different people, and we will see an equally colourful spectrum of contributions over the next two days.

As an emergent community, clearly we are not running a mega-conference yet—but holding a small, inclusive and welcoming meeting that is not too hasty to reject unfamiliar ideas should be taken as a feature, not a bug! Balancing that, we were of course still concerned to maintain quality, so that engaging with the people and papers repays the effort. Out of the 20 full paper submissions received, the programme before you has 8 full papers, and 2 short papers, mostly reviewed by three or four people, and subsequently revised. We are indebted to our distinguished Programme Committee for their hard work to feed back to authors so constructively.

To this lineup, we are delighted to add our distinguished keynote speaker Wolfgang Prinz whose work in CSCW is well known, plus an invited talk from Adrian Paschke, chair of the 2007 RuleML conference, a potential sister community.

Working in cooperation with ACM SIGWEB (Hypermedia & The Web) and IFIP WG8.1 (Community Information Systems) serves to raise the profile of this event and makes the proceedings more accessible, so our thanks to them for their support.

As a nascent community, our task is to reflect on the shape of the Pragmatic Web vision.
For instance:

- Is there a coherent set of themes emerging?
- What are the missing frameworks or foundations?
- Are there key comunities whom we should aim to engage?
- How do we take our development to the next level?
- Are you interested to help make this happen?

In addition to the usual discussion time after presentations, the refreshments breaks and conference dinner, we have planned in a plenary session at the end of each day to bring us all together, when we encourage you to share your reflections and perhaps see new connections between the contributions. Fittingly, this will be a conference of conversational sensemaking!

We look forward to engaging with you,

Hans, Mikael & Simon

Hans Weigand Mikael Lind Simon Buckingham Shum

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Manuel Zacklad, Univ. de Technologie Troyes, France

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Tilburg University, Oct 22-23, 2007, Room TZ-3 (Building T)

Programme

Monday 22 Oct

09.00 Meet and Greet

09.30 **Welcome**!
Hans Weigand, Mikael Lind & Simon Buckingham Shum

09.45 **Sowing the Seeds of Self: A Socio-Pragmatic Penetration of the Web Artifact**
Pär Ågerfalk[1,2], Jonas Sjöström[1]
[1]Jönköping International Business School, Sweden
[2]University of Limerick, Ireland

10.30 **Exploring the Gap between Interaction and Institutional Orders in Pragmatic Web Design**
Mark Aakhus
Rutgers University, USA

11.15 Refreshments

11.45 **Rule Responder: RuleML-Based Agents for Distributed Collaboration on the Pragmatic Web** (Invited Paper)
Adrian Paschke[1], Harold Boley[2], Alexander Kozlenkov[3], Ben Craig[4]
[1]RulrML Inc., Canada
[2]National Research Council, Canada
[3]Betfair Ltd., London
[4]Univ. of New Brunswick, Canada

12.30 Lunch

14.00 **Keynote Address**
Wolfgang Prinz
Fraunhofer FIT, Germany

15.00 Refreshments

15.30 **DISCOURSIUM for Cooperative Examination of Information in the Context of the Pragmatic Web**
Fahri Yetim
Cologne University of Applied Sciences, Germany

16.15 **Logical Argument Mapping: A Cognitive-Change-based Method for Building Common Ground** (Short Paper)
Michael Hoffmann
Georgia Institute of Technology, USA

16.45 **Plenary Discussion: Reflections on Day 1**

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Tuesday 23 Oct

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Harry Delugach
University of Alabama in Huntsville, USA

09.45 **A Practical Method for Courseware Evaluation**
Aldo de Moor
CommunitySense, The Netherlands

10.30 Refreshments

11.00 **Towards Pragmatic Patterns for Clinical Knowledge Management**
Göran Falkman[1], Marie Gustafsson[1,3], Mats Jontell[2], Olof Torgersson [1,3]
[1]University of Skövde
[2]Göteborg University
[3]Chalmers University of Technology, Sweden

11.45 **Mind the Gap! Transcending Contextualized Knowledge Sharing**
Pieter de Leenheer and Stijn Christiaens
Vrije Universiteit Brussels, Belgium

12.30 Lunch

14.00 **A Pragmatic Structure for Research Articles**
Anita de Waard
Centre for Content and Knowledge Engineering, Utrecht University, The Netherlands

14.45 **Information Seeking in a "Socio-Semantic Web" Application** (Short Paper)
Jean-Pierre Cahier, L'Hédi Zaher, Manuel Zacklad
Université de Technologie de Troyes, France

15.15 Closing Plenary:
Reflections on the Conference and the Future of Pragmatic Web

16.00 Farewell drinks

Sowing the Seeds of Self: A Socio-Pragmatic Penetration of the Web Artefact

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ABSTRACT
This paper analyses the concept of the information technology artefact in a pragmatic web context with a special focus on its user interface. Assuming a communicative socio-pragmatic view of the use of Web artefacts, a distinction is made between explicit performance of essential communication actions and “give offs”; our sometimes unintentional traces left on the Web, which we may even be unaware of. It is argued that both aspects are key to understanding the role of IT artefacts and user interfaces in the Web context.

Categories and Subject Descriptors
H.1.2 [**Models and Principles**]: User/Machine Systems – *human factors*. H.4.3. [**Information Systems Applications**] Communications Applications – *Bulletin boards, Information browsers*. H.5.2 [**Information Interfaces and Presentation**]: User Interfaces – *Theory and methods*. H.5.3 [**Information Interfaces and Presentation**]: Group and Organization Interfaces - collaborative computing, theory and models, web-based interaction.

General Terms
Management, Design, Theory.

Keywords
Web 2.0, Open innovation, User interface, Web system, Identity.

1. INTRODUCTION
Undeniably, the way we use the Web has changed dramatically since its inception in the mid 1990’s. As users have changed from passive consumers of information to active contributors, much of the content on the Web today is the result of individuals’ knowledge sharing and exchange of ideas. O’Reilly [17] conceptualized this emerging information infrastructure and referred to it as Web 2.0; a term now widely used when describing the business models, tools and technologies that facilitate and leverage such global interaction and communication on the Internet. He suggests that network effects arising from user contributions are key to market dominance in the Web 2.0 era and that in order to be successful, companies must learn to trust users as co-developers. This insight is a key factor also in the success of the open source software movement, which has proved that communities of volunteer developers are even capable of threatening the dominance of some of the world’s leading software companies. Conforming to the old “if you can’t beat them, join them” mantra, many commercial organizations are also entering the open source arena in an effort to build active communities around their products [10]. A fundamental question in relation to the success of these emerging “gift cultures” [3] is what motivates people to contribute time and knowledge without any apparent payback, at least not in the immediate monetary sense. Lerner and Tirole [15] argue that the two major motivations are career concerns and ego gratification, which they collectively refer to as the signalling incentive. By contributing to a Web community, such as an open source project, people gain reputation and status within that community, which thus appears to be the main driving force. Interestingly, well before the coining of the term Web 2.0, Flores [11] analysed the emerging networked society and came to the conclusion that Web systems are primarily identity creating systems. Drawing on Heidegger’s identity concept, he suggests that identity requires “both an intense Kierkegaardian total commitment to some cause or person that discloses a new world for an individual and a Hegelian working out of that commitment so that others recognize that new world as making more sense than their former world, so that they see the individual who brought it about as a leader and that new world as their world.” [11, p. 364] According to Flores, this is central to both personal and corporate identity on the Web. A successful company has to show commitment and build strong corporate identity to attract people (i.e. visitors) and an individual has to commit fully to a community in order to build a strong personal identity, motivated by the signalling incentive. Hence, while personal identity is important to oneself, it is also important to others in order for them to recognize ones contributions. In a similar vein, personal identity is important to corporations in order to recognize their users and customers and to tailor their own Web presence, thus building their own identity. However, while identity and recognition is important on the Web, the flipside of the identity coin is that of personal integrity. Consider, for example, the following: Last year, a team within AOL released search data of more than 650,000 users. Although actual

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user names were replaced with random numbers, all the search terms of single users were possible to track and by using these search terms it was possible to track down an individual [2]. Apparently, No. 4417749 conducted hundreds of searches over a three-month period and eventually the data trail led to Thelma Arnold, a 62-year-old widow in Lilburn, GA, who confirmed the searches were indeed hers (Barbaro and Zeller, 2006). Shortly after this report, AOL removed the search data from its site and apologized for its release, but the detailed records continue to circulate online. The story does not tell whether or not Ms. Arnold benefited from her strengthened identity in this particular community. However, the example clearly illustrates that some of the traces we leave on the Web are less intentional and probably less ego gratifying.

According to Flores [11], the speech act theoretical insight that institutions are constituted by their commitment structures is essential to understanding identity creation on the Web. We can, for example, use these structures "to determine whether we are witnessing new institutions or just different versions of old ones" [11, p. 357]. Hence, actors' intentions and the way these are used to coordinate interaction with other actors are essential for identifying institutions, such as corporations, communities and individuals' on-line presence. However, a focus on intentions alone seems to limit our analysis of social interaction through information technology (IT) to what the actor is aware of and purposively chooses to do. This is also mirrored by Weber's account of social action, which identifies such action with behaviour to which the actor attaches meaning [22]. Arguably, it is hard to attach meaning to something of which one is unaware. In an ideal speech situation – the casual face-to-face setting [5] – two communicating parties rely on many subtle cues besides the spoken word. Body language and other "give offs" are central in our day-to-day interpretation of social life, and these are often unintentional. Goffman [12, p. 2] writes, "The expressiveness of the individual appears to involve two radically different kinds of sign activity: the expression that he gives, and the expression that he gives off". According to Goffman, what we give are the things we communicate through verbal signs, such as spoken language. The things we give off, on the other hand, are the often non-verbal signs that help to situate and verify the things we say. Goffman [12] defines interaction as "the reciprocal influence of individuals upon on another's actions when in one another's immediate physical presence." An interesting aspect of communication though IT artefacts, such as through the Web, is that this casual face-to-face setting changes into a more structured computer mediated one. In this new setting, participants are typically not in one another's immediate physical presence; they may in fact neither see nor hear each other, and may recognize each other's action at considerable delay [1]. In this context, there appears to be another form of "give off", the kind that made it possible to track down Ms. Arnold in Lilburn, GA.

The traces she left while using the search engine helped to situate and verify her identity to the extent that even though the AOL employees' intention was to anonymize the users, she was still very much identifiable. It thus seems that Dietz [7, 8] distinction between essential (realization independent) issues and their realization becomes central to understanding communication action on the Web. While the essential aspect of Ms. Arnold's actions was to find information, her incidental traces, or "technology embedded give offs", were essential in establishing her identity.

With this backdrop, this paper aims at deriving a conceptualization of the IT artefact from a communication action perspective, given the characteristics of Web applications in general, and Web 2.0 in particular. Such a conceptualization should be a useful analytical instrument in future evaluation and design efforts and can also serve as a tool for further elaboration on the role of the IT artefact in Web communication and community building. In a sense, our work can be seen as a response to Orlikowski and Iacono's call for theorizing the IT artefact [18], and particularly its role within the Web context. As a basis for this conceptualization, we use the work of Sjöström and Goldkuhl [20] which provides a sound foundation in pragmatic social action theory that has proven useful in empirical contexts [e.g. 19]

The paper proceeds as follows. Section two presents the conceptual foundation of IT artefacts and their user interfaces as instruments for social action and communication. Section three lays a foundation for our conceptualization of the Web artefact by summarizing the empirical part of the work. Finally, section four discusses the conceptualization of the IT artefact in terms of possible refinements of the initially presented conceptual foundation and presents overall conclusions and future outlook.

2. A SOCIO-PRAGMATIC VIEW OF THE IT ARTEFACT

Drawing primarily on the semiotics of Bühler [4], Sjöström and Goldkuhl [20] present a conceptualization of user interfaces that emphasizes communication between actors (Figure 1). The proposed socio-pragmatic user interface perspective has been operationalized in a number of studies of information systems [e.g. 19, 20] where it has proven useful for highlighting user interface problems. With its roots in language/action theory [23], the perspective embraces the view that information systems are instruments for technology mediated social action [13].

This communicative perspective on user interfaces is grounded in concepts from Semiotic Engineering [e.g. 6], which distinguishes between three types of communication in user interfaces: *User-system interaction*, *user-user interaction*, and *designer-to-user communication*. The user interface is here conceptualized as a "one-shot messages from designers to users about the range of messages users can exchange with the system in order to achieve certain effects" [6., p. 462]. The focus in Semiotic Engineering is thus on designer-to-user communication, and the other types of communication are primarily related to specific types of application, such as groupware.

The model in Figure 1 can be seen as a reaction to this view, holding that all user interfaces support creation and/or interpretation of messages that together form the communication between users and between users and designers. Sjöström and Goldkuhl suggest the term *pragmatic duality* to represent the dual function of user interfaces: The user simultaneously interacts with the artefact and other users through the creation and/or interpretation of representations [20]. The model thus captures the "essential" computer mediated actions among actors in the organization, as well as navigation actions performed by the user.

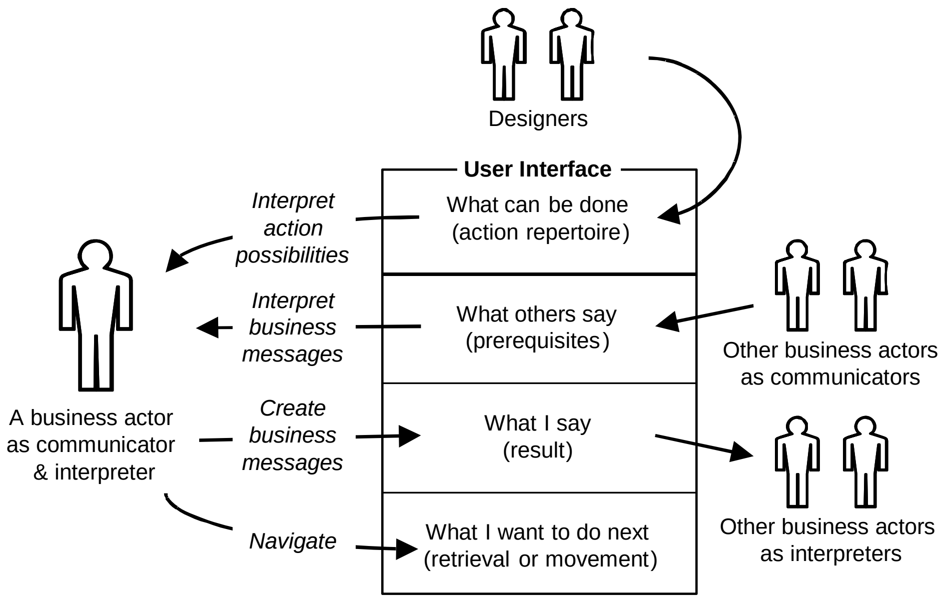

Figure 1 –A communicative perspective of user interfaces, after [20]

As indicated above, the proposed user interface model should be understood within a larger conceptualization of the IT artefact as an active instrument for communication. The IT artefact is here seen as both a medium for communication and as a mediator of human action. The latter implies that the artefact is seen to possess properties of agency. An IT artefact is not restricted to represent and transfer results of human action; it can also act semi-independently and transform such results into new messages and representations. We would not argue that an IT artefact possesses human attributes of intentionality and responsibility. It can, however, act as an agent on behalf of humans following pre-programmed rules [13]. It does also, as indicated above, contain a memory of previous action results and other prerequisites for action. This action memory and the agency aspect are two of the main characteristics that distinguish communication through IT artefacts from the use of passive media, such as telephone and traditional mail.

It is important to understand that the suggested way of conceiving user interfaces was developed in the context of traditional business supporting information systems. As we shall se below, to conceptualize communication action on the Web, the user interface model needs further elaboration.

3. THE AMAZON.COM CASE

In line with the discussion on give v. give off above, the distinction between what users purposively intends to do and the sometimes unintentional traces they leave behind, indicates a need to distinguish between different types of contextual information related to the performance of actions at Web pages. It has generally acknowledged that data is a valuable asset in the Web 2.0 philosophy [17] and that there are different types of data available: what users intentionally communicate to others and the traces of action that are gathered by the Web infrastructure as such (primarily through the content of HTTP requests and responses). Therefore, to understand Web communication we need to analyse both essential and incidental communication. In our study, essential communication action was manifested as screen documents and incidental communication action was collected and logged using a browser extension[1]. For this study, we chose the well-known web site Amazon.com since it embraces many characteristics of Web 2.0 [17].

3.1 Essential Action at Amazon.com

The perhaps most obvious essential action at Amazon.com is the purchasing of books. An interesting aspect of Amazon.com, however, is that it facilitates users' sharing of experiences and opinions about the various books on offer. In the following we will focus on this community-oriented activity. Specifically, we will focus on the *visible* results of user actions as represented by the Amazon.com website, as shown in Figures 2 and 3 below.

Figure 2 illustrates a review of a book, communicated by an anonymous user ("A reader"). Seven people have rated this review and unanimously stated that the review wasn't that helpful to them (perhaps as a result of its lack of argumentation).

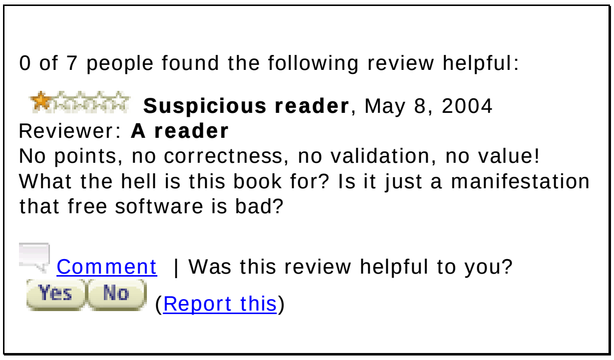

Figure 2 - An unknown user comments on a book by Feller and Fitzgerald [9] on Amazon.com

[1] The browser in use was Mozilla Firefox and the extention is called Live HTTP headers.

Figure 3 shows another review, provided by an individual who has chosen to identify himself as Mark Tarrani. It is even possible to follow the hyperlinked name and find additional information about this individual, including a personal photo. This person has apparently written many other reviews (hence the "Top 100 Reviewer" badge). 29 out of 30 people report they have been helped by the review, which thus signals that this reviewer is appreciated by the community. (It is perhaps not too far-fetched to assume that "A reader" was the one person out of the 30 who did not find Mike Tarrani's review very helpful.)

> 29 of 30 people found the following review helpful:
>
> **Balanced and business-focused**, March 26, 2002
>
> Reviewer: **Mike Tarrani "www.tarrani.com"** (Deltona, FL USA) - See all my reviews
>
> TOP 100 REVIEWER   REAL NAME   COMMUNITY FORUM 04
>
> This may be the perfect book about open source software because it places open source within the context of business value and does not promote it as the great panacea that characterize the message of far too many books on the subject.
>
> [...]

Figure 3 - An identified user comments on a book by Feller and Fitzgerald [9] on Amazon.com

3.2 Incidental Action at Amazon.com

The mechanism by which HTML (Hypertext Markup Language) pages are retrieved from a Web server for display by a browser is the HTTP (Hypertext Transfer Protocol) request command [21]. An HTTP request contains a certain amount of information sent when a used accesses a page on a web server. We expect that users of a Web application are aware of the parts of a message that are visible on the screen. If a user, for instance, writes a book review, they are probably aware that the entered information is communicated to someone through the browser, over the Internet, to a Web server. In addition to this visible part of the message, there are some "hidden" pieces of information added to the HTTP request, as defined in the HTTP standard [21]. This information is part of the communication context, and reveals some information about the user and the technology in use. There is not room to analyse an HTTP request in its entirety in this paper, but we will discuss a few parts of its content (an example request can be found as an appendix).

The request contains technical information such as the user's operating system (and version), the language in use, and the browser used and its version. Furthermore, the message contains the user's IP address[2], which can be used to identify the current user, at least indirectly. Using the Domain Name System, it is possible to map an IP address to a country, region, or even to a company and sometimes to an individual user. In addition, the HTTP request contains so-called "cookies". These are small pieces of information that are stored on the user's hard drive. Whenever a Web page in a certain domain is accessed through the browser, the browser sends the cookies associated with that domain to the web server. The web server then returns new (or changed) cookies, which the browser stores and sends again in the next request. Cookies are a common mechanism for maintaining state in longer transactions or for personalizing a context for a user [14]. Finally, the request contains information about "referring page" – if a user follows a hyperlink from site A to site B, site B is told that the visitor came from site A.

Consequently, we revealed quite a lot about ourselves when searching for a book on Amazon.com. We told them, not only that we were interested in the book by Feller and Fitzgerald [9], but that we were using English versions of Windows NT 5.1 and the web browser Firefox 1.5.0.11. We also told them that the search string "Fitzgerald Open Source" was entered from Amazon.com, and that we had visited the site before (a cookie was sent). Furthermore, we revealed our IP address, which in turn gives away that we were located at Jönköping University in Sweden at the time of the query.

Interestingly, when requesting the start page "http://www.amazon.com" a large number of HTTP requests are performed in the background (see Table 1). These requests would typically go unnoticed without the special analysis software. The anticipated requests (the page itself and the include files it needs to display properly) are marked with grey in Table 1 (next page). The other requests will be discussed below.

Requests #1, #4, and #7 are addressed to two different Google services: *Safe Browsing* and *Page Ranking*. These requests are sent by the Google Toolbar, a popular plug-in to the web browser. When installing this plug-in, the user is asked whether they want to activate these services or not. It is probably safe to assume, however, that many Internet users are, just as the authors were, unaware of the whereabouts of this plug-in. Effectively this means that every time a page is requested with this configuration, such requests are fully or partially forwarded to Google (possibly without the user knowing).

Requests #2 and #3 are the "essential" requests: The requests sent to retrieve the actual web page and its included files (e.g. images, style sheets and javascript includes).

Requests #5, #6, and #8 are sent to various (commercial) advertising services. The purpose of these appears to be to keep track of users' browsing across different Web sites. Krishnamurthy and Wills [14, p. 4] explain, "Cookies are also used by tracking servers to more accurately identify a user as the user navigates between different Web sites. If pages from these Web sites cause objects to be retrieved from the same tracking server and this server has a cookie associated with it then the server receives this cookie on each retrieval." Martin et al [16]

[2] Technically, the IP address is not part of the HTTP request but is communicated through the underlying TCP/IP protocol stack. Hence, all HTTP requests can be traced to a certain IP number.

Table 1 - Performed HTTP Requests when entering http://www.amazon.com using Firefox

#	Host	Explanation	Purpose	Performer	Agency
1	sb.google.com	The request is forwarded to Google's safe browsing service.	Verify host safety	Browser Plugin: Google toolbar	on behalf of user
2	www.amazon.com	The request to get a web page is sent to the Amazon web server.	Request action from server	Browser : User action	on behalf of user
3	[...]s-amazon.com	Request for images are sent to another Amazon web server.	Request images from server	Browser	on behalf of user
4	sb.google.com	Multiple requests are sent to Google's safe browsing service.	Verify host safety	Browser Plugin: Google toolbar	on behalf of user
5	[...]bleclick.net	A request is sent to some advertisment host.	Espionage	Browser: Webb application	on behalf of Amazon
6	[...]vertising.com	A request is sent to some advertisment host.	Espionage	Browser: Webb application	on behalf of Amazon
7	[...]eries.google.com	A request is sent to Google's page ranking service.	Contribute to page ranking	Browser Plugin: Google toolbar	on behalf of user
8	m1.2mdn.net	A request is sent to some advertisment host.	Espionage	Browser: Webb application	on behalf of Amazon

refer to such series of HTTP requests as "clickstreams", which can be used to, for example, maintain unique visitor counts, understand web usage patterns, assess the diffusion of advertisements, delivery of personalized offers, and general tailoring of web site content. Series of HTTP requests can thus be monitored through tracking cookies, which are stored, and used for various commercial purposes. It should be noted that there is information available about the use of cookies, both from Amazon and their partners in the advertising business. Also, the Google toolbar provides a reference to a privacy statement detailing what information is collected and what it is used for.

Apart from the recipients of the requests, it is also likely that there are additional logs of the requests, i.e. by the organisation responsible for providing access to the Internet.

4. DISCUSSION: A SOCIO-PRAGMATIC VIEW OF WEB ARTEFACTS

The Web artefact seems to have some characteristics that separate it from more conventional views of the IT artefact, i.e., in intra-organizational settings where users' tasks (as part of a pre-determined business process or similar form of institutionalized context) are often in focus. Based on the Amazon.com case we have identified four principles concerning the web artefact's communicative and agency characteristics, with consequences for the conceptualization of the IT artefact as presented in Section 2.

First, navigation actions needs to be recognized as user-to-user communication. Even though the primary intention of the user may not be to communicate, there are many recipients of the "message" or request that is sent to the Web server when a user requests a new page. In the technical implementation of HTTP requests, there is no differentiation between "navigation" and other types of action. On the social side, however, there are many parties apparently interested in the moves we make on the Web. Thus, we need to take into account the communicative dimension of navigation on the Internet. This way, our conceptualization allows for future studies where, for instance, social or ethical issues of the Web can be addressed. We refer to this as the principle of "communicative navigation".

Second, in a web context, we need to handle users primary intentions and the more or less incidental representations that are the results of user actions. The incidental representations – the "technological give offs" – are put in place by commercial actors as instruments for positioning themselves or their partners. While O'Reilly [17] speaks of data as the next "Intel Inside", this commercial interest in information about people as a vehicle to position themselves is also a part of building a corporate identity 11]. Flores' analysis of the identity concept also explains the behaviour of people who actively share their opinions or experiences on the web. Take, for instance, the case of the identified reviewer on Amazon.com, Mike Tarrani. Apparently, his actions as a reviewer is an endeavour connected to the institution of identity. The Amazon.com web site can be explained as an instrument, which is used by parts of the user community to create and maintain their identity. From a commercial perspective, this information, contributed by the users, enhance the commercial value of Amazon.com and their services, in line with the Web 2.0 ethos. There appears to be huge incentives for individuals and companies to create and collect data in these continuously ongoing communication processes, supported by the great number of Web applications that are out there. We would argue that any useful conceptualization of the Web artefact needs to take into account these communicatively oriented issues related to people, corporations, and the Web as an arena for identity building activities. People sow seeds of themselves when acting on the Web. The Web then has to provide a fertile ground for growing these into a total commitment to some cause that can disclose a new world for an individual and a working out of that commitment so that others recognize that new world as making more sense than their former world, to paraphrase Flores [11] as cited above. In other words, the traces of action that we leave behind, essential *and* incidental, are the foundation for our Web identity. In order to leverage the signalling incentive, Web sites then need to provide users with instruments to develop a proper understanding of the ongoing conversations and their contribution to the development of their own identity. We refer to this as the principle of "identity cultivation".

Third, there is a risk that many users install plugins such as Google Toolbar, and activate features such as "safe browsing" and "page ranking" without actually understanding the consequences with respect to communication and privacy. This can be regarded as an unreflective delegation of tasks to the IT artefact, which is unlikely to occur when communicating through some other medium. Therefore, issues of delegating actions to the IT artefact, and the ways in which such delegation is presented by designers and conceived by users, is an increasingly important issue from an ethical standpoint. This is also related to the more or less hidden communication taking place in the background in our case study, as a result of commercial interests. The scattered information about privacy policies raises the question if the users are really aware of the ongoing communication, which can be thought of as a type of surveillance of web site visitors [16]. We refer to this as the principle of "reflective delegation".

Fourth, in relation to the distinction between essential and incidental action, it seems that some features of an IT system are configured once and then used for a long time. Over this period of use, the awareness of the particular configuration may fade. For example, consider the case of the Google Toolbar plugin. A user may have had an understanding of, and an intention to actually share their surfing behaviour with Google. However, it appears this intention will become weaker or forgotten as time passes by. In a sense, then, the essential action changes into an incidental one. We refer to this as the principle of "maintained intentionality".

5. CONCLUSION

The aim of this paper was to derive a conceptualization of the IT artefact from a communication action perspective, given the characteristics of Web applications in general, and Web 2.0 in particular. Through a case study of Amazon.com we have identified four principles with consequences for the conceptualization of the IT artefact as presented in Section 2.

The *principle of communicative navigation* tells us that there are always "technological give offs" when performing navigation actions in a Web setting. Based on this, we conclude that it is necessary to recognise navigation actions as communication actions with social consequences.

The *principle of identity cultivation* emphasizes the role of web applications as instruments for identity creation and cultivation. The strive for recognition in some community motivates users' seemingly altruistically co-contributing through "essential actions". In the quest for strong corporate identity, "Web 2.0 aware" companies such as Amazon.com build their services around user engagement. This attracts people to their web site, and engages them in the co-development of the site, which in turn gives Amazon.com a strong corporate identity. Their strong identity and large number of committed visitors also leverages Amazon.com as a platform for third parties to build their identity through personalized advertisements. This has an impact on our view of the web artefact: we need to acknowledge multiple interests and the implications for gathering and storing information about both essential actions and give offs.

The *principle of reflective delegation* holds that users sometimes unknowingly delegate communicatively oriented tasks to the IT artefact. The problem may stem from the multiple interests mentioned above – there are no apparent reasons to excessively inform users beyond legal requirements. Although the importance of acknowledging responsibilities in relation to the agency of IT artefacts has been stressed previously [1], the multiple interests and "ecological growth" of Web communities suggest that this is particularly important to consider in a Web context.

The *principle of maintained intentionality* suggests that although users may initially be aware of their action responsibilities and commitments, this awareness may eventually fade. Clearly, understanding such dynamics has to be taken into account when analysing communication action on the Web where parts of the communication is "hidden" in the infrastructure. Also, Web artefacts should be designed as to support the maintaining of intentional awareness.

6. ACKNOWLEDGMENTS

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APPENDIX: HTTP REQUEST AND RESPONSE HEADERS WHEN SEARCH FOR A BOOK AT AMAZON.COM

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http://www.amazon.com/s/ref=nb_ss_gw/002-6061363-2284806?url=search-alias%3Daps&field-
     keywords=Fitzgerald+Open+Source&Go.x=0&Go.y=0&Go=Go

GET /s/ref=nb_ss_gw/002-6061363-2284806?url=search-alias%3Daps&field-
     keywords=Fitzgerald+Open+Source&Go.x=0&Go.y=0&Go=Go HTTP/1.1
Host: www.amazon.com
User-Agent: Mozilla/5.0 (Windows; U; Windows NT 5.1; en-US; rv:1.8.1.3) Gecko/20070309 Firefox/2.0.0.3
Accept: text/xml,application/xml,application/xhtml+xml,text/html;q=0.9,text/plain;q=0.8,image/png,*/*;q=0.5
Accept-Language: en-us,en;q=0.5
Accept-Encoding: gzip,deflate
Accept-Charset: ISO-8859-1,utf-8;q=0.7,*;q=0.7
Keep-Alive: 300
Connection: keep-alive
Referer: http://www.amazon.com/
Cookie: session-id-time=1179817200l; session-id=002-6061363-2284806; ubid-main=104-1608502-5738317

HTTP/1.x 200 OK
Date: Tue, 15 May 2007 12:53:56 GMT
Server: Server
x-amz-id-1: 0TEF1VDYTCHV9EFAAA7J
x-amz-id-2: DytYOW9qtroJ1dEMV6eqUoj0nU6+DXKW
Set-Cookie: session-
     token=G9qQ3EnFgLKORm3b72bAxDLMoOu8yLH/huNZIyoySaZWSX5/7jUqIVpq5F3kaWErff7HRI/Q6al86tflHcVobYxfanaAr+M1C
     RxmQPARk6uRaarF+n+O0nFIlD4bfWZCo9xfrbj7U2RG47MPXXDkH1to6bZs/OtThs7LawcHaziiEhFPoeR/2MrnRk4GRWewyh3fX0uF
     m0U=; path=/; domain=.amazon.com; expires=Tue May 15 13:03:56 2007 GMT
Vary: Accept-Encoding,User-Agent
Content-Encoding: gzip
Content-Type: text/html; charset=ISO-8859-1
Cneonction: close
Transfer-Encoding: chunked
```

Exploring the gap between interaction and institutional orders in Pragmatic Web design

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ABSTRACT
This paper explores the call to attend to the communication pragmatics of the pragmatic web by examining instances of institutional talk and internet based support for deliberative communication. The examples map the terrain between the intentional design of communication support and the tacit, often unintentional aspects of communication that shape what is made explicit. Even though there is ever more designed support for communication and increasing capacity to design support, the tacit dimension of communication still plays a role in how people formulate moves in web-based interaction and in what becomes explicit in online interaction. These moves may have subtle but profound consequences for the discourse that emerges from designs intended to augment interaction and reasoning.

Categories and Subject Descriptors
H.4.1 [Office Automation] – groupware; H.4.2 [Types of Systems] – decision support; H.4.3 [Communication Applications] – computer conferencing; H.5.3 [Group and Organization Interfaces] – collaborative computing, theory and models, web-based interaction

General Terms
Management, Design, Human Factors

Keywords
Communication Support, Tacit Communication, Interaction, Deliberation, Discourse, Articulation.

1. INTRODUCTION
In many aspects of life, such as ordinary conversation, conjuring up and sustaining interaction is an end in and of itself. Even the public sphere can have this type of freewheeling quality where the point is to carry on the conversation. As Goffman [3] puts it, conversation is like starting a fire that once started will burn anything put into it. The Pragmatic Web community is not, for the most part, interested in open ended conversation-for-conversation's sake type interaction. Instead, the interest is in conjuring up and sustaining forms of interactivity that achieve certain states of existence among participants (e.g., being understood, collaborative, legitimate, knowledgeable, entertained) and that produce particular intellectual, symbolic, and material products (e.g., ontologies, plans, agreements, decisions, policies, contracts). This reflects a concern for institutional orders moreso than the interaction order [4, 5].

The Pragmatic Web community aims to improve "the quality and legitimacy of collaborative, goal oriented discourses in communities" through the design and use of web-based technology [13]. What distinguishes the pragmatic web movement from the semantic web movement is an orientation toward process and context over data; services as agents in a rich system of interaction not simply distributed objects; grass roots meaning negotiation among community members; and the negotiation of commitments [9, 11, 13, 14]. It is a quest to understand and develop what Douglas Engelbart refers to as the augmentation of interaction and reasoning.

Schoop, de Moor, and Dietz [13] illustrate the interest of the pragmatic web community with the example of an architect responsible for building a low-energy house. The architect must work with several trades to complete the task and in so doing the members of this emergent community negotiate meaning and coordinate action. To do this the community must take into account the tacit, non-formalizable aspects of the social context. This example is characteristic of contemporary organizational and societal contexts where different professional, social, and cultural backgrounds need to work out what they can assume to be the shared background and commitments necessary to sustain their joint activity. The practical challenge for the pragmatic web community is to build socio-technical infrastructure that supports the negotiation of meaning and the coordination of action. Underpinning this practical challenge are the yet to be examined assumptions about the relationship between the tacit dimensions of communication and the dimensions of communication made explicit by technology (and by the participants themselves).

A fundamental challenge, and opportunity, for the pragmatic web community is found in the fact that discourse typically takes a life of its own. Goffman [4,5] shows how interaction is an order unto itself that serves its own ends and is not easily tamed by institutional orders. Interestingly, the Pragmatic Web marks off an arena of activity interested in disciplining and shaping the interaction order, which presupposes some understanding of communication pragmatics in web based environments.

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This paper explores the call to attend to the communication pragmatics of the Pragmatic Web by examining how the tacit, unexpressed dimensions of interaction matter for web-enabled communication. The paper does not present abstract models or stylized presentations of systems but instead works from detailed examples. First, examples from institutional forms of talk, airline crew interaction and dispute mediation, are discussed to illustrate how the tacit dimension of communication matters in institutional settings designed to support deliberation and decision-making. Second, examples from internet-based interaction that use threaded discussion and chat to support deliberation are discussed to illustrate how the tacit dimension of communication matters in ways similar to the problems identified for institutional talk. Third, an example from a web-based online discussion forum designed to support reflective dialogue is discussed. These examples sketch how relational, actional, and clashing interactional expectations – tacit dimensions of interaction – shape, often in unintended ways, the discourse participants produce when interacting through institutional formats designed to augment their interaction and reasoning.

2. Institutional Interaction

Institutional forms of talk are designed to achieve particular purposes. Institutional interaction can be characterized by its goal orientation for interaction, constraints on interaction, and preferred patterns for reasoning and inference making through interaction [3]. The attempts to shape and discipline ordinary interaction through information devices, formal roles, turn-taking procedures and so on in institutional forms of talk such as found in airline cockpits and dispute mediation provide a place to begin inquiring into the ways in which the tacit dimension of interaction plays a role in what is communicatively taken up, or not, in the interaction among the parties involved.

2.1 Airline Crew Indirectness

Despite the rich information environment of the airline cockpit and the structure of airline crews, the research by Linde [7] illustrates how these highly designed environments intended to support decision-making communication remain subject to the tacit dimensions of communication. Linde examined recordings of the cockpit interaction among airline crews in the context of real and simulated airliner crashes. In an early case study of an airline crash where 69 people perished and five survived, Linde found the copilot's attempts to point out errors in the pilot's judgment about takeoff readiness were not taken up by the captain. One reason for this may be that the co-pilot's warnings were formulated indirectly, as seen in the following examples [15]:

(1)
Copilot: Look how the ice is just hanging on his, ah, back, back there, see that?
Captain: Side there

(2)
Copilot: See all those icicles on the back there and everything?
Captain: Yeah.

(3)
Copilot: Boy, this is a, this is a losing battle here on trying to de-ice those things, it (gives) you a false feeling of security, that's all that does.

(4)
Copilot: Let's check these tops again since we been setting here awhile.
Captain: I think we get to go here in a minute.

(5)
Copilot: That don't seem right, does it? (3 second pause). Ah, that's not right. (2 second-pause) (Well). . .
Captain: Yes, it is, there's eighty.
Copilot: Naw, I don't think that's right. (7 second pause). Ah, maybe it is.
Captain: Hundred and twenty.
Copilot: I don't know

The airliner crashed but not for lack of the copilot calling attention to problems such as the weather and ice build-up on the other planes. Upon further examination of other cockpit recordings made during actual crashes and flight simulator training, Linde found that indirectness was prevalent when copilots spoke to captains. Indirection, such as seen in this case, can make it easier for someone to misunderstand or to ignore what another person is saying. This finding suggests a clear remedy – be direct. It would seem that had the copilot been more direct in representing his sense of the situation to the captain the situation and doubts of the copilot would have been more available for the captain to act accordingly.

Linde examined the merits of the directness remedy and came up with some surprising results. She found that (1) people from different parts of North America recognized and interpreted indirectness differently; (2) there are ways of making requests that are technically indirect but that pilots treated as direct; and, perhaps most surprising, (3) that crews classified as highest in safety performance had higher rates of indirectness in their cockpit communication. The directness remedy misses how communication is multifunctional. Any communicative move may perform a representation of some aspect of the world while at the same time adapting to or extending in some way the relationship among the participants. In the case of the crews, the issue is not simply about communicating the most direct representation of the world but also situating a move within the ongoing relational expectations of the crew and the ongoing context of activity. Thus, any training in directness, as Linde suggests, would have to involve teaching subordinates to respectfully and successfully challenge superiors.

The cockpit communication case illustrates how the problems in the institutional order of the cockpit arise in the uptake of requests and challenges. These errors in deliberation and decision-making are interactional achievements that occur despite the shaping of the context to augment interaction and reasoning. The tacit dimension of communication seems to be the central source of the decision-making troubles more than the semantics. In particular, the trouble interactants have in formulating a new line of interaction rather than staying in the 'programmed' line of interaction.

2.2 Relevance and Digression in Dispute Mediation

Dispute mediation is another type of institutionalized format for interaction that provides special procedures and roles so that disputing parties can amicably resolve their differences of opinion. Jacobs and Jackson [6] have examined transcripts of divorce mediation sessions where formerly married spouses attempt to renegotiate aspects of their divorce decrees regarding the care of their children. Jacobs and Jackson note that these interactions often digress from the purpose of working out an acceptable custody proposal. In so doing, the potential for argumentation to resolve their differences and work out an agreement is lost. Digressions are collaborative achievements of the disputants that occur even though the resources of mediation are present. This can be seen in the example that follows:

(6) An example of digression in custody negotiation from Jacobs & Jackson (1992). The brackets indicate overlapping talk, the equal sign indicates contiguous talk, the single parentheses indicate inaudible or hard to distinguish words, and double parentheses indicate transcription notes.

398 W: I still have my basic feelings, that maybe at some point, something like this could be worked out
but I don't, feel at this time
399 H: [Isn't this kind of a method, uh I-aren't you basic feelings ((Pause)) basically trying to punish
me, as opposed to what the children ((Pause)) (that's all)
400 W: [No it's not not trying to punish] you ((Pause)) I am not trying to punish you at all I, think you, I'd be punishing myself by going with something like this at this time=
401H: =why
402 W: Number one I know your involvement with the children ((Pause)) and how you have stated in the past you would be involved and you would do certain things and then you do not
403 H: Like what
404 W: Like homework schoolwork ((Pause)) Also too, I do not feel that you're mentally stable at this point in your life
405 H: I don't feel you're mentally stable either
406 W: Okay ((Pause)) um, so maybe we should go for the psychiatric examinations ((Pause)) I'm more inclined to do that I've asked John to go to counseling for years, and he's refused *I* have been in counseling
407 H: Vivian I recommended a marriage counselor and (you said no) and your attititude was you didn't want
to go it was a waste of time
408 W: [Not at that time, not at that
point I didn't want the marriage
409 H: [When we] went to marriage counsel on our first separation and he said a few negative things to you, you, immediately dropped out.
410 W: We didn't go to a marriage counselor
411 H: [Yes we did]
412 W: Who
413 H: In fact it was even he was our psychiatrist he, wanted to talk to us about marriage counseling=
414 W: =No, we went to Dr. H( ) for Michael
415 H: [That's not what I'm talking about, I'm talking about I'm talking about the, psychiatrist on ( ) Boulevard, who we went to, on two occasions and you just said, I don't agree with what this guy is saying so we're not going back
416 W: [Oh okay] I know who you're talking about sure
417 H: Okay
418 W: Then, I went to a different one, and I wanted to go to=
419 H: [( )]
420 W: =a different one
421 H: [Yeah] because he didn't agree with you that' why you didn't want to go there, that's the whole problem=
422 W:=No, no I've got other feedback from other people
423 H: [How about Dr. (Frankel)]
424 W: How 'bout Dr. Frankel
425 H: [We stopped] going to Dr. Frankel because you didn't like what he was saying to us
426 W: John, we, you were the one who stopped going, you were the one who said that we should stop., Michael from going to Dr. Frankel because you saw no progress being made
427 H: That's right, I saw no progress being made but you didn't want to go to him because he started asking about your background and you thought that was irrelevant
428 W: No I didn't

This segment of discussion between the ex-husband and ex-wife begins (lines 398-406) with each making moves that appear to address the relevant issue of parental competence in regard to the custody proposal at hand. While morally tinged, each move also brings information to bear on the question of the custody negotiation by making and contesting plausible arguments about the other's parental involvement and stability. The discussion begins to shift at about line 407 when they begin making accusations and complaints about who had recommended and who had resisted therapy and counselling in the past. At about line 415 the discussion is fully an exchange of criticism, accusations, and complaints about each other's past behaviour in regard to attempts at marriage counselling.

Jacobs and Jackson point out that the argumentative potential of what is said is realized through the relationship between information relevance, which is the bearing of information on deciding the acceptability of some proposition, and pragmatic relevance, which is the "use of information to justify or refute a contested standpoint." The digression in example 6, and digressions in general, happen because participants' moves often do not bear on the issues at hand (i.e., lack information relevance) but also because the moves refocus attention away from the argumentative potential of the move and toward some other potential [6]. Whatever argumentation takes place in example 6, takes place indirectly as the parties are not making arguments so much as they are making complaints, accusations, and criticisms. The digression happens because the argumentative potential of these moves is not drawn out but abandoned.

Digressions happen in custody negotiations due to the use of otherwise relevant information in argumentatively unproductive ways and to superfluous defense. These types of pragmatic irrelevance are generally "a *collaborative* failure, a problem produced jointly by the expressive choices of one party and the responsive choices of another" [6]. As Jacobs and Jackson point out, the problem with irrelevant moves is not so much that they somehow distort the way individuals' reason but that such moves create possibilities for others to take up what was said in unproductive ways. Moreover, problems for argumentation do not arise simply due to the way information is framed but from how others respond to the framing of information.

Sections 2.1 and 2.2 point out how two aspects of the tacit dimension of communication, the relational and the actional, shape interaction over and above the institutional aims for interaction. Despite an intensive information environment, the pilots' attention to the relational shaped the possibilities for expressing and managing differences of opinion in cockpit decision-making. Despite procedures and specialized roles, the disputants' responses abandoned development of the argumentative potential of their contributions for resolving differences and instead expanded the conflict potential of their contributions.

3. Technological Support for Deliberation

In this section, attention is turned to the relation between the tacit dimension of communication and web based interaction. Internet-based technologies for interaction, such as threaded discussion and chat are meant to be generic tools for communication support that presumably leave the articulation of communicative possibilities to the ad hoc improvisation of the participants. The technological design, however, highlights some aspects of making a move in an interaction while leaving other aspects unmarked in the way the technology reflects choices about roles, turns, types of turns, goals and such matters related to the interaction to be supported. Thus, like other forms of institutional talk internet-based technologies make visible goals for interaction, constraints, and particular ways of drawing inferences about participation [3]. The examples that follow examine problems that arise for designs intended to augment human interaction and reasoning in deliberation about important public matters. The examples illustrate a clash between the institution for talk and the type of talk the community of users pursues. The clash resembles the problems the relational and the actional dimensions of communication raised for institutional formats. And, as foreshadowed by the examples in section 2, the examples of threaded-discussion and chat that follow begin to shed light on how clashes between designed affordances and community use can have invisible, unanticipated, and possibly perverse effects for discourse quality from technological interventions.

3.1 Threaded Discussion and Community Sense-Making

Aakhus [2] examined an episode of online discussion following a national broadcast of an investigative news story in 1999. (At this time, news organizations were first linking news broadcasts with internet-based support for further exploring the news story.) The online discussion was conducted via a threaded discussion forum. The discussion occurred in an information rich environment. The transcript of the story was posted along with other information and links to related sources. This setup would seem supportive of a vibrant public deliberation.

After the broadcast of the story, the first 111 messages posted to the website during the first 24 hours following the broadcast were primarily criticizing and complaining about the quality of the investigative report (see table 1). For the most part, the contributions were against the story. The news organization's 2 contributions occurred 24 hours after the threaded discussion began and warned people not to post advertisements or phone numbers. This is contrary to what would be expected if the web-based interaction were being used as a means for the audience to engage the shows producers.

The analysis of the online discussion suggests that there were differing expectations about the relationship between the news organization and the viewing audience. The viewing audience that participated in the threaded discussion appear to be pursuing the online dialogue as though the news organization would respond. In addition, there were differing expectations about the form of interactivity. The viewing audience was treating the online forum as an opportunity for debate but the threaded discussion treated the interaction more like a quarrel among the masses. The upshot was that there was no engagement between the viewers and the story creators despite many features of the story and challenges that could easily be refuted or turned into an opportunity to advance the argument of the news story.

Table 1: Message Type

Message Type	Number For	Against	Example
Supportive by thanks or by acknowledging report's truth value	5		Thanks for this interesting report. Although, I don't plan to stop using my cellular phone, I appreciate your explaining how to use it more safely.
Questions seeking clarification of report or its implications	10		So, you move the phone away from your head. You are not getting the maximum risk of radiation but, what about the cell phone emitting radiation to other parts of your body…while it is in your pants pocket, your purse, sitting next to you on the car seat? Should this also be a consideration? Other than giving up the use of our phones, is there a way to avoid this potential hazard?
Challenge report's conclusion or implications		42	Come on…the "cell phones cause cancer" thing a-GAIN? Get real. If two-way radios caused cancer I think we'd see an increase in the incidence among emergency service workers, who have been using higher powered two-way radios in these frequencies for decades. Your microwave oven is legally allowed to LEAK about 30,000 times the energy it takes to power a cell phone.
Replies to others that support the reporting of the news	13		I sort of agree and disagree with this posting. You can only cover so much on the television. TV is not the media for extensive coverage. A better choice is to ask Consumer Reports to do a thorough study of all wireless devices, such as remote controls, pagers, Palm VII, GPS, cordless phones, cellular phones, walkie-talkies, etc., to see what effect they have on human biology. Perhaps a new standard will be developed to not just apply to Cellular phones, but to all wireless devices that transmit and receive data.
Replies to others challenge the report		41	I guess the "news" industry had to go Hollywood to pay the "reporters" the salaries they demand these days. A favorite quote of mine that perhaps the powers that be should heed is "your standards are a reflection of what you allow" it is clear to me that abc standards are not worth the paper they are printed on. What a shame!
	28 For	83 Against	

3.2 Internet Chat and Argument

Weger and Aakhus [17] examined chat room interaction about public issues. While many commentators complain about the state of argumentation in online environments, Weger and Aakhus chose to focus on how the design features of chat rooms contributed to discourse quality. They found that there is a lack of conversational coherence, under-developed arguments and flaming. The features of chat rooms – continuous scrolling transcripts, contribution limits, and unidentified participants – contribute to these conditions and appear to afford a form of interactivity organized around having-arguments rather than making-arguments. Thus, at least from the perspective of argumentation ideals there appears to be no argument happening in Internet chat. The interaction bears a resemblance to digressions in divorce custody.

It should be noted that Chat turn taking resembled something more like the several conversations that take place at holiday dinner tables or parties where people are focused on being together but not necessarily on sustaining one line of conversation for the group. However, at these occasions the group can quickly organize itself around one line of conversation and then back to several conversations. Indeed, in the chat interactions participants had worked out ways of attending to particular lines of "conversation" amidst all the "chatter." A common strategy was to begin each turn with the name of the person being addressed.

In the following example (7), taken from [17], the interaction between two participants was carried on in the midst of chat room chatter and is here represented as only their turns not all the turns in the chat. The two have been arguing about the legality of Linda Tripp's taping phone conversations with Monica Lewinski regarding Lewinski's illicit affair with U.S. President Bill Clinton.

(7) Chat Transcript taken from Weger and Aakhus (2003).

01 Insolente: AUB…YOU SAID that she did not know she was breaking the law and that's why she leaked the
02 Insolente: the tapes
03 AUBldr: INSOL….nope, not once…
04 Insolente: AUB…I'm tired for your moronic laugh
05 Insolente: Oh really AUB? What did you say then?
06 Insolente: AUB..why are you lying?
07 Insolente: AUB.. what did you really say AUB?
08 AUBldr: INSOL….I said in many states only 1 person has to know tapes are being made, thats all..
09 Insolente: I gotta hear this one
10 Insolente: AUB..Meaning what?

11 AUBldr: INSOL…but apparently you still can't read…
12 Insolente: AUB…That she thought she was cleared?
13 AUBldr: INSOL….Nope…
14 Insolente: AUB..What do you mean by that?
15 Insolente: AUB..what is the point you are trying to make?
16 AUBldr: INSOL…How many things can that mean?
17 Insolente: If any?
18 Insolente: AUB…Is this how you do this?
19 AUBldr: INSOL…you are too childish to debate with ….shoo…
20 Insolente: AUB…Your reasoning means shit so you don't answer direct questions?
21 Insolente: AUB…Shoo?
22 Insolente: LMAO
23 AUBldr: INSOL…lol shoo
24 Insolente: AUB…Is this how you do this>?
25 AUBldr: INSOL…child

This example ends with an exchange of ad hominem attacks. In contrast to standard explanations of flaming as errors in reasoning and misuses of emotion, the emergence of flaming – in the form of ad hominem – by Insolente and AUBldr appears to result at least in part from mutual efforts to exert norms of a good argumentation. Indeed, ad hominem arguments often take place to force unexpressed commitments into the discussion [17]. Early in the example Insolente begins a line of questioning to draw out the reasons AUBldr's has for the position taken and this shifts into the ad hominem attacks.

The flaming evident in this example, and possibly more generally in chat rooms, may result from strategic responses to the opportunities and resources afforded by the chat room – that is there are limited ways to develop positions and refutations. Thus, what appears on the surface as poor argumentation could indeed result from the effort to engage in good argumentation but that was not afforded by the forum where the participants engage each other.

In both examples 3.1 and 3.2, there was a struggle over the interactivity to be pursued in the web-enabled interaction that was consequential for the discourse produced. In 3.1, the community of viewers presumes their relationship to the producers of the investigative report to be that of engaged interlocutors. Yet, the interactional design of the threaded discussion rendered the producers distant and inaccessible. The community of viewers could not use the information rich environment to effectively raise their objections and requests – something like the situation of the co-pilots in example 2.1. In 3.2, the parties were able to express their disagreement but could not make it productive. This is in part follows from their struggle with the affordances of the chat system in producing their positions and responses. As in the mediation example (2.2) there was little support for drawing out the argumentatively productive aspects of the contributions made and thus the interaction became digressive. In both cases, it appears that the community of users attempted to handle differences through normatively good argumentation but were thwarted by the affordances of the internet-based technology. The relational, the actional, and the technological combine to shape the communicative possibilities and what might otherwise be seen as the ad hoc improvisation of the participants. Moreover, the preceding examples suggest how the clash between designed affordances and the community of users is consequential for discourse and any record of that discourse.

4. Design

The examples in section 3 are drawn from uses of Internet-based technologies for interaction that principally provide platforms for interaction. Threaded-discussion and chat obviously provide affordances and constraints for interactivity. The articulation of communicative possibilities, however, was largely ad hoc articulation, in Schmidt & Simone's [12] sense where the users were left to their own devices to articulate the activity they wanted. It was the next generation of groupware technologies that went further in providing "designed articulation" (Schmidt & Simone, 2000) of communicative possibilities. The groupware technologies provided further specification of interactional features that were intended to guide the users toward particular forms of interactivity. Not only was this seen in group decision support systems (GDSS) but it was also evident in the interactional resources websites provided to support communities such as RedHerring.com, MotleyFool.com, Amazon.com, and Ebay.com. This wave of technology, which continues today, provides more specific and sophisticated support for orchestrating interaction among groups, communities, and organizations. These web-based discussion technologies are used to support interactions that in turn create knowledge repositories used by knowledge communities [8].

Figure 1

The ad hoc and unintentional aspects of discourse may exert directions on online interaction in ways similar to the institutional talk and web cases previous. Aakhus [1] examined the online discussion of a community of practice supported by an online web-based discussion forum. The participants in the community were undergraduates in an internship program who used the online forum to discuss what they were experiencing in work and professional life. The participants were asked to share dilemmas they experienced at work and how they handled these dilemmas by contributing updates to the discussion forum. To complete an update, the participant answered a set of questions that guided the participant toward describing and articulating background assumptions related to the event reported. Participants were also encouraged to contribute responses to others' updates. Response were made by answering questions about the update in way that drew out underlying assumptions the update makes about work. The updates and responses were posted in threads and formed a repository of experiences and opinions used for other course assignments.

Over the course of the semester and over different semesters a common theme emerged in the way participants responded to others updates. It was not unusual for respondents to ask questions or make suggestions about talking-to-the boss as a way to solves the reported dilemma. The "couldn't go" update (see Figure 1) represents a common dilemmatic theme interns wrote about in their updates about making choices to balance commitments to school and their internship work.

The update describes the intern's concern that the internship supervisor would be upset with the intern's course of action. The update describes how the intern attempted to make the situation right but the update is ultimately framed on the theme that "I am not a bad person, I simply chose school over work."

The update is particularly interesting when it is treated not simply as a report about an event but instead as an account constructed for an overhearing audience of peers (the relational dimension). The update appears to be formulated to anticipate potential criticism or advice based on the ideal of open-communication between supervisor and subordinate. The update has built in evidence and implicit objections to any advice built on the idea of go-talk-to-your-boss. Here we see the possibility that the content contributed to the online form is shaped by anticipation of particular lines of advice and criticism (the actional dimension).

The micro-level design that defines the types of turns to be taken enables the sharing of updates and responses. It also helps surface participant assumptions about the domain of interest. The challenge posed by the example discussed here is that while the designed interaction appears to realize preferred aspects of interactivity, the product of that interactivity is a corpus or a macro level of interaction organized around premises that individuals may not be committed to but to which the community members hold each other accountable. The premises play a role in shaping what types of turn are taken and what subsequent content is developed.

This last example, in the context of the other examples, suggests that information technologies such as databases, knowledge repositories, and ontologies representing these entities may be subtly influenced by tacit dimensions of communication. Such influence is a challenge that arises at the interface of interactional and institutional orders as well as an opportunity for developing ways to support the collective management of participation and meaning. In particular, tools that render the processes of discourse production available for reflection and intervention.

5. Conclusion

This paper has briefly explored the terrain between designs for interaction and communication and the tacit dimensions of the interaction order that shape the communication patterns people observe.

Even though there is ever more designed support for communication and increasing capacity to design support, the tacit dimension of communication still plays a role in how people formulate moves in online interaction and in what becomes explicit in online interaction. These influences may have subtle if not profound effects on how moves are made, what is made explicit in online forums, and what is regarded as the representation of the communities discussion. Efforts to build ontologies, for example, are undoubtedly subject to the tacit dimension of communication identified here in terms of the relational, actional, and design clash features of supported communication. These emergent aspects of interaction and communication present both problems and opportunities for pragmatic web design.

Technologies, just like institutions, are not merely information conduits or neutral platforms for interacting but technologies, especially those emerging in the era of the pragmatic web, are acts of intervention, reconstruction, and representation. Looking at institutional forms of talk and then using that as scaffold for appreciating web-enabled interactions that begins a mapping of the territory of the pragmatic web and the opportunities and constraints that exist therein.

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Rule Responder: RuleML-Based Agents for Distributed Collaboration on the Pragmatic Web

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ABSTRACT

The Rule Responder project (responder.ruleml.org) extends the Semantic Web towards a Pragmatic Web infrastructure for collaborative human-computer networks. These allow semi-automated agents – with their individual (semantic and pragmatic) contexts, decisions and actions – to form corporate, not-for-profit, educational, or other virtual teams or virtual organizations. The project develops an effective methodology and an efficient infrastructure to interchange and reuse knowledge (ontologies and rules). Such knowledge plays an important role for (semi-automatically and contextually) transforming data, deriving new conclusions and decisions from existing knowledge, and acting according to changed situations or occurred (complex) events. Ultimately, this might put AI theories on distributed multiagent systems into larger-scale practice and might form the basis for highly flexible and adaptive Web-based service-oriented/service-component architectures (SOAs/SCAs).

Categories and Subject Descriptors

I.2.11 [**Artificial Intelligence**]: Distributed Artificial Intelligence; I.2.4 [**Artificial Intelligence**]: Knowledge Representation Formalisms and Methods

General Terms

multi agent systems, representation languages, coordination

Keywords

Pragmatic Agent Web, Rule Interchange Format, Reaction RuleML, Complex Event Processing, Prova

1. INTRODUCTION

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The Semantic Web and Web Services have the potential to profoundly change the way people collaborate. The Semantic Web builds upon XML as the common machine-readable syntax to structure content and data, upon RDF [11, 14] as a simple language to express property relationships between arbitrary resources (e.g., objects or topics) identified by URIs, and ontology languages such as RDFS [4] or OWL [16] as a means to define rich vocabularies (ontologies) which are then used to precisely describe resources and their semantics. The adoption of de facto standards such as Dublin Core [7], vCard [5], Bibtex [24] and iCal [6] for metadata descriptions of Web content and the emerging organization/person-centric vocabularies such as FOAF [9] and SIOC [27] and micro-formats such as GRDDL [10] are enabling a more machine-processable and relevant Web. This also prepares an infrastructure to share the relevant knowledge and its meaning between between distributed self-autonomous agents and loosely coupled Web-based services and tools

On top of the syntactic (XML) and semantic (RDF/RDFS, OWL) layer, rules play an important role to automatically and contextually transform data, derive new conclusions and decisions from existing knowledge and behaviorally act according to changed conditions or occurred events. Rules provide a powerful and declarative way to control and reuse the manifold meaning representations published on the Semantic Web. Services and intelligent agents can exploit rules to represent their decisions on how to use knowledge for a particular purpose or goal, including active selection and negotiation about relevant meanings, achievement of tasks, and internal and external reactions on occurred events, changing conditions or new contexts. This extends the Semantic Web to a rule-based *Semantic-Pragmatic Web*[1] which puts the independent micro-ontologies and domain-specific data into a pragmatic context such as communicative situations, organizational norms, purposes or individual goals and values.

In linguistics and semiotics, pragmatics is concerned with the study of how context influences the meaning interpretation of sentences usually in the context of conversations. A distinction is made in pragmatics between sentence mean-

[1]Following [26], we will briefly call this the *Pragmatic Web*, since each of the syntactic-semantic-pragmatic layers is understood to include all the lower layers.

ing and speaker meaning, where the former is the literal meaning of the sentence, while the latter is the piece of information (or proposition) that the speaker is trying to convey. In other words, the Pragmatic Web does not intend to subsume the Semantic Web, but it intends to utilize the Semantic Web with intelligent agents and services that access data and ontologies and make rule-based inferences and autonomous decisions and reaction based on these representations. The focus is on the adequate modelling, negotiation and controlling of the use of the myriad (meta)data and meaning representations of the Semantic Web in a collaborating community of users where the individual meanings as elements of the internal cognitive structures of the members become attuned to each others' view in a communicative process. This allows dealing with issues like ambiguity of information and semantic choices, relevance of information, information overload, information hiding and strategic information selection, as well as positive and negative consequences of actions.

As a result, this Pragmatic Web becomes more usable in, e.g., decision support systems (DSS), heterogenous information systems (HIS) and enterprise application systems (EAS) for distributed human teams and semi-autonomous, agents and IT (web) services: (1) It meaningfully annotates, links, and shares distributed knowledge sources according to common ontologies. (2) It employs rule-based logic for reasoning about source content and metadata. (3) It adds rule-based delegation and integration flow logic to distribute incoming requests towards appropriate virtual (team or organization) members and to collect their responses. By using the Semantic Web as an infrastructure for collaborative networks and by extending it with a rule-based pragmatic and behavioral layer, individuals agents and (Web) services – with their individual contexts, decisions and efforts – can form corporate, not-for-profit, educational, or otherwise productive virtual teams or virtual organizations that have, beside their individual context, a shared context consisting of shared concepts, joint goals and common negotiation and coordination (communication) patterns. Ultimately, this might put the ideas of the AI community on distributed self-autonomous multi agent systems (MAS) into large scale practice and might form the basis for highly flexible and adaptive Web-based service-oriented/service component architectures (SOA/SCA) and event-driven architectures (EDA).

In this paper we contribute with a declarative rule-based service-oriented methodology and a scalable architecture to operationalize such a distributed rule-based approach where event-based communication and rule-based use of meaning plays a central role in connecting the various resources and Web-based services/agents in virtual organizations and teams [20]. The addressed application domain of virtual organizations and rule-based services is of high industrial relevance. We follow a constructivistic design science research methodology [12] and implement an improved rule-based agent technology based on a distributed rule management service and a modern enterprise service middleware providing enhanced usability, scalability and performance, as well as less costly maintenance in engineering and deploying agent/service-oriented architectures. Our Rule Responder system [20] allows to externalize and publish rules on the Web, and to manage them in various modules deployed as online services/agents which are then weaved into the main applications at runtime. In particular, the contributions are as follows:

- Extends the Semantic Web with a pragmatic rule-based layer (Pragmatic Web), which defines the rules for using information resources and ontologies to support human agents in their decisions and react partially self-autonomously by means of automated agents or services
- Blends and tightly combines the ideas of multi-agent systems, distributed rule management systems, and service oriented and event driven architectures
- Addresses real-world software engineering needs for a highly distributed, open, interoperable, efficient and scalable Semantic Web service and agent infrastructure
- Demonstrates the interoperation of various distributed platform-specific rule execution environments based on Reaction RuleML as a platform-independent rule interchange format interchanged over an enterprise service bus as transport middleware
- Applies rule-based technologies to the management of virtual organizations and collaborative teams
- Applies negotiation and distributed coordination mechanisms of rule-based complex event processing and rule-based workflow like reaction rule patterns
- Demonstrates the integration and interoperation of rule standards (RuleML), Object-Oriented programming (Java) and Semantic Web (RDF, RDFS, OWL) and metadata standards (e.g. iCal, vCard, FOAF)

The rest of the paper is organized as follows: In section 2 we propose an extension of the current Semantic Web towards a Pragmatic Agent Web where agents and services practically make use of the data, vocabularies and resources of the Syntactic and Semantic Web. In section 3 we evolve and implement the core concepts and technologies used to make this design artifact of rule-based autonomous agents and rule inference services a reality in industrial real-world settings. In section 4 we demonstrate the applicability of the proposed approach by means of a real-world use case, namely the RuleML-200x symposium organization as a virtual organization. Finally, in section 5 we conclude this paper with a summary of the approach towards a pragmatic agent web and a discussion of the applied research methodology.

2. A RULE-BASED PRAGMATIC AGENT WEB MODEL FOR VIRTUAL ORGANIZATIONS

A virtual organization consists of a community of independent and often distributed (sub-) organizations, teams or individual agents that are members of the virtual organization. Typical examples are virtual enterprises, virtual (business) cooperations, working groups, project teams or resource sharing collaborations as in e.g. grid computing or service-oriented computing (SOC) where the vision is to build large scale resource / service supply chains (a.k.a. business services networks) which enable enterprises to define and execute Web services based transactions and business processes across multiple business entities and domain boundaries using standardized (Web) protocols.

A virtual organization is typically represented by an organizational agent and a set of associated individual or more specific organizational member agents. The organizational agent might act as a single agent towards other internal and external individual or organizational agents. In other words, a virtual organization's agent can be the single (or main) point of entry for communication with the "outer" world (external agents). Typically, the organizational agent consists of the following:

1. Common syntactic information resources about the virtual organization such as public Web pages showing general contact information, goals and service offerings, but also internal resources such databases or OO representations (e.g. EJBs) to manage customer data, shared project and task data (e.g. calendars) and data about the community members.

2. A semantic layer which describes the common context of the virtual organization such as the shared common concepts and ontologies that evolved during the interaction with the community members and other external agents.

3. A pragmatic and behavioural/decision layer which consists of the organizational norms and values (e.g. deontic norms, needs, avoidance), the joint goals/ interests/ purposes (beliefs/ wants/ desires), the strategies and decision logic (deductive logic and abductive plans), the behavioural reaction logic, and the used negotiation and coordination interchange patterns with the community members but also with external agents.

Similar to an organizational agent, each individual agent is described by its syntactic resources of personal information about the agent, the semantic descriptions that annotate the information resources with metadata and describe the meaning with precise ontologies and a pragmatic behavioural decision layer which defines the rules for using the information resources and ontologies to support human agents in their decisions or react autonomously as automated agents/services. In fact, since each individual agent might be a member of various virtual organizations in which it plays a different role, an individual agent itself might be seen as a "small virtual organization" with shared goals but also with possibly contradicting goals in each of its roles. For instance, a person might be a member of a commercial enterprise and of a research working group with different possibly orthogonal or contradicting goals and norms such as social welfare vs. individual ambitions. If the level of autonomy of decisions is low an agent reduces to a Web service and the virtual organization is implemented by a flexible composition of several services to so called service component architecture (SCAs) which enable distributed application development and integration over the Web. Figure 1 illustrates this general picture.

In this architecture of a *Pragmatic Agent Web* (PAW) model the *syntactic level* controls the appearance and access of syntactic information resources such as HTML Web pages. The formal nature of representation languages such as XML, RDF and OWL on the *semantic level* make these Web-based information more readable and processable not only to humans, but also to computers, e.g., to collect machine-readable data from diverse sources, process it and infer new knowledge. Finally, the *pragmatic level* defines the rules how information is used and describes the actions in terms of its pragmatic aspects, i.e. why, when and for what purpose or with what goals they are done. These rules e.g. transform existing information into relevant information of practical consequences, trigger automated reactions according to occurred complex events/situations, and derive answers to queries from the existing syntactic and semantic information resources.

In this paper we focus on the pragmatic and behavioural layer which makes use of the meaningful domain data and metadata knowledge from the syntactic and semantic layer and transforms the existing information into relevant information which is accessible by Web-based service interfaces. Declarative rules play an important role to represent the conditional decision and behavioural logic of the agents as well as the strategic and pragmatic contexts in which collaboration takes place such as communicative and coordination situations, beliefs, wants, needs and avoidances, individual values, organizational norms etc. This also includes (semi-)automated negotiation and discussion about the meaning of ontological concepts, since agents might use their own micro-ontologies and must agree on relevant shared concepts to enable an efficient communication and knowledge interchange between the nodes. Modularization and information hiding is another important concept for a virtual collaboration of independent agents, since each agents might have its own goals, strategies and rich tacit meaning of ontological concepts that should not or cannot be made explicit. That is, a certain level of ambiguity and hidden information should be allowed, as long as they do not endanger the higher goals and the communication of the virtual organization. Communication within the collaborative community and with external agents based on an adequate "webized" interchange format for rule sets, queries and derived answers but also for communicative, pragmatic and ontological semantic contexts is needed.

Our agent and service-oriented approach which evolves from former multi agent technologies and novel enterprise service architectures enables to naturally capture more complex constraints on what Web-based services are willing to offer and how they can be combined and collaborate in virtual organizations respectively enterprise business networks. Agents are self-autonomous, distributed, loosely-coupled, long-lived, persistent computational entities that can perceive, reason, act and communicate [13]. Depending on their behavioural and decision constraints/logic which is typically rule-based and their ongoing interactions they act with varying levels of autonomy. Because of their autonomy and heterogeneity agents are not specific to a particular underlying knowledge representation or programming paradigm and there are various possibilities to implement the rule-based logic, e.g., if-then constructs in procedural programming languages such as Java or C/C++ (with control flow), decision tables/trees, truth-functional constructs based on material implication, implications with constraints (e.g., OCL), triggers and effectors (e.g., SQL trigger), non-logical approaches such as semantic networks, frames or logical knowledge representation (KR) approaches based on subsets of first order predicate logic such as logic programming (LP) techniques. In this paper we employ a declarative logic-based approach which has several advantages: reasoning with rules is based on a semantics of formal logic, usually

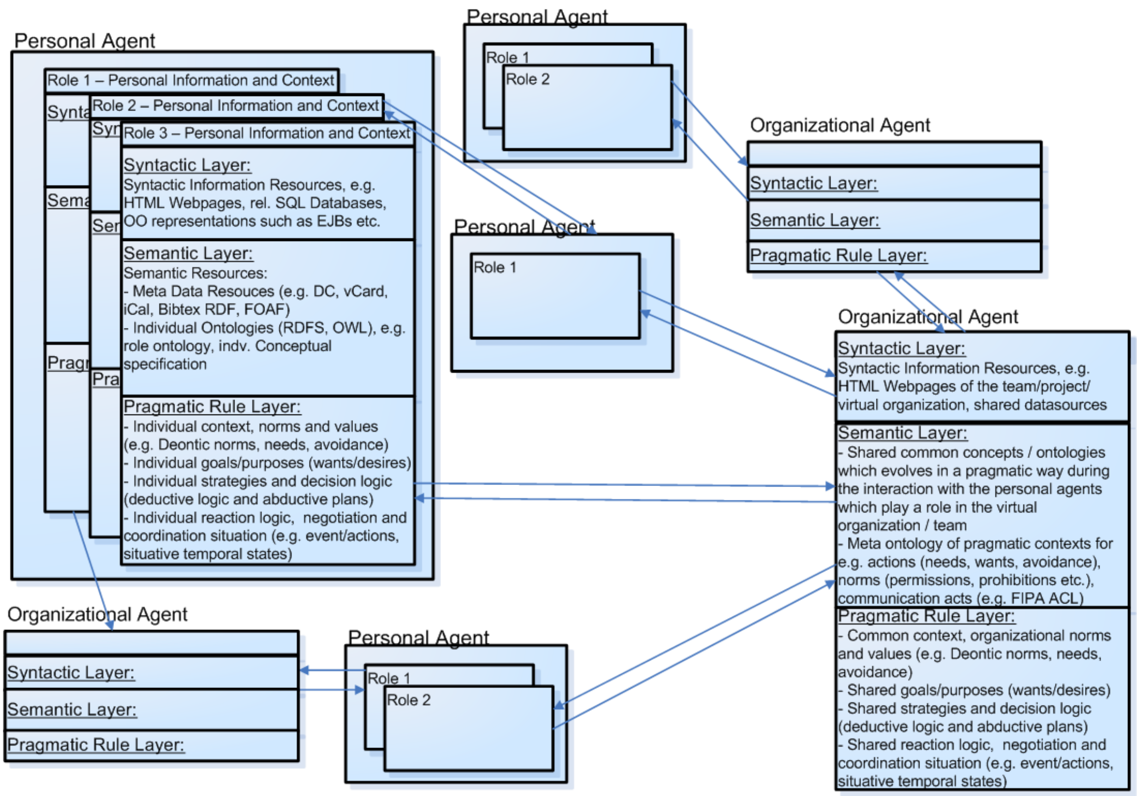

Figure 1: A Pragmatic Agent Web for Virtual Organizations

a variation of first order predicate logic which also underpins Semantic Web ontology languages, and it is relatively easy for the end user to write rules. The basic idea is that users/agents employ rules to express *what* they want, the responsibility to interpret this and to decide on *how* to do it is delegated to an interpreter (e.g., an inference/rule engine or a just in time rule compiler). Traditionally, rule-based systems have been supported by two types of inferencing algorithms: forward-chaining as e.g. in production rule systems and backward-chaining as in logic programming systems such as Prolog derivatives. We are not specific which particular rule language and rule engine (execution environment) is used on the platform dependent layer since this technical layer is wrapped by our rule management middleware which provides general message-oriented communication interfaces using arbitrary transport protocols such as HTTP, JMS, SOAP, ... and translation services into a standardized platform-independent rule interchange format in order to enable interaction with other agents and services which implement different rule execution environments.

We build the rule-based pragmatic agent layer upon existing technologies and common language formats of the Semantic Web such as HTML/XML Web pages, RDF/RDFS and OWL variants of de facto standards such as Dublin Core, vCard, iCal or BibTeX/BibTeXML and other emerging vocabularies such as FOAF or SIOC, which are used to describe personal and institutional metadata and information, project and event data as well as ontological conceptualizations of the individual and common domains/vocabularies. We assume that there is already a critical mass of such data sources on the semantic and syntactic layer, e.g. RDF Bibtext libraries of publications, RDF vCard or FOAF profiles for each member and role, online event calendars using vCal or gData feeds. Furthermore, we integrate data and functionality from legacy applications such as rel. databases, enterprise applications or Web services into the rule-based decision and execution logic. Depending on the particular rule execution environment the integration can happen dynamically at runtime or by pre-transformation and replication of the external data into an internal executable format (e.g. a set of logical facts replicated in the internal knowledge base).

This general approach towards a rule-based PAW model includes a great variety of technical design science and Software Engineering decisions, such as how to access the various external data sources and ontologies (e.g. homogenous translation and integration vs. heterogeneous integration), how to manage and maintain the rule modules on the various levels (e.g. distributed scoped knowledge based vs. centralized knowledge base in central organizational agent node), how to integrate and interoperate with various execution environments (e.g. various rule engines with various logical expressiveness classes), how to communicate and negotiate semantics and pragmatic meaning, how to deal with complex events and situations, what is a scalable approach to operationalize and communicate between the agent nodes (e.g. enterprise service bus vs. ad-hoc communication e.g. via SOAP or JMS messages). Figure 2 exemplifies these technical design and implementation questions of a PAW model. In the next section we will detail the main technical

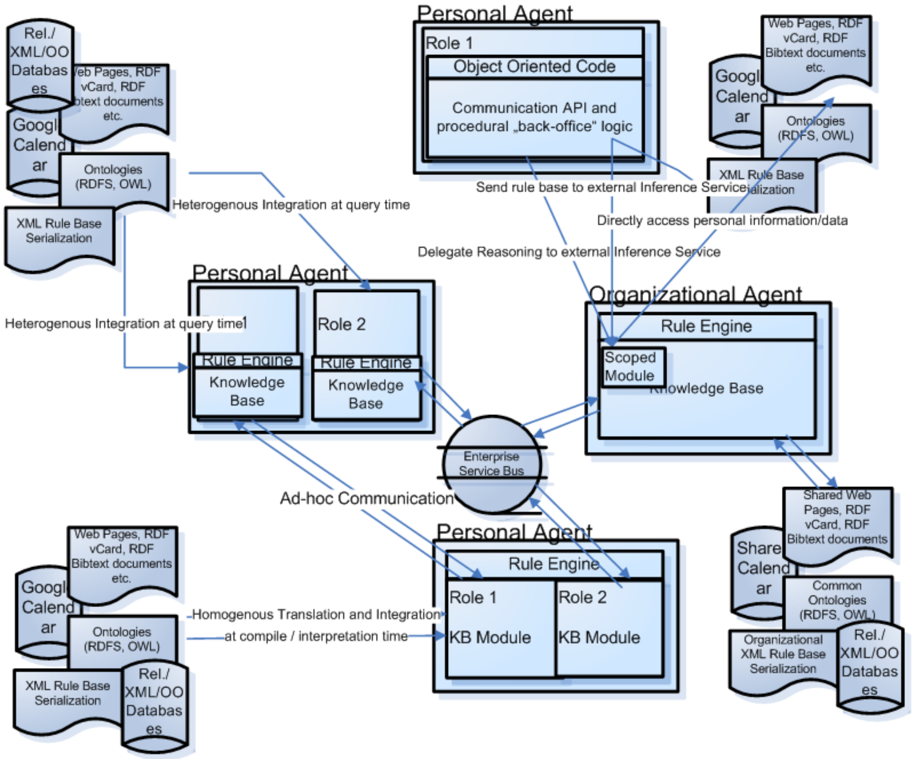

Figure 2: Rule-based Pragmatic Agent Web Architecture

components of this architecture.

3. DISTRIBUTED RULE RESPONDER AGENT SERVICES

In this section we will introduce the main components of the distributed Rule Responder architecture for a Pragmatic Agent Web [20]. The three core parts are (1) a common platform-independent rule interchange format to interchange rules and events between arbitrary agent services, (2) a highly scalable and efficient agent/service-broker and communication middleware, and (3) platform-specific rule engines and execution environments.

3.1 RuleML as Platform-Independent Rule Interchange Format

The Rule Markup Language (RuleML).

[2] is a modular, interchangeable rule specification standard to express both forward (bottom-up) and backward (top-down) rules for deduction, reaction, rewriting, and further inferential-transformational tasks. It is defined by the Rule Markup Initiative [3], an open network of individuals and groups from both industry and academia that was formed to develop a canonical Web language for rules using XML markup and transformations from and to other rule standards/systems. The language family of RuleML covers the entire rule spectrum, from derivation rules to reaction rules including rule-based complex event processing (CEP) and messaging (Reaction RuleML [23]), as well as verification and transformation rules. In the following we will briefly summarize the key components of RuleML language (Horn logic layer of RuleML) and then introduce the Reaction RuleML language [23, 22] which extends RuleML with additional language constructs for representing reaction rules and complex event / action messages, e.g. for complex event processing. The building blocks of RuleML are: [2]

- Predicates (atoms) are n-ary relations defined as an $< Atom >$ element in RuleML. The main terms within an atom are variables $< Var >$ to be instantiated by ground values when the rules are applied, individual constants $< Ind >$, data values $< Data >$ and complex expressions $< Expr >$.

- Derivation Rules ($< Implies >$) consist of a body part ($< body >$) with one or more conditions (atoms) connected via $< And >$ or $< Or >$ and possibly negated by $< Neg >$ which represents classical negation or $< Naf >$ which represents negation as failure and a conclusion ($< head >$) which is derived from existing other rules or facts applied in a forward or backward manner.

- Facts are deemed to be always true and are stated as atoms: $< Atom >$

- Queries $< Queries >$ can either be proven backward as top-down goals or forward via bottom-up processing. Several goals might be connected within a query and negated.

Besides facts, derivation rules and queries, RuleML defines further rule types such as integrity constraints and transformation rules [2].

Reaction RuleML.

[23, 22] is a general, practical, compact and user-friendly XML-serialized sublanguage of RuleML for the family of reaction rules. It incorporates various kinds of production, action, reaction, and KR temporal/event/action logic rules as well as (complex) event/action messages into the native RuleML syntax using a system of step-wise extensions. The building blocks of Reaction RuleML (version 0.2) are: [23]

- One general (reaction) rule form ($< Rule >$) that can be specialized to e.g. production rules, trigger rules, ECA rules, messaging rules ...
- Three execution styles defined by the attribute @*style*
  - *Active*: 'actively' polls/detects occurred events in global ECA style, e.g. by a ping on a service/system or a query on an internal or external event database
  - *Messaging*: waits for incoming complex event message and sends outbound messages as actions
  - *Reasoning*: Knowledge representation derivation and event/action logic reasoning and transitions (as e.g. in Event Calculus, Situation Calculus, TAL formalizations)
- Messages $< Message >$ define inbound or outbound event message

A reaction rule might apply globally as, e.g. global ECA rules or locally nested within other reaction or derivation rules as e.g. in the case of messaging reaction rules (e.g. complex event processing rules). The general syntax of a reaction rules consists of six partially optional parts:

```
<Rule style="active" evaluation="strong">
   <label> <!-- metadata  --> </label>
   <scope> <!-- scope --> </scope>
   <qualification> <!-- qualifications --> </qualification>
   <oid> <!-- object identifier --> </oid>
   <on>  <!-- event -->  </on>
   <if>  <!-- condition --> </if>
   <then> <!-- conclusion --> </then>
   <do>  <!--  action -->  </do>
   <after> <!-- postcondition --> </after>
   <else> <!-- else conclusion --> </else>
   <elseDo> <!-- else/alternative action --> </elseDo>
   <elseAfter> <!-- else postcondition --> </elseAfter>
</Rule>
```

Inbound and outbound messages $< Message >$ are used to interchange events (e.g. queries and answers) and rule bases (modules) between the agent nodes:

```
<Message mode="outbound" directive="pragmatic performative">
  <oid> <!-- conversation ID--> </oid>
  <protocol> <!-- transport protocol --> </protocol>
  <sender> <!-- sender agent/service --> </sender>
  <content> <!-- message payload -->  </content>
</Message>
```

- @$mode = inbound|outbound$ - attribute defining the type of a message
- @*directive* - attribute defining the pragmatic context of the message, e.g. a FIPA ACL performative
- $< oid >$ - the conversation id used to distinguish multiple conversations and conversation states
- $< protocol >$ - a transport protocol such as HTTP, JMS, SOAP, Jade, Enterprise Service Bus (ESB) ...
- $< sender >< receiver >$ - the sender/receiver agent/ service of the message
- $< content >$ - message payload transporting a RuleML / Reaction RuleML query, answer or rule base

The directive attribute corresponds to the pragmatic instruction, i.e. the pragmatic characterization of the message context. External vocabularies defining pragmatic performatives might be used by pointing to their conceptual descriptions. The typed logic approach of RuleML enables the integration of external type systems such as Semantic Web ontologies or XML vocabularies. [2, 18] A standard nomenclature of pragmatic performatives is defined by the Knowledge Query Manipulation Language (KQML) and the FIPA Agent Communication Language (ACL) which defines several speech act theory-based communicative acts. [8] Other vocabularies such as OWL-QL or the normative concepts of Standard Deontic Logic (SDL), e.g., to define action obligations or permissions and prohibitions, might be used as well.

The conversation identifier is used to distinguish multiple conversations and conversation states. This allows to associate messages as follow-up to previously existing conversations, e.g. to implement complex coordination and negotiation protocols, message-oriented workflows and complex event processing situations. For an overview and description of several negotiation and coordination protocols see [21]. Via sub-conversations it is possible to start e.g. meaning negotiations about the common shared pragmatic context and the shared ontologies which are necessary to understand the rule and event-based content of the interchanged messages.

The protocol might define lower-level ad-hoc or enterprise service bus transport protocols such as HTTP, JMS, and higher-level agent-oriented communication protocols such as Jade or Web Service protocols such as SOAP. More than 30 different transport protocols are supported by the enterprise service bus which is the main communication backbone in our implementation.

The content of a message might be a query or answer following a simple request-response communication pattern or it might follow a complex negotiation or coordination protocols where complete rule sets, complex events or fact bases serialized in RuleML / Reaction RuleML are interchanged.

The RuleML Interface Description Language.

(RuleML IDL) as sublanguage of Reaction RuleML adopts the ideas of interface definition languages such as Corbas' IDL or Web Service WSDL. It describes the signatures of public rule functions together with their mode and type declarations and narrative human-oriented meta descriptions.

Modes are states of instantiation of the predicate described by mode declarations, i.e. declarations of the intended input-output constellations of the predicate terms with the following semantics:

- "+" The term is intended to be input
- "−" The term is intended to be output

• "?" The term is undefined/arbitrary (input or output)

We define modes with an optional attribute @*mode* which is added to terms in addition to the @*type* attribute, e.g. $< Var\ mode = " - "\ type = "java : //java.lang.Integer > X < /Var >$, i.e. the variable X is an output variable of type *java.lang.Integer*. By default the mode is undefined "?".

For instance, the interface definition for the function $add(Arg1, Arg2, Result)$ with the modes $add(+, +, -)$ is as follows:

```
<Interface>
    <label>
       <Expr>
          <Fun uri="dc:description"/>
          <Ind>Definition of the add function which takes two
               Java integer values as input and returns the
               Integer result value
          </Ind>
       </Expr>
    </label>
    <Expr>
      <Fun>add</Fun>
      <Var type="java://java.lang.Integer" mode="-">Result</Var>
      <Var type="java://java.lang.Integer" mode="+">Arg1</Var>
      <Var type="java://java.lang.Integer" mode="+">Arg2</Var>
    </Expr>
</Interface>
```

3.2 Enterprise Service Bus as Communication Middleware

To seamlessly handle message-based interactions between the responder agents/services and with other applications and services using disparate complex event processing (CEP) technologies, transports and protocols an enterprise service bus (ESB), the Mule open-source ESB [17], is integrated as communication middleware. The ESB allows deploying the rule-based agents as highly distributable rule inference services installed as Web-based endpoints in the Mule object broker and supports the Reaction RuleML based communication between them. That is, the ESB provides a highly scalable and flexible application messaging framework to communicate synchronously but also asynchronously with external services and internal agents.

Mule is a messaging platform based on ideas from ESB architectures, but goes beyond the typical definition of an ESB as a transit system for carrying data between applications by providing a distributable object broker to manage all sorts of service components. The three processing modes of Mule are [17]:

- Asynchronously: many events can be processed by the same component at a time in various threads. When the Mule server is running asynchronously instances of a component run in various threads all accepting incoming events, though the event will only be processed by one instance of the component.
- Synchronously: when a UMO Component receives an event in this mode the whole request is executed in a single thread
- Request-Response: this allows for a UMO Component to make a specific request for an event and wait for a specified time to get a response back

The object broker follows the Staged Event Driven Architecture (SEDA) pattern [28]. The basic approach of SEDA is to decomposes a complex, event-driven application into a set of stages connected by queues. This design decouples event and thread scheduling from application logic and avoids the high overhead associated with thread-based concurrency models. That is, SEDA supports massive concurrency demands on Web-based services and provides a highly scalable approach for asynchronous communication.

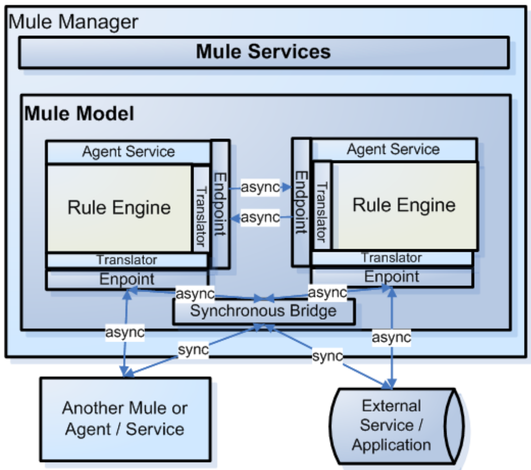

Figure 3: Integration of Mule into RBSLM

Figure 3 shows a simplified breakdown of the integration of Mule into Rule Responders' Pragmatic Agent Web.

Several agent services which at their core run a rule engine are installed as Mule components which listen at configured endpoints, e.g., JMS message endpoints, HTTP ports, SOAP server/client addresses or JDBC database interfaces. Reaction RuleML is used as a common platform independent rule interchange format between the agents (and possible other rule execution / inference services). Translator services are used to translate inbound and outbound messages from platform-independent Reaction RuleML into the platform-specific rule engines execution syntaxes and vice versa. XSLT and ANTLR based translator services are provided as Web forms, HTTP services and SOAP Web services on the Reaction RuleML Web page [23].

The large variety of transport protocols provided by Mule can be used to transport the messages to the registered endpoints or external applications / tools. Usually, JMS is used for the internal communication between distributed agent instances, while HTTP and SOAP is used to access external Web services. The usual processing style is asynchronous using SEDA event queues. However, sometimes synchronous communication is needed. For instance, to handle communication with external synchronous HTTP clients such as Web browsers where requests, e.g. by a Web from, are send through a synchronous channel. In this case a synchronous bridge component dispatches the requests into the asynchronous messaging framework and collects all answers from the internal service nodes, while keeping the synchronous channel with the external service open. After all asynchronous answers have been collected they are send back to the still connected external service via the synchronous channel.

3.3 Platform-dependent Rule Engines as Execution Environments

Each agent service might run one or more arbitrary rule engines to execute the interchanged queries, rules and events and derive answers on requests. In this subsection we will introduce Prova [15, 19], a highly expressive Semantic Web rule engine which we used in our reference implementation for agents with complex reaction workflows, decision logic and dynamic access to external Semantic Web data sources. Another rule engine which we applied was the OO jDrew rule engine [1] in order to demonstrate rule interchange between various rule engines. Further rule engines and event correlation engines (CEP engines) are planned to join the Rule Responder project.

Prova follows the spirit and design of the recent W3C Semantic Web initiative and combines declarative rules, ontologies and inference with dynamic object-oriented Java API calls and access to external data sources such as relational databases or enterprise applications and IT services. One of the key advantages of Prova is its elegant separation of logic, data access, and computation and its tight integration of Java and Semantic Web technologies. It includes numerous expressive features and logical formalisms such as:

- Easy to use and learn ISO Prolog related scripting syntax
- Well-founded Semantics for Extended Logic Programs with defeasible conflict resolution and linear goal memoization
- Order-sorted polymorphic type systems compatible with Java and Semantic Web ontology languages RDF/RDFS and OWL
- Seamless integration of dynamic Java API invocations
- External data access by e.g., SQL, XQuery, RDF triple queries, SPARQL
- Meta-data annotated modular rule sets with expressive transactional updates, Web imports, constructive views and scoped reasoning for distributed rule bases in open environment such as the Web
- Verification, Validation and Integrity tests by integrity constraints and test cases
- Messaging reaction rules for workflow like communication patterns based on the Prova Agent Architecture
- Global reaction rules based on the ECA approach
- Rich libraries and built-ins for e.g. math, date, time, string, interval, list functions

For a detailed description of the syntax, semantics and implementation of several of these formalisms see e.g. [19].

4. RULE RESPONDER USE CASE

In this section we describe a real-world use case, namely the *RuleML-200x Symposium organization*, which address typical problems and tasks in a virtual organization. Further use cases can be found on the Rule Responder project site: *responder.ruleml.org*.

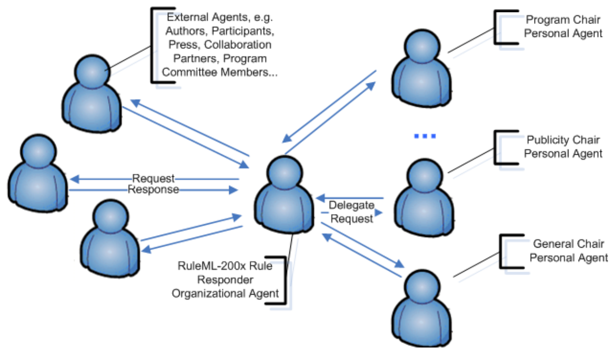

Figure 4: RuleML-200x Use Case

The RuleML-200x Responder use case implements the RuleML-200x symposium organization as a virtual organization consisting of self-autonomous rule-based agents who fulfil typical conference organization and project management tasks and who respond to incoming requests from external agents, e.g., from authors, participants, program committee members ... (see figure 4).

The RuleML-200x Responder agent (organizational agent) acts as a single point of entry for the RuleML-200x organization. It filters, decides and delegates incoming queries and requested tasks to the organizations' members (e.g. the organizing committee members) which are implemented as distributed rule-based personal agents. Project management techniques such as a responsibility assignment matrix (see table 1) and role models are implemented by the RuleML-2007 Responder as ontological models (in OWL) to describe the roles and responsibilities of the personal agents in the virtual organization. Negotiation and distributed coordination protocols are applied to manage and communicate with the project team and external agents.

Table 1: Responsibility Assignment Matrix

	General Chair	Program Chair	Publicity Chair
Symposium	responsible	consulted	supportive
Website	accountable	responsible	
Sponsoring	informed, signs	verifies	responsible
Submission	informed	responsible	
...	...	...	...

The personal agents act as self-autonomous agents having their own rule-based decision and behavioural logic on top of their personal information sources, Web services, vocabularies / ontologies and knowledge structures. This allows them, e.g., to selectively reveal personal information such as contact information (e.g. show only parts of FOAF profiles or vCards) or react and proactively plan according to the occured situation (e.g. schedule a meeting based on personal iCal calendar data - see figure 7).

As shown in figure 5, each agent in the RuleML-200x virtual organization is implemented as a Web-based service consisting of a set of internal or external data and knowledge sources and a rule execution environment (a rule engine). Reaction RuleML is applied as common rule interchange and event messaging format, Prova and OO jDrew are used as two exemplary rule engines in the implemen-

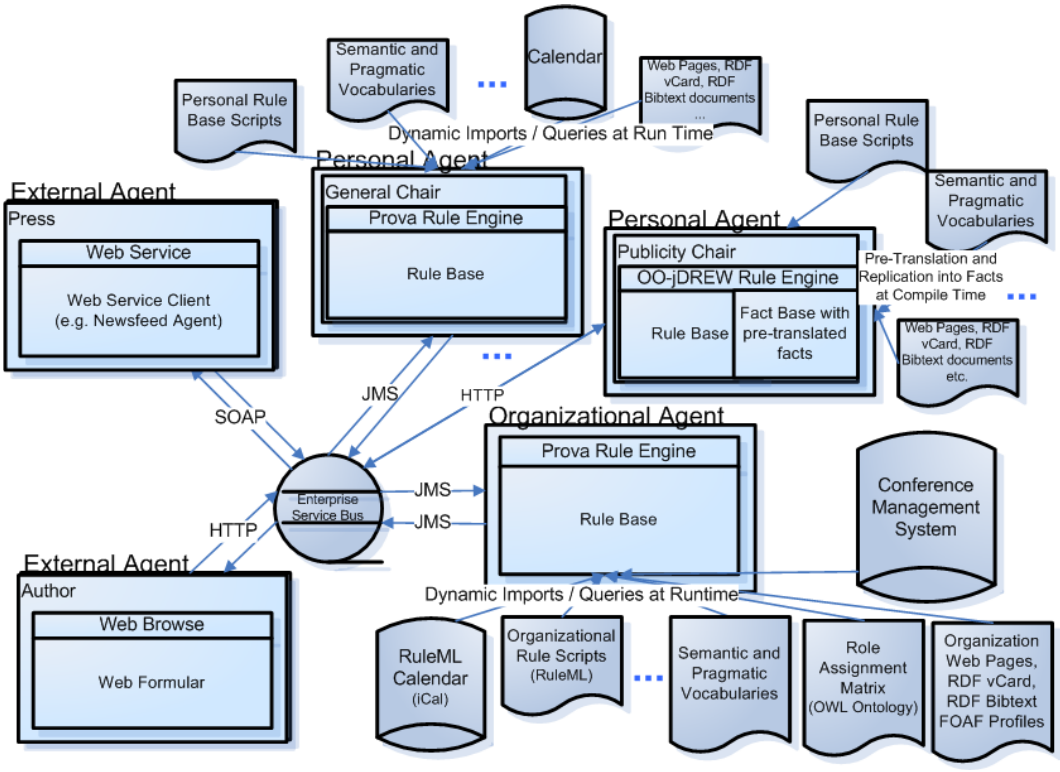

Figure 5: RuleML-200x Use Case Implementation

tation of the organizational and personal agents, and the Mule ESB is used as communication middleware between the agent endpoints. Reaction RuleML messages (event messages) are transported by the ESB to the appropriate internal agent nodes or external communication interfaces based on a broad spectrum of selectable transport protocols such as HTTP, JMS, Web Service protocols (SOAP) or e.g. agent communication languages (JADE). The platform-independent interchanged RuleML messages which contain the message payload, e.g. queries or answers, as well as meta information about the conversation and the pragmatic context of the message, are translated by translator services (e.g. XSLT style sheets) into the platform-dependent, specific execution language of the rule-based execution environment at the agent endpoint(s).

The Role Activity Diagram (RAD) shown in figure 6 describes a simple query-answer (request-response) pattern. An external agent requests some information from the Rule ML-2007 organization. The organizations' responder agent tries to understand the query and starts a sub-conversation informing the requester if the pragmatic context or the message content was not understood. In this case the requester agent informs the organization agent with further relevant information which is need to understand the query, e.g. references to relevant ontology parts or synonyms. If the message is understood by the organizational agent it delegates the query (possibly executing some further preprocessing) in a new sub-conversation to the responsible personal agent (according to the responsibility assignment matrix). Other roles (personal agents) might be informed in parallel (not shown here). The personal agent derives the answers and

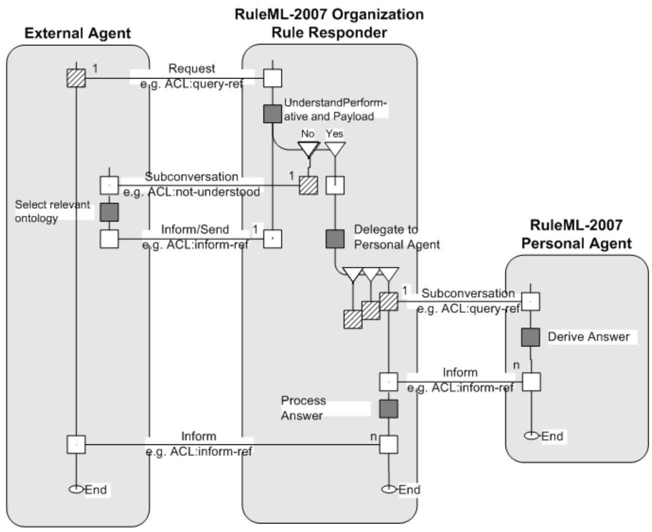

Figure 6: Role Activity Diagram for a simple Query-Answer Conversation

sends them back one by one to the organizational agent which might simply forward them to the original external requesting agent.

The implementation in Prova uses messaging reaction rules which send and receive outbound and inbound messages. For instance, the rule receives a query from the ESB, sends it to another agent in a new sub-conversation, receives the answer from the agent, and sends back the answer to the original requester: (variables start with upper case letters)

```
rcvMsg(CID,esb, Requester, acl_query-ref, Query) :-
 ...
 sendMsg(Sub-CID,esb,Agent,acl_query-ref, Query),
 rcvMsg(Sub-CID,esb,Agent,acl_inform-ref, Answer),
 ...
 sendMsg(CID,esb,Agent,acl_inform-ref,Answer).
```

On the PIM layer this Prova rule is serialized in Reaction RuleML as a reaction rule:

```
<Rule style="active">
   <event> <!-- receive inbound message -->
       <Message mode="inbound">...</Message>
   </event>
   <condition>
     <And>
        <Rule style="active"> <!-- send outbound message -->
           <action>
              <Message mode="outbound">...</Message>
           </action>
        </Rule>
        <Rule style="active"> <!-- receive inbound messages -->
           <event>
              <Message mode="inbound">...</Message>
           </event>
        </Rule>
     </And>
   </condition>
   <action> <!-- send outbound message -->
       <Message mode="outbound">...</Message>
   </action>
</Rule>
```

The corresponding reaction rule on the personal agents' side might look at follows:

```
% answers query
rcvMsg(XID, esb, From, Performative, [X|Args]):-
    derive([X|Args]),
    sendMsg(XID,esb,From, answer, [X|Args]).
```

This rule tries to derive every incoming query and sends back the answers. The list notation $[X|Args]$ will match with arbitrary n-ary predicate functions, i.e., it denotes a kind of restricted second order notation since the variable X is always bound, but matches to all functions in the signature of the language with an arbitrary number of arguments $Args$. For instance, a function $p(X,Y)$ is equivalent to a list $[p,X,Y]$ where the function name being the first element in the list. Note, that the complete conversation is local to the conversation ID, the used protocol and the pragmatic context denoted by the performative(s).

With this flexible reaction rules process flows can be implemented such as complex negotiation and coordination protocols [21]. For instance, a typical process in a virtual organization such as the RuleML-200x organization is the scheduling of a meeting (e.g. a telephone conference) as described in figure 7.

The RuleML-200x organizational agent creates a possible date for the meeting from the public organizational calendar (accessed e.g. via iCAL) and proposes this date to all personal agents. The agents compare this date with their

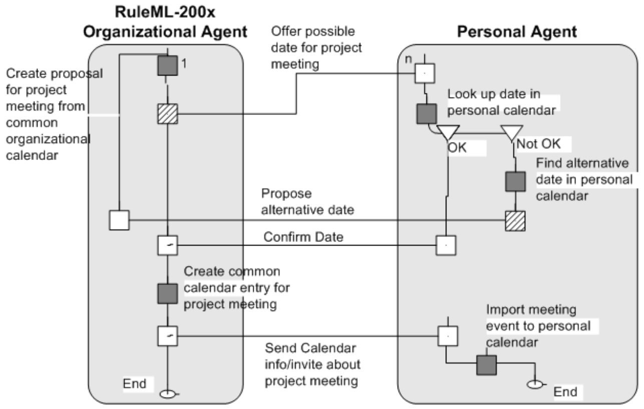

Figure 7: Role Activity Diagram for Scheduling a Meeting

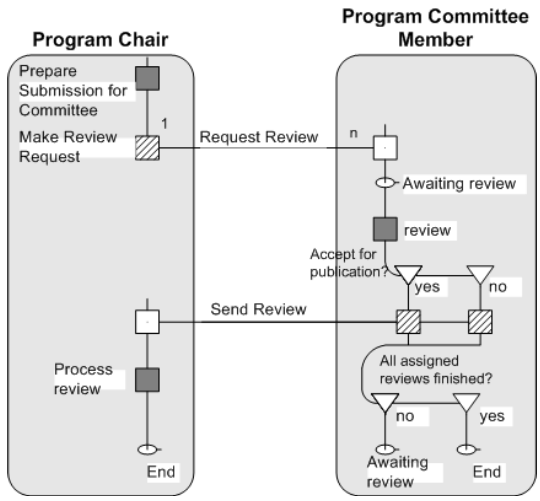

Figure 8: Role Activity Diagram for the Reviewing Process

personal calendars and send counter-proposals if the deadline does not fit according to their personal decision logic. The organizational agent then creates a new proposal. This process is repeated until all agents agreed on the proposed meeting date; the organizational agent then creates an entry in the public calendar and informs all agents about this date. The personal agents add this date to their personal (not public) calendars. Note, that the personal agents implement their own, self-autonomous decision logic. For instance, they can lie and pretend they have no time at a certain date or propose strategic counter-proposals.

Another scenario is the reviewing process of submissions to the conference, as modelled in figure 8.

The program chair assigns papers to program committee members and sends requests to them. Each program committee members then reviews the assigned submissions and informs the program chair about the review comments and the acceptance or rejection decision. If there are further pending reviews the program committee member agent iterates the "awaiting review" state until all assigned papers have been reviewed. The program chair processes the received reviews.

Several other typical processes in conference organizations demonstrating the interplay of the different agent roles, e.g., between the responsible, supportive, consulted, sings, informed, ... role for a particular task according to the role assignment matrix, have been implemented in this use case.

In summary, conversations via event messages are used to coordinate the agents in the RuleML-200x organization. A conversation is local to the conversation id, the pragmatic context, the used protocols and the sender,receiver agents. Each agent implements his own decision and reaction logic in terms of rules with public interfaces which can be accessed and queried and not public rules. These rules might e.g., represent personal strategies, failure handling policies or negotiation patterns, e.g. for meaning clarification. External data sources such as calendars, vocabulary definitions, databases, web pages, meta data sources, personal data (e.g. FOAF profile, vCard) are dynamically queried at runtime and used as facts in the internal knowledge base of an agents.

5. CONCLUSION

Recently, there have been many efforts aiming on rule interchange and building a general rule markup and modelling standard for the (Semantic) Web. This includes several important *general standardization or standards-proposing efforts* including RuleML [3], W3C RIF [25], OMG PRR and others. However, to the best of our knowledge no methodological and architectural design and comprehensive implementation exists which makes this idea of a practical distributed rule layer in the Semantic Web a reality. Moreover, in the current rule interchange formats the pragmatic aspect is missing.

In the Rule Responder project we follow a constructivists design science research methodology [12] and contribute with a rule-based middleware based on modern efficient and scalable enterprise service technologies, complex event processing techniques and standardized web rule and Semantic Web languages in combination with existing meta data vocabularies and ontologies to capture and negotiate the individual and shared semantic and pragmatic context of rule-based agents and service networks. The application in virtual organizations such as Agent communities or (business) service networks is of high practical relevance and transfers the existing work in multi-agent systems (e.g. Jade, FIPA-OS) to the Semantic-Pragmatic Web and rule-based service architecture.

Rule Responder builds upon these existing ideas and technologies in multi-agent systems and tackles the manifold challenges which are posed by the highly complex, dynamic, scalable and open distributed nature of semi-automated pragmatic agents communities or service component architectures. Our proposed design artifact exploits RuleML and Reaction RuleML for the XML-based representation of reaction rules and message based conversations at the platform-independent level as a compact, extensible and standardized rule and event interchange format. A highly scalable and efficient enterprise service bus is integrated as a communication middleware platform and web-based agent/service object broker. Via translator services the interchanged RuleML messages are translated into the platform-specific execution syntaxes of the arbitrary agents' rule execution environments such as Prova. In sum, the proposed design artifact addresses many practical factors of rule-based service technologies ranging from system engineering features like modular management and encapsulation to interchangeability and interoperability between system and domain boundaries in open environments such as the Web.

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DISCOURSIUM for Cooperative Examination of Information in the Context of the Pragmatic Web

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ABSTRACT
This paper argues that examination of information in the context of the Pragmatic Web needs to be conducted in a discursive and structured manner. It focuses on examination dialogues and proposes a novel approach to supporting these dialogues in DISCOURSIUM, a tool and methodology for discursive practice based on the meta-communication architecture [29]. To achieve its objective, this paper firstly describes the characteristics of examination dialogues and justifies the relevance of the meta-communication concepts for critically examining information. It secondly illustrates how they can be modeled in the context of the discourse-support system Compendium in order to provide users with templates for examination dialogues. After discussing the limitations of such a modeling, the paper then presents the rationale and methodology of the DISCOURSIUM. It particularly illustrates how DISCOURSIUM can build on the strengths and potential of some current argument mapping technologies, and how the argument maps created can further be critically examined. Finally, this paper concludes that the objective and characteristics of DISCOURSIUM focusing on the pragmatic aspects of information and examination dialogues intersect with the concepts of the Pragmatic Web.

Categories and Subject Descriptors
H.1.2 [**Models and Principles**]: User/Machine Systems – *human factors.* H.5.3 [**Information Interfaces and Presentation**]: Group and Organization Interfaces – *collaborative computing, computer-supported cooperative work, evaluation methodology, theory and models.*

General Terms
Design, Human Factors, Theory

Keywords
Examination Dialogues, Argument Mapping, Discourse-Support Systems, Information Quality, Pragmatic Web.

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1. INTRODUCTION
In contrast to the Semantic Web, the research on Pragmatic Web emphasizes, as its name suggests, pragmatic aspects of the Web [17]. This implies by definition the inclusion of many research issues and challenges that have been articulated within the research framework "Universal Actability" [31], which concern – among others – enabling actions under the condition of diversities of contexts, views, needs, values as well as abilities of users. We may view them as challenges that arise because of the heterogeneities at various levels of communication such as: the media level (e.g., differences in technological standards); the syntactical level (e.g. differences in formats, language structures); the semantic level (e.g., differences in meanings of terms or ontology); and the pragmatic level (e.g. differences in expectations, norms, values, and information needs of actors). These heterogeneities not only may affect the organization and transmission of messages, but may have also an impact on the receiver's perception and interpretation of the messages [19]. In other words, on the Web, they play a role in information actions of both the information seekers/receivers, who aim to find relevant information for acting in a context, and the information providers/senders, who aim to communicate relevant information to others to support their actions.

As far as the pragmatic level is concerned, *relevance issues* may be seen as one of most significant issues. Many approaches to information filtering determine the relevant information by considering subjective preferences and interests or group profiles. In a group, community members often need to make a collective decision on what information or knowledge is needed, and thus, should be created, managed and transferred to the individuals as well as to the whole society [12, 32]. Different expectations, interests, and values may lead to conflicts, which need to be articulated, negotiated and resolved. In addition, there are other kinds of pragmatic-level challenges that may be referred to as *validity issues.* The conditions of the creation and transmission of the information raise serious issues regarding the validity of information. They concern the authenticity of the person or the institution with which one is communicating as well as the authenticity of the information itself. These quality features of information communications have an impact on the trustworthiness of information and also involve ethical-moral issues [3, 14]. Finally, we may speak of *rationality issues* to refer to those pragmatic-level conflicts which arise because people do or prefer to do things in different ways [10]. This concerns the rationality of processes or activities when creating information as well as when interacting with information (e.g., the rationality of search activities or navigation options, offered by online books or user interfaces).

The diversities may cause complexities and uncertainties as well as conflicts while interpreting or constructing information [19]. The challenges force us to offer support for a collective and critical examination of the information in the context of the Web. The relevance of discourse-oriented approaches and tools for supporting *sense-making* activities (i.e., capturing, comprehending and managing competing interpretations and arguments) on the Pragmatic Web has already been articulated, e.g. in [5, 22, 29]. Previous research has also shown that adding structures to online discussion environments improves the group's ability to reach consensus and make higher-quality decisions [8]. Motivated by these reasons, this paper addresses the issue of how examination of information can be achieved in a discursive and structured way; it suggests a tool and methodology called DISCOURSIUM that aims to support critical examination dialogues in a discursive manner and thereby enables the integration of cognitive inputs and expertise from diverse perspectives. This paper contributes to the research on the Pragmatic Web by proposing a new approach to examination of information based on the meta-communication architecture [29] and a demonstration of the matching of the meta-communication architecture and its potential support in DISCOURSIUM.

This paper is organized as follows. Section 2 introduces the theoretical background needed for a good understanding of the paper. This consists of a review of works related to examination dialogues, including the author's work on the meta-communication architecture, and issues related with examining information on the Pragmatic Web. Next, section 3 illustrates the potential use of the discourse-support system Compendium to model the meta-communication concepts in order to provide users with templates for examination dialogues. After discussing the limitations of such a modeling, this paper presents DISCOURSIUM as a new tool and methodology for cooperative examination dialogues and discusses its rationale and discursive methods for structured dialogues. It particularly illustrates how DISCOURSIUM can build on the strengths and potential of some current argument mapping technologies, and how the arguments maps created can further be critically examined. Finally, this paper provides some conclusions.

2. THEORETICAL BACKGROUND

2.1 Characteristics of examination dialogue

Walton and Krabbe [24] suggested a classification of human dialogues in six primary dialogue types: (1) *Information-seeking dialogues*, where one participant seeks the answer to some question(s) from another participant; (2) *Inquiry dialogues*, where participants collaborate to answer some questions; (3) *Persuasion dialogues*, in which one participant seeks to persuade another to accept a statement; (4) *Negotiation dialogues,* where the participants bargain over the division of some scarce resource; (5) *Deliberation dialogues*, where participants collaborate to decide what action(s) should be adopted in some situation; (6) *Eristic dialogues*, in which participants seek to vent perceived grievances.

This typology has been recently extended by a special type called *examination dialogue* [7; 26]. According to Dunne et al [7]:

"In such dialogues one party – the Questioner Q – elicits statements and opinions from another – the Responder R – with the aim of discovering R's position on some topic, either to gain insight into R's understanding and knowledge of the topic, or to expose an inconsistency in R's position. Examples include education by the Socratic method, viva voce examination, cross-examination of witnesses, and political interviews. In contrast to information seeking or inquiry dialogues, Q may already have beliefs on the topic: unlike persuasion dialogues, Q may have no intention of converting R to his position. Examination dialogues may, however, be nested within information seeking dialogues: probing for inconsistency increases confidence in the veracity of R's beliefs; similarly, in persuasion dialogues, exposing inconsistency is a useful prelude to persuasion." [7, p. 1560].

Similarly, Walton [26] argues that examination intervals can occur in various kinds of dialogues and that examination dialogue is more than just information-seeking; it involves elements that we normally associate with persuasion dialogue. Concerning the central characteristics of this type of dialogue, he shows that examination dialogues have two goals: the extraction of information and the testing of the reliability of this information. The first goal is carried out by two means: by asking questions in order to obtain information from the respondent, and by an exegetical function used to obtain a clear account of what the respondent means to say. The second goal is carried out with critical argumentation used to judge whether the information elicited is reliable. The information is tested, for example, against other known facts or statements.

At this point we should note that, in this paper, we do not limit examination dialogue to a conceptualization that is based on a dyadic dialogue (Questioner and Responder). Rather: we consider broader, group-based collaborations for critical examination.

Concerning the structure of examination dialogue, Walton [26] distinguishes two basic levels, and argues that examination as a whole needs to be seen as based on a characteristic dialectical shift from the first level to the second. For example, in the case of examination of written texts, an examination dialogue begins with some text of discourse in natural language. At the first level, the exegetical reconstruction of a text needs to be judged on its own merits. In this clarification mode, meaning may be negotiated between the participants. The second level is more openly argumentative. The dialogue at this level can have the form of critical discussion, in which the critic may, for example, express doubt about the argument attributed to the author. Somebody may represent the viewpoint of the author and may respond to the critic. Thus, Walton concludes that: "It is the joining together of these two levels that represents the structure of examination and defines it as a type of dialogue" [26, p.775].

This characterization of examination dialogue fits well with the two level architecture of meta-communication which was suggested within the Language-Action Perspective on communication modeling [11, 33] and has been further developed in [29]. The meta-communication architecture distinguishes between *the conversation for clarification level*, where clarifications take place, and *the discourse level*, where conflicts are discussed with arguments. Participants can shift from clarification mode to discourse mode to resolve conflicts. When regarding a text of natural language as an object of the communication action level, an examination dialogue on the text can be viewed as a type of meta-level communication. Thus, the two levels of examination dialogues correspond to that of the meta-communication architecture. Hence, our first conclusion from this similarity is the applicability of the concepts of the meta-communication model [29] for structuring examination dialogues. This is one of the background assumptions of this paper.

The second assumption concerns the relevance of these concepts for the Pragmatic Web, particularly, for examining information for action in the context of the Web. For this purpose, we next briefly describe the theoretical foundation of these concepts and justify their relevance.

2.2 Examining information on the Pragmatic Web

The concept of information has gained attention in many disciplines, including the Computer and Information Sciences as well as Information Systems (for an overview, see [1, 28]. A great deal of emphasis is placed on understanding the differences between data, information, and knowledge. The diversity of views exists concerning not only what is deemed to be information and knowledge, but also concerning the direction of transformation from one into another.

One commonly held view is that data consists of raw numbers and facts, information is processed data, and knowledge is authenticated information. Knowledge is regarded as information stored in the minds of individuals: It presumes a hierarchy from data to information and from information to knowledge. Contrary to this view, it is also argued that the assumed hierarchy from data to knowledge is actually inverse; knowledge must exist before information can be formulated and before data can be measured to form information. In other words, knowledge exists which, when articulated, verbalized and structured, becomes information which, when assigned a fixed representation and standard interpretation, becomes data [1].

Although these views differ in their understanding of the hierarchy, they both assume that knowledge does not exist outside the knower. Either information is converted into knowledge once it is processed in the minds of individuals, or knowledge becomes information once it is articulated and presented in the form of text, graphics, words, or other symbolic forms [6]. However, what some researchers call information is for others explicit knowledge [15] or codified knowledge. Berger and Luckmann [3] speak of a social stock of knowledge, which is constructed through the articulation of subjective experiences, i.e. a person's subjective knowledge is translated into signs and transmitted to other persons. Kuhlen [14] expresses that for a specific action all actors need not only specific knowledge, but also a specific form. In this view, information is regarded as a relevant subset of knowledge. "Information work" takes existing knowledge and transforms it in such a way (i.e., adds value to it) that it can more easily become information (i.e. understandable and relevant) for specific actions.

Depending on the definitions used, information and/or knowledge are regarded as necessary conditions for rational action. Actors not only have knowledge about things, but also knowledge for action, and knowledge can also be gained in and through action. Habermas [10] points out that possession of knowledge alone cannot secure rational practice and that "rationality has less to do with the possession of knowledge than with how speaking and acting subjects *acquire and use knowledge*" (ibid. p.8).

By acknowledging the diversity of views on the concepts of information and knowledge and their relation to action, Yetim [32] suggested an interpretation of the relationship of these concepts from two different perspectives, the perspective of the receiver and that of sender/provider. Figure 1 shows a possible interpretation of the interdependency of information, knowledge, and rational action. The idea of organizing the three concepts in form of a 'staircase' is borrowed from [21], who only considers a one-sided staircase (the left side) within the context of system development. In [32] the double-sided staircase is considered to include both receiver's and sender's perspectives in our interpretations. Accordingly, the left side expresses the perspective of receivers/users of information whereas the right side the perspective of senders/providers of information.

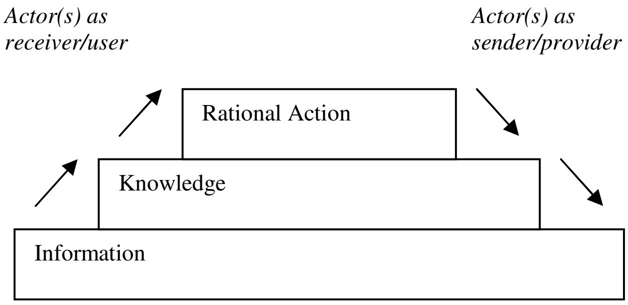

Figure 1. Information, knowledge, and rational action.

From the perspective of a receiver, data becomes information when it is comprehensible and relevant. Being comprehensible and relevant does not also mean being valid or free of errors. Information becomes knowledge when it is validated. Knowledge is then applied for conducting rational action (i.e. information → knowledge → rational action). In other words, in the receiver's perspective, an actor's main goal is conducting rational action and reflecting whether received information is also relevant knowledge for that purpose (e.g., Is this information reliable? Does it allow rational practice?).

In the provider's perspective, an actor's main goal is informing others (i.e., rational action → knowledge → information). Actors(s) can reflect on what knowledge (or subset of knowledge) and experiences from previous actions should be provided/articulated/transferred, and in what form in order to become information for the potential receivers (e.g., what knowledge was useful? What knowledge was not appropriate? How should I articulate and transfer my experiences? For whom? For what purpose?).

Of course, both perspectives can be taken by a single person as well. For example, a teacher searching for slides in the Web can critically examine the slide found before using them in the class (receiver perspective). He or she can also rewrite/improve them after having used them, i.e. constructing information for others. This kind of reflections during and after doing something have been characterized as "reflection in action" and "reflection on action" [18] or - in relation to communication - as meta-communication-in-action and *ex ante* meta-communication [29].

We claim that a detailed analysis of the concepts of information, knowledge, and standards of rationality of actions can provide the basic issues to be used for the systematic examination during the interpretation and use of information received from others as well as during the articulation and transferring of experiences as information to others. Yetim [29] provides a detailed description of these issues and concepts of the model.

Issues at the clarification level (extended from [21]) are called: *Physical Clarity* of signs; *Syntactic Clarity* of signs; *Semantic*

Clarity of signs; *Relevance* of signs; *Expressive Validity* of statements; *Empirical Validity* of statements; *Normative Validity* of statements; *Instrumental Rationality* of action; *Strategic Rationality* of action; *Aesthetic Rationality of* signs; *Communicative Rationality* of decisions.

The discourse level of the model contains several types of discourses and reflective media proposed by Habermas [9,10]. They are: *Explicative Discourse* for justifying the comprehensibility of signs; *Pragmatic Discourse* for justifying the relevance (purposefulness) of the choices; *Therapeutic Critique* for critical examination of the sincerity of expressions; *Legal Discourse* for justifying the legitimacy of actions/expressions; *Theoretical Discourse* for explaining/justifying the truth of expressions and the efficacy of actions; *Aesthetic Critique* for critical examination of aesthetic value standards; *Ethical Discourse* for justifying actions from a (cultural) value perspective; *Moral Discourse* for justifying the universal rightness of norms or practices. See Confer [29] for a detailed discussion.

It should be obvious that many of the clarification issues characterize different aspects of information communication, dealing particularly with the pragmatics of communication. They thus help to address many of the issues related with the Pragmatic Web, as articulated in the introduction part. In what follows we present how these theoretical concepts can be used in practice.

3. FROM THEORY TO PRACTICE: MODELING WITH COMPENDIUM

3.1 Compendium

Compendium[1] is one of the advanced discourse-support tools available today, which facilitates the capture and structuring of ideas. It can be used not only to model dialogues around problems, but also to model problem domains in a manner that structures contributions [4, 5]. Compendium's ontology expresses Rittel's IBIS (Issue-Based Information Systems). The representational focus is on capturing key issues, possible responses to these, and relevant arguments. Compendium allows users to define their own ontology or to map concepts in an unconstrained manner. Two modeling methodologies, *Dialog Mapping* and *Conversational Modeling,* have been developed around the capabilities of Compendium. In Dialog Mapping, Issues are usually unconstrained freetext expressions summarizing an agenda item or participant's contribution. In Conversational Modeling, they are driven from a modeling methodology (for example, an organizational procedure), and Issue nodes can be saved as reusable *issue-template structures* to seed different kinds of discussions [5].

This capability of Compendium to provide predefined structure to aid structured conversations is one of its characteristics that makes it particularly relevant for this paper. Such a tool can be of practical value, not only for investigating how its functionality can be used to model our structures for examination dialogues, but also for enriching Compendium's own catalogue of reusable conversation structures or issue-templates. For modeling, Compendium offers some flexibility concerning the usage of its links and nodes. Consequently, there are different options for modeling our concepts. For example, we may use either Issue nodes or Maps to realize the issues and discourses. We may integrate clarification issues and discourses in a single level or separate them. In what follows, we illustrate some options and discuss their pros and cons.

3.2 Modeling each level as an independent pattern

Figure 2 shows the usage of the concepts of both levels as two separate *patterns* or templates for discussions. The issues at the conversation for clarification level are modeled by issue nodes whereas discourses by maps. Alternatively, one might model the clarification issues as maps to reduce the complexity in

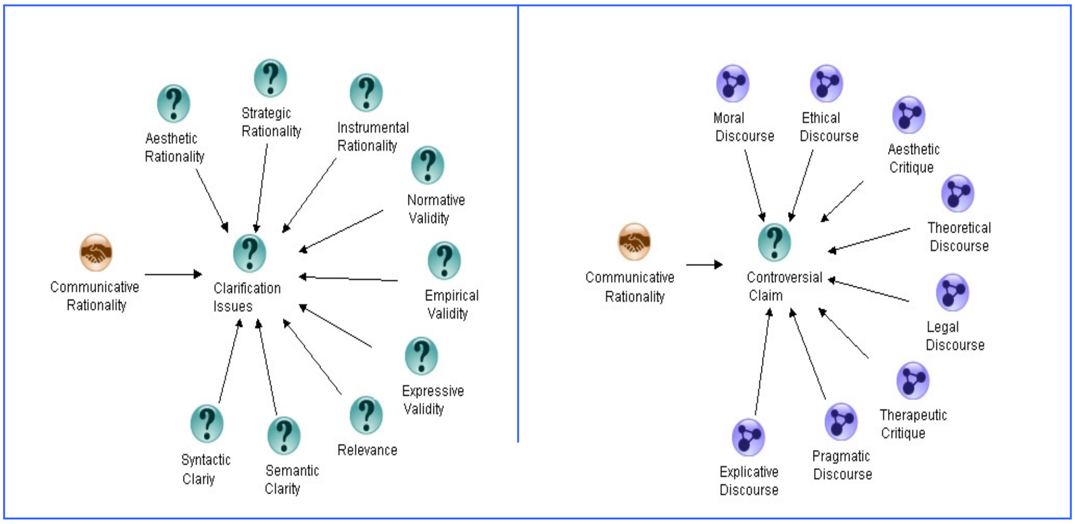

Figure 2. Clarification issues and discourses as independent templates.

discussions. As the issues and discourses are thematically related, one might prefer to use only one of the two patterns to structure conversations. In both templates, the node "communicative

[1] Available at: www.CompendiumInstitute.org

rationality" is used to capture the decisions. Alternatively, this node can also be used for each issue or discourse map separately.

Such patterns can seed conversations of different sorts with issues, positions and arguments. However, for examination dialogues, more interesting is their usage in combination, in order to separate "just talking" from argumentation in support of conflicting positions.

3.3 Modeling two levels as an integrated complex pattern

The concepts of both levels can be integrated in two different ways, either by integrating the issues into the discourse maps or by connecting the issues and discourse maps.

Figure 3 illustrates the realization of the first option, which suggests modeling each discourse as a map and integrating the related clarification issues. As an example, the figure also shows the explicative discourse with its issues. The primary concern of the explicative discourse is examination of the controversial claim to comprehensibility of signs. The clarification issues are viewed as sub-issues of it. This pattern with initial clarification issues can be extended with additional (sub)issues which may emerge in real time.

the related concepts of both levels, as shown in Figure 4. This complex template provides a structure of expected clarification issues to which responses can be linked in a conversation. At the same time, emerging conflicting positions can be captured within the related discourses. In this way, discourses contain only conflicting positions with pro and con arguments, whereas contributions to the issues are conversations for clarifications. When contributions to issues grow, the issue nodes can be changed to maps to integrate them and to manage the complexity to some extent.

Based on these illustrations, we can conclude that our templates can enrich Compendium's catalogue of reusable patterns for team deliberation. Yet, some challenges remain, despite the fact that there are many ways of modeling the concepts to provide issue-templates or patterns to enable structured and systematic examination within the Compendium system. One important challenge is that realizing the rationale behind the two-level architecture [29] in the form as shown in Figure 4 may lead to complexity in real time. When an issue or position in a discourse map needs further examination (for example, an ethical issue in pragmatic discourse), this can be done: (a) within the same map (i.e. the pragmatic discourse) by adding new positions/arguments; or alternatively, (b) by examining it in the thematically related map (i.e., in the ethical discourse) and then creating relation to the

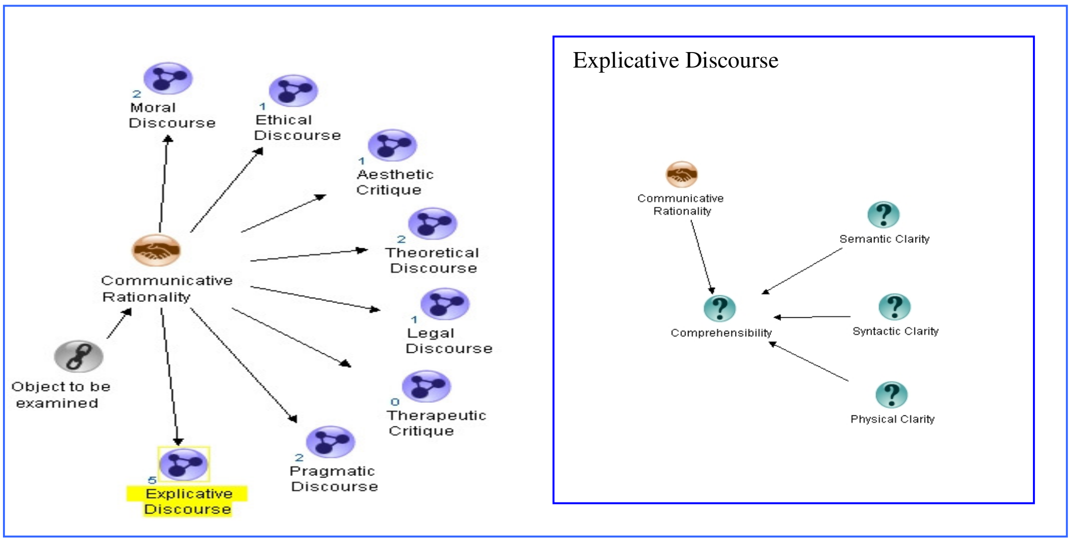

Figure 3. Explicative discourse with integrated clarification issues.

This option thematically structures/groups the conversations by discourse maps, and within each map, by specific issues. The advantage of this hierarchical organization is that it reduces the number of nodes visible to the users. On the other hand, this option does not allow users in real conversations to clearly separate conversations for clarifications from arguments for conflicting positions since it implies the capturing of all types of relevant communicative contributions within a map.

The second option for modeling concepts aims at separating clarification issues from argumentative discourses, by connecting

initial map (i.e. to the pragmatic discourse). In the first case, with the growing number of contributions, the content of a map may become not only complex, but also it may not clearly separate clarification issues that may emerge during a dialog and arguments. On the other hand, the second option requires switching between discourses in dependence of the nature of issue at hand, which would create additional complexity and difficulties for managing dependencies between discourses.

In the next section, we discuss how we can deal with these challenges of the two-level architecture within DISCOURSIUM.

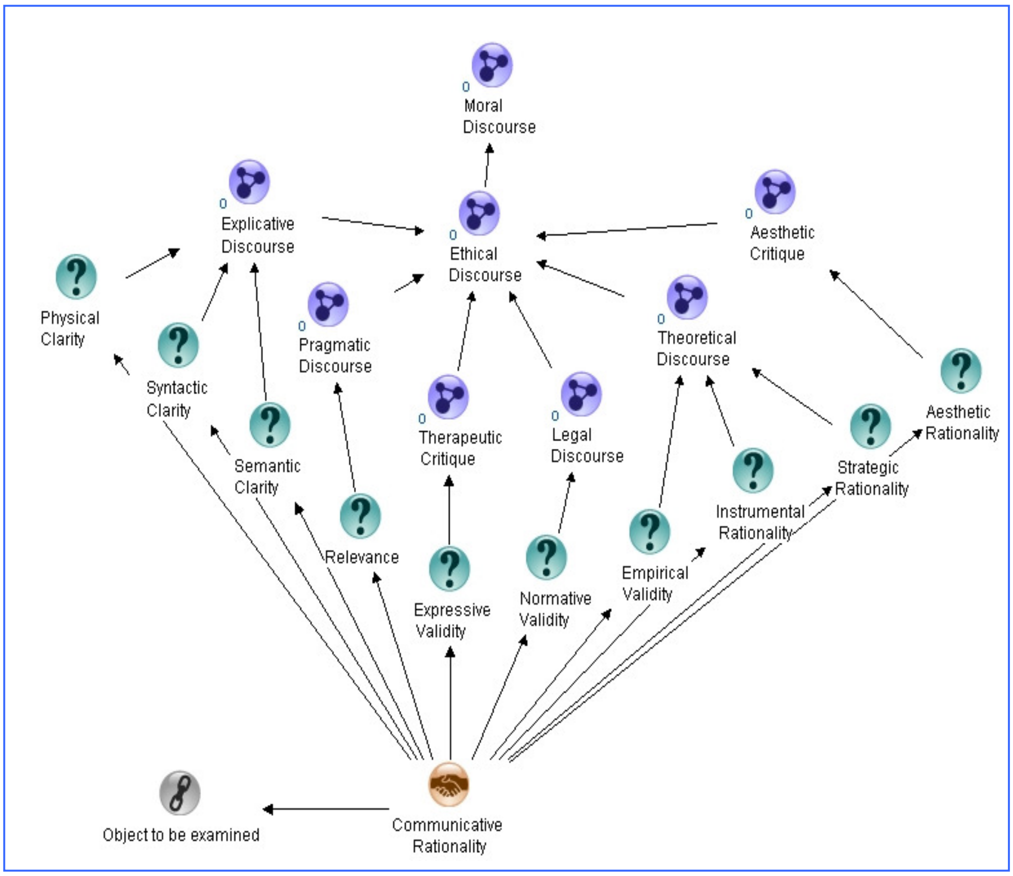

Figure 4. Modeling the interconnection of two levels as a template.

4. FROM COMPENDIUM TO DISCOURSIUM

DISCOURSIUM can be conceived as both a tool and a methodology for facilitating structured and discursive examination practice. As the tool is currently under development, we will first briefly describe its rationale and basic components, and then discuss and illustrate how realization of the discourse-level concepts of the DISCOURSIUM can build on the strengths and potential of some current argument mapping technologies and argument schemes.

4.1 The rationale and basic components of DISCOURSIUM

As mentioned above, one of the rationales behind the two-level architecture (i.e., the clarification and the discourse level) is to separate conversations for clarifications and interpretations from argumentation around controversial claims. In addition, deliberativeness is viewed as a criterion for good discourses - at least from the perspective of Habermas' discourse theory [10] - which requires a dialogical form of discussion. Although theoretically reasonable, from a practical point of view the full implementation of the two separate levels with dialogical discussion at each level may add additional complexity to the abstract concepts used in our model. For example, practicing threaded discussions at each level may lead to inefficiency. Moreover, as mentioned before, each discourse type is responsible for examining specific types of controversial claims, and the theoretical idea of switching between discourses to examine controversial claims in related discourses may in practice become challenging for the participants, as articulated by Wellmer [29]. The management of the complex relationship between the discourses in real time requires also additional cognitive and technical efforts. Another problem concerns the expertise required for the usability of such a system, as participants are expected to know which discourses are appropriate for which types of controversies or communication breakdowns, in order to place their positions in the right discourse.

These challenges drive the exploration of alternative design. Without giving up the theoretical idea of separating discourses for different validity claims, we suggest the following compromise solution for practical reasons, which, one hopes, can make the complexities mentioned to some extent manageable.

- First, we consider one level for interaction where examination dialogues take place in a structured way. The examination issues presented earlier make the semantics of possible contributions explicit, and participants can articulate themselves as in a discussion forum by selecting the appropriate issue and contributing to it.
- Second, we deal with the argumentative examination of conflicting positions in discourses in the following way: We consider a facilitator or moderator who is responsible for analyzing/summarizing positions at the conversation for clarification level mentioned above and

creating an "argument map" (or "discourse map") for each discourse. He or she submits each discourse map containing the controversial positions with associated pro or contra arguments into the system for further examination. This means that participants do not enter the discourse level to directly contribute to a map with their arguments. Rather, they use the forum with the repertoire of critical issues to articulate their views/critiques on a discourse map. In this way, they indirectly interact with the positions and arguments of other participants at the discourse level.

That means that both the objects (e.g., texts or any other design proposals) subjected to examination dialogues and the discourse maps created to capture controversial positions are examined within the same forum. This relieves participants from having to know what issue/claim is to be discussed in which discourse. They just need to learn using critical issues for examination. The main activities are: (1) Users examine an object (e.g., a text or a design proposal); (2) A facilitator creates argument maps for each discourse; (3) Users examine the maps.

The DISCOURSIUM system that aims to support such an interaction can be split into the following basic components:

- A window which allows users to open (a) an object (e.g., a text) from a file or URL, or (b) a discourse map for examination;
- A forum which provides users with the categories of issues and allows them to explicitly name the problem that they address;
- An editor which allows argument diagrams to be constructed from discussions;
- Finally, an interface to the database of discussions, examination objects, and maps.

As the system is under development and the current version does not support argument diagramming, we illustrate in the following the DISCOURSIUM methodology by exploiting the capabilities of current argumentation technologies. Due to limited space, we focus on the argumentation-related aspects of the discourse-level and ignore the initial activities of users such as opening a text for examination and providing contributions to the forum. In particular, we will first discuss some options for DISCOURSIUM moderators to construct argument maps for discourses, and then, discuss how users may examine the maps.

4.2 Mapping arguments for discourses

To analyze or construct arguments is hard, not only for the naïve users, but also for moderators as well. A variety of tools and techniques have emerged from the theory of argumentation, which support the task of analysis and diagrammatic representation/visualization of arguments (e.g., [13]). In what follows, we illustrate three different approaches for diagramming and visualizing arguments for discourses by using three different argumentation tools. One is the Compendium with its IBIS method for diagramming as introduced earlier, the others are the Rationale (www.austhink.org) and the Araucaria system [16], which allow use of the conventional "box-and-arrow" approach and also support Toulmin-like schema representations [20] with its six parts (Data, Warrant, Claim, Backing, Rebuttal, Qualifier).

For illustrations, consider the scenario of examination of a design proposal for presenting information on an interface. While examining a proposal, participants provide their concerns with respect to the issue of *relevance*. For example, some participants claim that they need a multilingual version of the system and provide some reasons for their position, others disagree. In this situation, a moderator's task is to construct a map for the "Pragmatic Discourse", which is related to the issue of *relevance,* in order to visualize the conflicting positions with associated arguments. How can the same arguments be mapped using three different tools?

4.2.1 Mapping arguments with Compendium

Figure 5 shows an example of the IBIS argument structure constructed for the pragmatic discourse. Although Compendium incorporates slightly different terminology (i.e., Question node, Answer node, Pro node, and Con node), moderators were able to rename the icons to represent argumentation in a given context. This flexibility of naming allows representing the multiple components of Toulmin's model of argument as well. A moderator may introduce a controversial claim in the form of an issue (e.g., "Do we need a multilingual version of the system?"), and link the available positions to them. Or, he or she can represent the controversial claim as a position statement (e.g., "We need a multilingual version of the system."), and link the pro or counter-arguments to this position. Rebuttals (e.g., "Unless we can recoup …") and arguments supporting rebuttals can also be added.

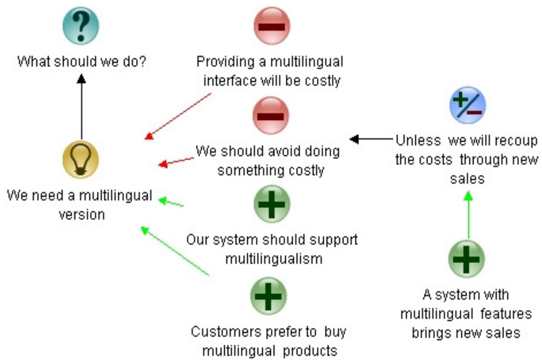

Figure 5. Visualizing arguments of a discourse as IBIS.

Additionally, moderators can create links (e.g., supports, contradicts, competes with, etc.) that indicate relationships between arguments. Finally, the communicatively achieved agreement among participants (in the sense of communicative rationality) can be articulated in the same map by using a *decision node*.

Of course, there are alternative ways of mapping the same example. This is a rudimentary example; arguments can become extremely complex and elaborate. Yet, it is important to emphasize that each discourse map should have its main controversial validity claim or issue. A discourse map (e.g., a map for the pragmatic discourse) can have different types of reasons (e.g., ethical or aesthetical reasons), which provide support for the main claim of the map. However, one should discuss the validity of these reasons in the related discourses, e.g., by creating ethical or aesthetical discourse maps.

4.2.2 *Mapping arguments with Rationale*

The Rationale[2] is another tool for analyzing and constructing arguments. The system offers two types of argument maps: Reasoning and Analysis. A reasoning map is used to show the relationship between claims, or sentences that state a *position*, *reason* or *objection*. An analysis map extends the reasoning map and facilitates understanding of multiple claims and their evaluation.

The map in Figure 6 is constructed using the analysis map. The top node is the *position*, which is also called the contention, the conclusion or the issue, depending upon the context. A *reason* is a claim which provides evidence that another claim is true. An *objection* is a claim which provides evidence that another claim is false. A rebuttal is an objection to an objection. In the argument map, the colors of the boxes signify the sort of claims they represent, e.g., green for supporting reasons, red for objections, and orange for rebuttals. Additionally, Rationale provides bases boxes such as "expert opinion", "personal experience", "common belief" "example", etc., which can be used to display the basis of a claim. Finally, there are other labels to indicate the role of a reasoning box, such as "because" for a reason, "but" for an objection and "however" for a rebuttal.

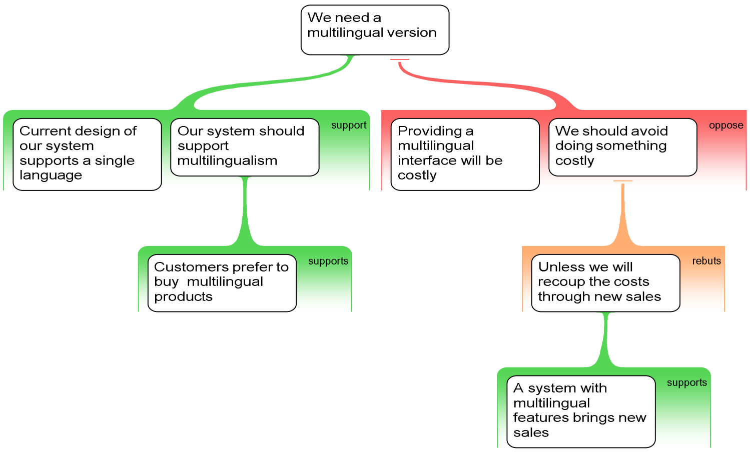

Figure 6. Visualizing arguments by using Rationale.

4.2.3 *Mapping arguments with Araucaria*

Araucaria[3] is designed to support the manual analysis and diagramming of arguments and the subsequent storage of that argument for a variety of computational and pedagogic purposes [16]. Like Rationale, Araucaria employs a tree structure for mapping out the relationships between components in an argument. Figure 7 illustrates our example created using Araucaria.

Araucaria differs from all other argumentation software in its provision of Argument Markup Language. In addition, Araucaria allows argumentation representation within different theoretical frameworks. Once a diagram is constructed, Aracuaria is able to transform this diagram into another, e.g., from the standard "box-and-arrow" into the Toulmin schema [20]. While using Araucaria a moderator can decide in which framework (s)he wants to work.

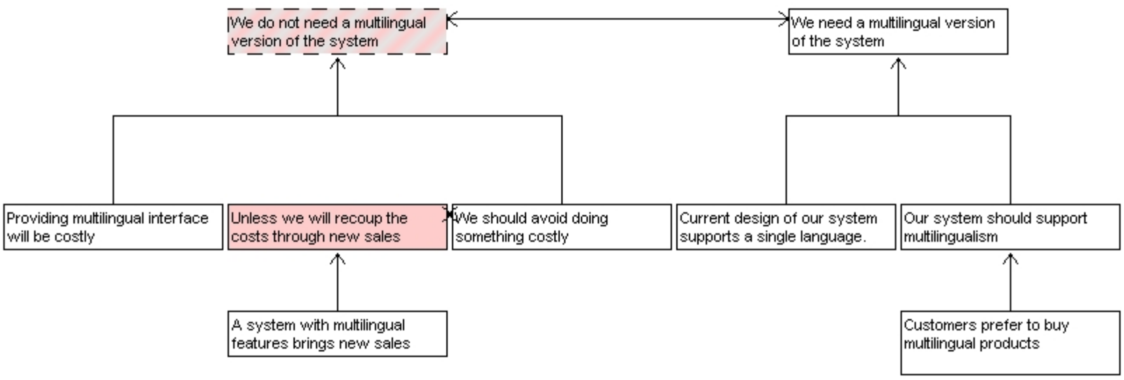

Figure 7. Visualizing arguments of a discourse as standard method using Araucaria.

4.2.4 *Concluding remarks to maps for discourses*

In conclusion, the different argument support systems provide different options and theoretical frameworks in which a moderator

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[2] www.austhink.org

[3] http://araucaria.computing.dundee.ac.uk

can work to analyze the discussions in DISCOURSIUM forum and to visualize them in a map. Having a Toulmin-like structure of an argument in mind, we have illustrated by means of a simple example that the same content can be visualized using these tools. As the tools provide different means or constructs to express and visualize arguments, facilitators need first of all to make a decision on which framework they want to work within.

Whatever tool is used for mapping, it is particularly important to consider that a discourse map has a main controversial issue or validity claim to which arguments in the map provide supporting or challenging reasons. As mentioned above, arguments in a discourse map (e.g. in the pragmatic discourse) can have different types of reasons (e.g., ethical or aesthetic reasons). However, when the validity of these reasons is challenged, an extensive discussion should not be carried out in the same map. Instead, facilitators can create related submaps for each of them (e.g. ethical and aesthetical discourse maps) and link them to the corresponding position. This conforms to the theoretical idea of using different types of discourses for different validity claims. In addition, it has practical value because a submap that captures the justification of a specific claim can be linked to other discourse maps where the corresponding claim is used for supporting or challenging arguments. On the other hand, this requires effective management and presentation of interlinked maps in order to make them usable.

The usability of argument visualizations is, in general, a relevant issue worth for further investigations. It concerns the usability of tools for facilitators, and more important, the usability of argument maps for the participants. Assessing the recent empirical research into the effectiveness of visualization tools, van den Braak et al. [23] conclude that most research points to a positive effects of the tools on the users' argumentation skills. After working with the three tools, we find that both Compendium and Rationale offer advanced visualization options, whereas Aracuaria's strength is its ability to provide an interlingua for different frameworks and to translate between diagrams. That said, we will next address the issue of how the discourse maps can be examined.

4.3 Examining discourse maps

Visualized arguments for each discourse can be critically examined or evaluated in different ways. One option is to ask some critical questions (e.g., those presented in this paper) in a forum-like discussion. This approach is advocated in DISCOURSIUM. Another approach suggests using argumentation schemes from argumentation theory that are considered fundamental to examination dialogues [26]. In this section, we will briefly introduce the schema-based approach and then discuss its integration within the approach of DISCOURSIUM. For this purpose, let us first look at the argument map in Figure 8, which is adopted from the Rationale system. It illustrates how different sources can be used for justifying claims.

The relevant issue here is, when someone argues, for example, that (s)he should be believed because an expert agrees with her or him, what the assumptions behind such an argument are and how such an argument can be challenged.

In argumentation theory, argument schemes represent stereotypical kinds of ordinary reasoning, and are used to identify, analyze, and evaluate arguments [26]. There is a set of common schemes, including argument from expert opinion, argument from sign, argument from example, argument from analogy, argument from position to know, argument from popular opinion, argument from popular practice, argument from an established rule, argument from consequence, etc. These schemes are called presumptive or defeasible, meaning that they fail in some instances, for example when challenged by critical questions. Each scheme has a special set of critical questions matching it. An argument is evaluated using the critical questions. The critical questions pinpoint the assumptions behind an argument.

Consider the scheme for "argument from expert opinion", which is seen as fundamental to examination dialogues. Walton [26, p.750] presents it in the following way:

> *Appeal to expert opinion*
> *Source Premise*: Source E is an expert in subject domain S containing proposition A.

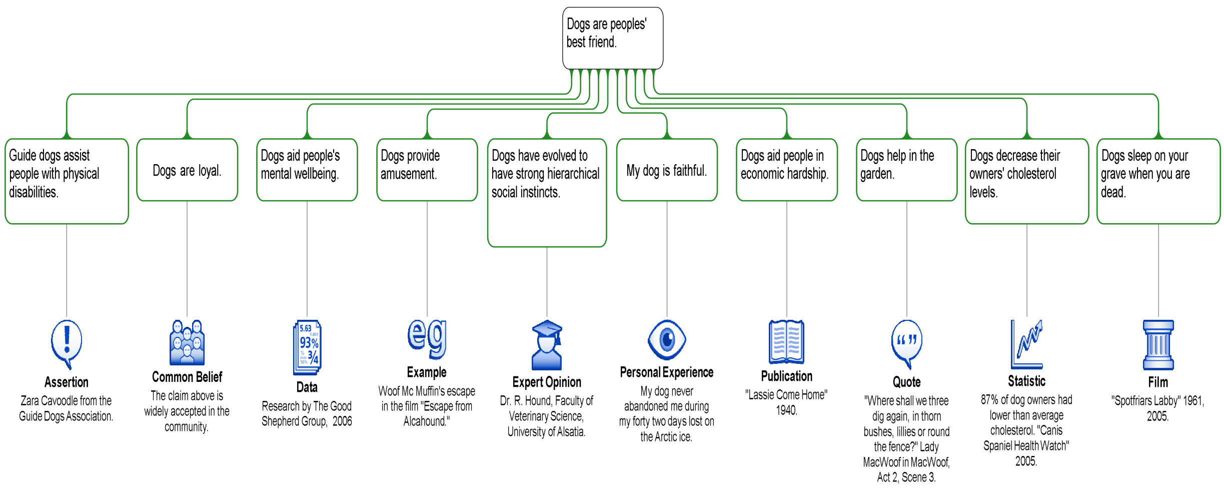

Figure 8. Example of diverse arguments in a map adopted from Rationale (© Austhink Software).

Assertion Premise: E asserts that proposition A (in domain S) is true (false).
Warrant Premise: If source E is an expert in subject domain S containing proposition A, and E asserts that proposition A (in domain S) is true (false), then A may plausibly be taken to be true (false).
Conclusion: A may plausibly be taken to be true (false).

For the argument to be of this type, it must have the three types of premises represented in the argumentation scheme. There are six critical questions matching this scheme.

1. *Expertise Question*: How credible is E as an expert source?
2. *Field Question*: Is E an expert in the field that A is in?
3. *Opinion Question*: What did E assert that implies A?
4. *Trustworthiness Question*: Is E personally reliable as a source?
5. *Consistency Question*: Is A consistent with what other experts assert?
6. *Backup Evidence Question*: Is E's assertion based on evidence?

The critical questions represent different ways of challenging the premises of appealing to expert opinion. This argument scheme can be used to evaluate any given case in which appeal to expert opinion has been used as an argument.

From a theoretical point of view, there is no doubt concerning the usefulness of argumentation schemes for analyzing and evaluating arguments. Yet they may appear too complex to the users, except the experts, and thus give rise to such issues as: How much from the large set of schemes should be provided as templates without making the system too complex for the user? Or how many schemes can easily be learned by the users? Can users easily identify in a dialogue which scheme applies, in order to be able to ask the matching critical questions? Moreover: Do they need to know the schemes to ask critical questions?

Having a closer look at the critical questions matching not only the scheme above, but also many other schemes in [25], we recognized that many critical questions – if not all – can be reinterpreted or regarded as instances or sub-issues of those clarification issues presented in this paper. As space does not permit a detailed discussion of these issues, we briefly illustrate our position with the help of Table 1. As the example questions illustrate, many critical questions can be asked with respect to expert opinion. Similarly, critical questions matching other schemes can be integrated. In addition, as shown in the table, the maps themselves can also be critically examined by using the same categories of issues. In this case, the respondent of the critical questions is/are the moderator(s) who analyzed the discussions and created the maps. As participants can articulate their critiques with respect to both the content of a map (i.e., arguments of participants) and the design of a map (for which the moderator is responsible), moderators should be seen in a collaborative examination dialogue with other participants.

All in all, this paper argues that using the categories of DISCOURSIUM, participants can ask many of the critical questions matching the schemes. Once again, the issue is: Do we need to identify the scheme for asking appropriate questions? Or can we just ask questions that we regard as appropriate, and let others challenge our questions in case of inappropriateness? We claim that our abstract issue categories reduce the set of questions that need to be learned, while providing orientation for the creation of semantically related sub-issues for specific cases. Based on this, we hypothesize that the issue categories used within the forum of DISCOURSIUM can be of value for critical examination of the contents and forms of the argument maps, and thus, for their improvements.

Table 1. Examples for critically examining argument maps.

Categories of Critical Issues	**Examples for questioning expert opinions**	**Examples for questioning maps**
Physical Clarity	"Is the expression of the expert perceivable/readable by all?"	"Are texts/nodes/links on the map readable/visible?"
Syntactic Clarity	"Is the expression of the expert syntactically clear?"	"Are expressions/links on the map syntactically correct?"
Semantic Clarity	"Is the meaning of what expert said comprehensible?"	"Are texts/links on the map comprehensible?"
Relevance	"Is the assertion of the expert relevant to the domain?"	"Are all relevant arguments included in the map?"
Expressive Validity	"Is the expert known to be trustworthy?"	"Do expressions on the map reflect the sincere intentions of their owners?"
Empirical Validity	"Is expert's assertion based on evidence?"	"Are all claims on the map really asserted?"
Normative Validity	"Is the expert really authoritative in the relevant field?"	"Do representations on the map violate any legal norm or cultural value (e.g., ownership, copyrights)?"
Instrumental Rationality	"Is the expert (known to be) well organized?"	"Are boxes/nodes on the map efficiently organized?"
Strategic Rationality	"Is the assertion covertly motivated by expert's egocentric calculation of success?"	"Are some arguments strategically omitted/ misinterpreted/ wrongly placed?"
Aesthetic Rationality	"Is the expression of the expert emotionally loaded/ aesthetically appealing?"	"Do symbols/colors on the map look beautiful?"

5. CONCLUSIONS

In this paper, we have argued that examination of information in the context of the Pragmatic Web needs to be conducted in a discursive and structured manner. Motivated from this, we briefly described the characteristics of examination dialogues and discussed some structural concepts and basic issues for examining information. As demonstrated, these concepts may have practical value and may enrich the repertoire of templates to support deliberation in Compendium. We have shown that DISCOURSIUM methodology can facilitate structured examination dialogues in a manner compatible with critical discursive practice, and can build on the strengths and potential of existing argument visualization tools. The proposed issues for clarifications can also be used for critically examining arguments. Therefore, we conclude that the objective and characteristics of DISCOURSIUM focusing on the pragmatic aspects of both information and examination dialogues intersect with the concepts of the Pragmatic Web.

This paper raises several issues that may be of value to practitioners and researchers. One practical issue concerns the management of the relationships between the maps or parts of the maps as well as between the maps and the discussions in the forum, e.g., for the purpose of the traceability, accountability and authorship. In addition, this paper has focused on mapping arguments for discourses in a declarative way without considering the complexities involved in supporting the processes of argumentative dialogue and the way such representations are actually dynamic in 'real' argumentative discourse. Some of these complexities of live discourse need to be considered in the context of the modeling approach that is proposed. Finally, experimental work would help to understand the use of the proposed system/methodology in real situations.

6. ACKNOWLEDGMENTS

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Logical Argument Mapping: A cognitive-change-based method for building common ground

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ABSTRACT

In this paper, I situate Logical Argument Mapping (LAM) within the broader context of IBIS-based Computer Supported Argument Visualization (CSAV) and Dialogue Mapping, and argument mapping as realized in *Rationale*. While the primary goal of these methods is to clarify issues and to augment cognitive processes, LAM's purpose is to motivate cognitive change by establishing a normative standard of argumentation.

Categories and Subject Descriptors

H.1.2 [**Models and Principles**]: User/Machine Systems – *human factors, human information processing, software psyckology*

General Terms

Management, Documentation, Human Factors, Languages, Theory.

Keywords

Computer Supported Argument Visualization (CSAV); diagrammatic reasoning; Dialog Mapping; Logical Argument Mapping (LAM); Rationale; Jeff Conklin; Charles S. Peirce; Tim van Gelder.

1. INTRODUCTION

Talking about the role "the Web" can play in fostering mutual understanding across cultural, intellectual, and other boundaries, and in building common ground among people who often experience difficulties in understanding each other based on their very specific perspectives, values, and interests, the first thing that comes to mind is the fact that communication and cooperation can be improved by *visualizations* on which people collaborate synchronously. "Putting something in the middle" helps to maintain focus ([17], [24], [29]) and stimulates dialogue, argumentation, creativity, and the "negotiation of meaning" [27]; and when visualizations are performed by means of representtation systems that are defined by a set of rules and conventions and a certain ontology (elements and relations that can be represented), then the process of visualization itself imposes a structure on the participants' thinking and acting that promotes coherence and understandability ([2], [5], [6]). If all this could be done on the web with software tools that allow us to work synchronously and collaboratively on visualizations in order to clarify problematic or controversial issues, we would get a powerful instrument to support communication and mutual understanding on a global level.

My focus in this paper is not on software tools, but on a general method of visualization that has been developed for a very specific purpose. The method is called Logical Argument Mapping (LAM), and its purpose is to induce cognitive changes in people who are using it. LAM has originally been developed as a method to facilitate negotiations in conflicts [6], but here I will talk mainly about its usage as an analytical method to map the structure of texts, narratives, and argumentations from an observer's point of view. In both these fields, however, LAM's primary purpose is cognitive change. Based on the old epistemological argument that there is no perception and understanding that is independent of cognitive conditions that determine what we perceive, think, and belief ([11], [20]), the rationale behind Logical Argument Mapping is to visualize the mostly implicit logic of people's reasoning in order to stimulate self-reflection and the modification of implicit assumptions.

The focus on cognitive change marks the crucial difference to many similar approaches from Toulmin's model of argumentation [28] to Computer Supported Argument Visualization (CSAV, [14], [31]) and Dialogue Mapping [2]. The primary goal of these approaches is to *clarify* the structure of discourses, but not to *change* the ways people frame what is going on. In the following section, I will elaborate on this distinction by criticizing some of the more recent CSAV contributions for their insufficient conceptualization of what an "argument" is. This criticism, however, is only intended to redefine the boundaries of these approaches, and to define the space in which Logical Argument Mapping can be located as a method with a very specific function *within* the broader context of Computer Supported Argument Visualization and Dialogue Mapping.

In the third section, I will say a few words about the philosophical foundations of Logical Argument Mapping and its ability to

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initiate cognitive change. The method is based on Charles Peirce's concept of "diagrammatic reasoning" as developed in his semiotic pragmatism ([5], [13], [26]). Peirce's central idea was that, by externalizing our reasoning in diagrams, we create "something (non-ego) that stands up against our consciousness. … reasoning unfolds when we inhibit the active side of our consciousness and allow things to act on us" ([9], 282, 287, cf. [18], CP 1.324).

Logical Argument Mapping can help to build three different forms of "common ground": (1) in negotiations, LAM can be used to deepen mutual understanding and to stimulate cognitive change in cases where the clarification of what people think is not sufficient to find an agreement; (2) in the analysis of texts and narratives, LAM can help the analyst to find common ground between her interpretation and the intentions of the author whose utterances she tries to analyze; and (3) in intercultural communication, there is some hope that LAM maps can be used as a sort of universal language in which a variety of culturally shaped *styles* of argumentation can find a common ground—e.g. arguing by examples, or by generating surprise, or only implicitly arguing by arranging statements in a certain way. In the fourth section of this paper I will show how LAM works by mapping an example for the second point of this list.

2. WHAT IS AN "ARGUMENT"?

By now, the best overview of various CSAV approaches may be available in *Visualizing Argumentation: Software Tools for Collaborative and Educational Sense-making* [14], and the most elaborated single methodology in Jeff Conklin's *Dialogue Mapping: Building Shared Understanding of Wicked Problems* [2]. The terms "argument" and "argumentation" are central in both books, but as their subtitles already indicate, they are used here in a broader sense.

Visualizing Argumentation starts of with a list of four definitions from an English dictionary ([14], ix). An "argument" is, first, a "discussion in which disagreements and reasoning are presented"—yes, one might say, but that seems to be the case in every discussion, so why not simply talking about "discussions," or "controversies," instead of "arguments"? Then: a "course of reasoning aimed at demonstrating truth or falsehood"—yes, but where does such a "course" begin and where does it end? A "course of reasoning," let's say about the existence of God or atoms, can stretch over thousands of years, but if everything said about these issues is part of one "argument," then it is hard to define the boundaries of this argument. The third definition hints at a "fact or statement put forth as proof or evidence; a reason"—yes, but that is precisely that: a *reason*, not an argument. (The same can be said when Conklin defines an argument as "an opinion or piece of evidence that either supports or objects to one or more ideas," [2], 99: the piece of evidence is just this, a piece of evidence, not an argument). Then: a "set of statements in which one follows logically as a conclusion from the others"—yes, but there are also arguments that are not logically valid *per se*, for example inductive arguments.

The breadth of these definitions corresponds to a certain vagueness with regard to the *activities* that count in both books as "argument visualization." While Tim van Gelder defines this activity clearly as "a presentation of reasoning in which the evidential relationships among claims are made wholly explicit using graphical or other non-verbal techniques" ([30], 98), other authors include in the process of argument visualization not only the presentation of "evidential relationships" but also activities like problem solving, the generation of hypotheses and evaluation criteria; expressing doubt and disbelief; reifying, contrasting, criticizing, and integrating perspectives; "an open-ended, dialectic process of collaboratively defining and debating issues"; ([14], vii; 12; 52); and the formulation of "Questions, Ideas, Pros, and Cons" ([2], 60).

Since scientific communication presupposes a certain clarity regarding the meaning of concepts, it would be better to replace this plethora of definitions and activities by something that is simple and clear. What is an "argument"? It turns out, however, that this question is not easily to answer. A definition that seems to be widely shared in philosophy goes like this: an argument is "any set of statements in which the truth of one statement is *intended* to be supported by the other statement (or statements)" ([16], 13). The authors emphasize "intended" deliberately in this definition, because also bad arguments are arguments. They are ready, for instance, to accept the following as an argument: "They had a bad winter in Alaska last year, because the *zampogna* is an Italian bagpipe." The *intention* to use the statement on the *zampogna* as a reason for the bad winter in Alaska is sufficient to call this an argument.

Although it should indeed be a most simple and precise way to define an argument as a constellation of statements that consists of a claim and at least one reason for this claim, there is a fundamental problem with this definition: What counts as "reason for"? We can distinguish two attempts to answer this question. One of them is indicated in the definition just quoted from Luckhard and Bechtel: A reason is simply what is *intended* to be a reason by somebody. The problem of this approach—let's call it the *cognitive* approach—is that it is sometimes hard to know what somebody "intends." If Peter links a statement about the last winter in Alaska with a statement about the *zampogna*, does he really *intend* the latter to support the former, or is his intention rather to joke, or to create a typical philosophical example? In both these cases the sentence wouldn't be an argument according to Luckhard and Bechtel's definition.

The other way to determine what counts as a reason for a claim has been chosen by Joel Katzav and Chris Reed in the following definition of an "argument": "A proposition is an argument if and only if it consists (just) in a representation of one fact as conveying some other fact and as wholly doing so. We will say that one fact conveys another if and only if, in the circumstances, it necessitates or makes liable the obtaining of the other. We will say that a fact wholly conveys another if and only if all of its constituent facts play a part in conveying the other. As to facts themselves, they are simply identified with what true propositions represent. The idea that one fact conveys another has been explicated in terms 'necessitating' and 'making liable'. In order to get to grips with these terms note, to begin with, that if, in circumstances C, fact A necessitates fact B, then, in circumstances C, A's obtaining is not possible without B's obtaining. As to the term 'making liable', note that, if, in circumstances C, fact A makes fact B liable, then, in circumstances C, A's obtaining makes B's obtaining likely" ([12], 243-44).

Although pretty impressive in its wording, this definition does not say much more than that in an argument we provide reasons for a claim. The crucial difference to Luckhard and Bechtel's definition, however, concerns the criteria we need to determine what can be accepted as a "reason." By contrast to cognitive approaches that presuppose someone's intention, Katzav and Reed use a *logical* and an *ontological* criterion that can be identified in the argument itself—without reference to the cognitive state of its author. What makes that "one fact conveys another" is either logical necessity or some factual truth. While logical necessity is a clear and unproblematic criterion—although, taken in isolation, it would limit the range of arguments to those that are deductively valid—the reference to factual truths is highly problematic. In order to determine whether a reason is a "true proposition," and whether "A's obtaining makes B's obtaining likely"—where likelihood does not mean "subjective probability" but "some form of frequency probability" (257)—we are facing a serious epistemological problem: both preconditions for calling a statement a "reason" are difficult to justify. Based on long-lasting debates in philosophy of science about things like "theory-ladenness of observation" ([4]; [15]) and "holism" ([3]; [19]), we know that any assumption about the truth of a singular statement is highly questionable. As Quine says, what we are doing in science is looking for a "convenient conceptual scheme," not for truth ([21], 46). Using factual truth as a precondition for being a "reason" poses the threat that we will hardly find *any* "reason."

However, it might be possible to turn Katzav and Reed's approach upside down, declaring the clarification of ontological assumptions as the *goal* of an argument analysis, not a precondition of the identification of arguments. What I mean is the following. If we assume that any constellation of statements that we would accept as an "argument" can be transformed into a *logically valid argument* through adding suitable premises, we can say that the *standard forms* of arguments are the well-known forms of deductively valid reasoning. Given those standard forms, we would simply say that any constellation of statements that can be *transformed* into one of the standard forms *is* an argument. There is no problem to transform any argument into a logically valid argument. For example, "They had a bad winter in Alaska last year, because the *zampogna* is an Italian bagpipe," can be transformed into the valid *modus ponens* form by adding the premise: "If the *zampogna* is an Italian bagpipe, then the next winter in Alaska will be bad." While Katzav and Reed are forced to verify or falsify the truth of everything claimed to be a reason, and to determine the likelihood of a factual relationship between reason and claim, *before* they can figure out whether something is an argument or not, according to my proposal we would simply accept the sentence as an argument since it can be transformed into a logically valid argument form, and only then we would talk about the truth of all the presupposed premises. Obviously, there are two advantages of this approach: first, ontological and epistemological questions are only part of argument *evaluation*, not of argument *identification*, and, second, the *quality* of arguments can be measured in terms of the amount and verisimilitude of additionally introduced premises.

Summing up this discussion, we can indeed define an argument simply as a constellation of statements that consists of a claim and at least one reason for this claim—as long as it is possible to transform such a constellation of statements into one of the well-known logical argument forms.

From my point of view, a clear definition of the term "argument" is decisive for understanding the scope, power, and limitations of so-called argument visualization tools. It is important to note that especially IBIS, the well-known "Issue Based Information System" on which Conklin's *Dialogue Mapping* and many of the studies in *Visualizing Argumentation* are based, is neither an "argumentation scheme" ([2], 87) nor "an argument mapping notation" ([1], 13) if we define "arguments" in the way I propose. IBIS is primarily a system to *clarify* issues. Conklin uses it to provide a visualization method that allows groups to cope with problems of social complexity and "wicked problems" in meetings, and in *Visualizing Argumentation* goals are problem solving in social settings, supporting "collaborative learning" in education [10] and "keeping track of a plethora of ideas, issues, and conceptual interrelationships" ([24], 138). Even if we accept what Conklin calls "Cons" and "Pros" as *arguments*—although what he lists here are often simply assessments, like "too vague," that reveal "what stances" people take upon issues and ideas (cf. also [22], 129)—these statements are only a *part* of IBIS, not the whole thing.

Nevertheless, in cases where finding an agreement depends on finding a common ground on those "pros" and "cons," that is where a shared perception of what those evaluations really mean with regard to the problem in question is necessary, it makes sense to think about tools and methods that are specifically designed for this purpose. Exactly this is what Logical Argument Mapping is supposed to be: a method that can be useful *within the context* of dialogue and issue mapping.

3. LAM AND COGNITIVE CHANGE

With regard to both the foundation in a clear concept of "argument" and the cognitive dimensions of argument mapping, the method that comes closest to LAM is realized in *Reason!Able* and its successor *Rationale*, two software tools that Tim van Gelder developed (http://www.austhink.com/). Similar to the tools already discussed, the general purpose of *Rationale* is to "improve thinking by providing an easy way to diagram reasoning on any topic." For this purpose, two kinds of maps can be produced by means of templates (besides "templates" for Conklin-style dialogue maps): on one hand, so-called "reasoning maps" that are suitable for structuring reasons and objections and, on the other, "analysis maps." The main characteristic of "Analytic Argument Mapping" is the possibility to construct and to evaluate logically valid arguments (see also the many argumentation schemes available at http://wiki.austhink.com/).

For van Gelder, the main *cognitive* function of *Rationale* is clarifying one's own thinking, that is "to help us work out what the reasoning actually is. Prior to the process of mapping, we usually do not have in our minds a fully refined conception of the reasoning just waiting to be diagrammed. Rather, we generally only arrive at such a conception through an iterative process of drafting and revision. When we see reasoning laid out clearly before use, we are better able to identify gaps, obscurities, errors, etc., prompting reformulation. In cases of very complex reasoning, this can go on indefinitely" ([31], 7).

This cognitive function of argument mapping has already been described by Charles Peirce with regard to what he called "diagrammatic reasoning" about a hundred years ago. In Peirce's semiotics, a "diagram" is a specific form of icons, where "icon" is defined as a sign whose primary function is to represent relations (therefore, also algebraic expressions and sentences are icons for Peirce). Already with regard to icons, Peirce emphasized their "capacity of revealing unexpected truth." Similar to what van Gelder says about argument mapping, Peirce points out that "a great distinguishing property of the icon is that by the direct observation of it other truths concerning its object can be discovered than those which suffice to determine its construction. Thus, by means of two photographs a map can be drawn, etc." ([18], CP 2.279).

For Peirce, the crucial difference between "icons" and "diagrams" is—and that leads us to a point that is only hidden in van Gelder's approach but decisive for Logical Argument Mapping—that diagrams are icons that are constructed by means of a certain "system of representation" ([18], CP 4.418). Peirce developed the concept of diagrammatic reasoning in order to understand creativity in mathematics (although his logical notation of the so-called "Existential Graphs" is based on the same idea [23, 25]). Thus, the best example of a "system of representation" would be an axiomatic system. (Another example would be the grammar of a language; this means, algebraic expressions and sentences are more precisely *diagrams*, not icons). A system of axioms does not only define the representational means that are available in a field, but it determines also the necessary outcome of any operation or experimentation we perform within such a system. Let us take a simple example from geometry that Kant already used to demonstrate that "mathematical knowledge is the knowledge gained by reason from the construction of concepts" in what he calls "pure intuition," that is the Euclidean space in this case ([11], B 741). With regard to a construction of a triangle like the one in Figure 1, Kant shows that we can prove the fact that the triangle's inner angles sum up to two right angles simply by drawing an auxiliary line, i.e. a parallel to the triangle's bottom line. The equality of $\alpha=\alpha'$ and $\beta=\beta'$ guarantees then that the sum is 180°.

Peirce would say that the axiomatic system of Euclidean geometry creates "realities" in our constructions that "compel us to

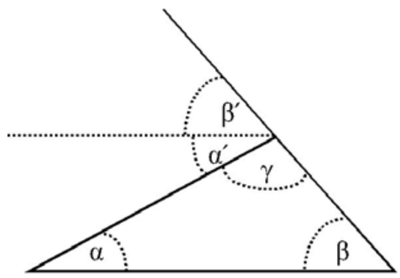

Figure 1. Kant's construction to prove that the sum of the triangle's inner angles equals 180° degrees ([11], B 744).

put some things into very close relation and others less so" ([18], CP 1.383). Only Euclidean geometry provides the parallel we need to perform the proof. It is the ontology (elements and relations) and the rules of the chosen system of representation that determines which experiments with diagrams are possible, and their necessary outcome [8]. For Peirce, this is the foundation of his pragmatism: the fact, namely, "that if one exerts certain kinds of volition [in constructing a diagram, M.H.], one will undergo in return certain compulsory perceptions. … certain lines of conduct will entail certain kinds of inevitable experiences" ([18], CP 5.9).

The compelling character of representations that are performed by the means of representation systems is exactly what we need to explain the possibility of cognitive change. However, it is important to note that a representation is the more "compelling" the more we *understand* and *accept* the rules of our system of representation. That means—with regard to our goal of using argument mapping to build common ground—that we need, first, a *standard* of argumentation that is as strong as possible and, second, the readiness of people to pursue the goal of meeting this standard as strictly as possible.

Both these dimensions of a strong argumentation standard and of educating people to meet this standard are missing in the argument visualization methods that are available so far. Even Tim van Gelder, who comes closest to this goal by offering a set of argumentation schemes, does neither emphasize the need of using them, nor does he argue for their strength or educate people much in their usage.

Logical Argument Mapping, by contrast, is based on a system of representation that forms a standard we have to meet if we want to apply the method successfully. In addition to some *conventions* that are described in the next section by means of an example, the LAM system of representation entails three basic *rules* that form its normative standard: (1.) structure your map according to an argument form (or scheme) whose logical validity is evident and generally accepted (e.g.., *modus ponens, modus tollens,* alternative syllogism, disjunctive syllogism, conditional syllogism, etc.; see [7]); (2.) make sure that all your premises (reasons and warrants) are true, and provide further arguments for their truth if they are not evident; and (3.) make sure that all your premises are consistent with each other.

To follow these rules, the first step in the *procedure* of Logical Argument Mapping is to identify a logical argument form that represents best what one tries to map as an argument. Usually, the arguments we see and use in everyday life, or that we find in texts, do not follow the first rule since it is too cumbersome to explicate everything we need to get a valid argument. Based on their convenience, we use mainly enthymemes: incomplete arguments in which either one of the premises or even the claim is only implicitly assumed. For that reason, the second step is to transform something that is identified as an argument into a *logical* argument by adding what is missing, and by reformulating the elements of the argument in a way that its validity becomes evident. Those elements are only three: a claim (i.e., the conclusion of the argument); a reason, or a combination of reasons (if reasons for the same claim *can* be separated, it is always better to formulate different arguments); and what Toulmin calls a "warrant," that is a statement that is sufficient to justify taking a certain statement *as a reason* for a certain claim. In LAM, the warrant is assumed to represent a universal law. On one hand, this guarantees the validity of the argument and, on the other, it opens up a flank at which an argument can be attacked in the next step. Depending on the clarity of the given argument, the transformation of the second step is a more or less *creative* undertaking, but this creativity is constrained and guided by the three rules.

The third step in the LAM procedure is to consider possible objections against both the reason and the warrant. At this point, the compelling character of LAM as a representational system plays out. Since we are challenged to explicate everything that is needed to get a logically valid argument, we can see exactly where the argument can be weakened. Especially vulnerable is the warrant. Since it is formulated as a universal statement, we only need to find one counter example to this statement to refute the whole argument. Based on the consideration that all those cognitive processes that determine in a certain situation how we frame and perceive an issue, and that are partly deeply hidden in our unconsciousness, will be visible in the form of warrants [6], the need to reflect on the justifiability of the warrant is the decisive step for the possibility of cognitive change.

The fourth step, then, is to decide whether to give up the whole argument, or to reformulate it in a way that it can be defended against the objections, or to develop new arguments against the objections.

Visualizing logical arguments in the form of maps that are constructed roughly as suggested by Toulmin—but stripped of all those features that would jeopardize the logical strength of the argument, like probabilities—is crucial to structure the process of reflection. This, however, is common to all argument mapping approaches. What is different with LAM, by contrast, is the following: The normative standard formulated above challenges the LAM user to explicate *everything* that is necessary to get a *logical* argument map, and to refine her or his map as long as it takes to meet this standard. This means, first, that all those implicit background assumptions that determine how we frame an issue—and that are mostly responsible for problems of mutual understanding—become visible and an object of reflection; and it means, secondly, that *all* the parts of an argument—not only what someone explicitly mentions—are on the table and can be questioned so that a *process* of building common ground will be motivated [6]. Visualizing what hinders most in building common ground is essential for cognitive change.

4. AN EXAMPLE

From an epistemological point of view, the truth of premises in arguments is either evident or has to be justified in an ongoing process of argumentation. Thus, Logical Argument Mapping leads either to assumptions that can be accepted as socially shared, or to a certain modesty regarding truth claims. However, whatever the outcome might be, it is a *process* that we engage in when mapping the logical structure of an argument.

In order to provide an example of how this process unfolds in practice, I will show here how Logical Argument Mapping can be used for the analysis of texts and narratives; or more precisely: for texts and narratives *in so far as* they contain elements that can be reconstructed as arguments according to the definition of an argument suggested in section 2. My example is a flyer (Figure 2) that was intended, obviously, as an argument, though there is not even an explicit conclusion. (Further examples are available via [7].)

Since we know as part of our historical background knowledge that the information the flyer provides refers to Israel's construction of a separation barrier between the West Bank and Israel, we can assume that the authors' intention was to defend this activity by means of an argument. Indeed, at the same time as this flyer was distributed, a group of Palestinian students tried to mobilize against this barrier only about 50m away.

Figure 2. A flyer distributed by an Israeli student group on the Georgia Tech campus in 2005 or 2006.

Assuming the intention to argue for this fence, such an argument can be mapped as a *logical* argument as shown in Figure 3. Obviously, this map cannot represent the *process* of analyzing the argument, but only a snap shot within such a process. The map itself represents only one of three attempts that we produced and discussed in our work group. The mapping process has been recorded. The record shows a kind of dialectical process that led us back and forth between improving our own understanding of the flyer and revealing the limitations of the argument we tried to analyze. We experienced the mapping process as a process of finding common ground between our interpretation and the intentions of the flyer's authors.

In order to read and to work with LAM maps we need to know something about the *conventions* according to which they are constructed. These conventions concern, on one hand, the *layout* of the map's structure and, on the other, the way LAM's *ontology* is presented, that is elements and relations. It is not really surprising to represent relations by means of arrows, but important is that each arrow has to be specified not only regarding

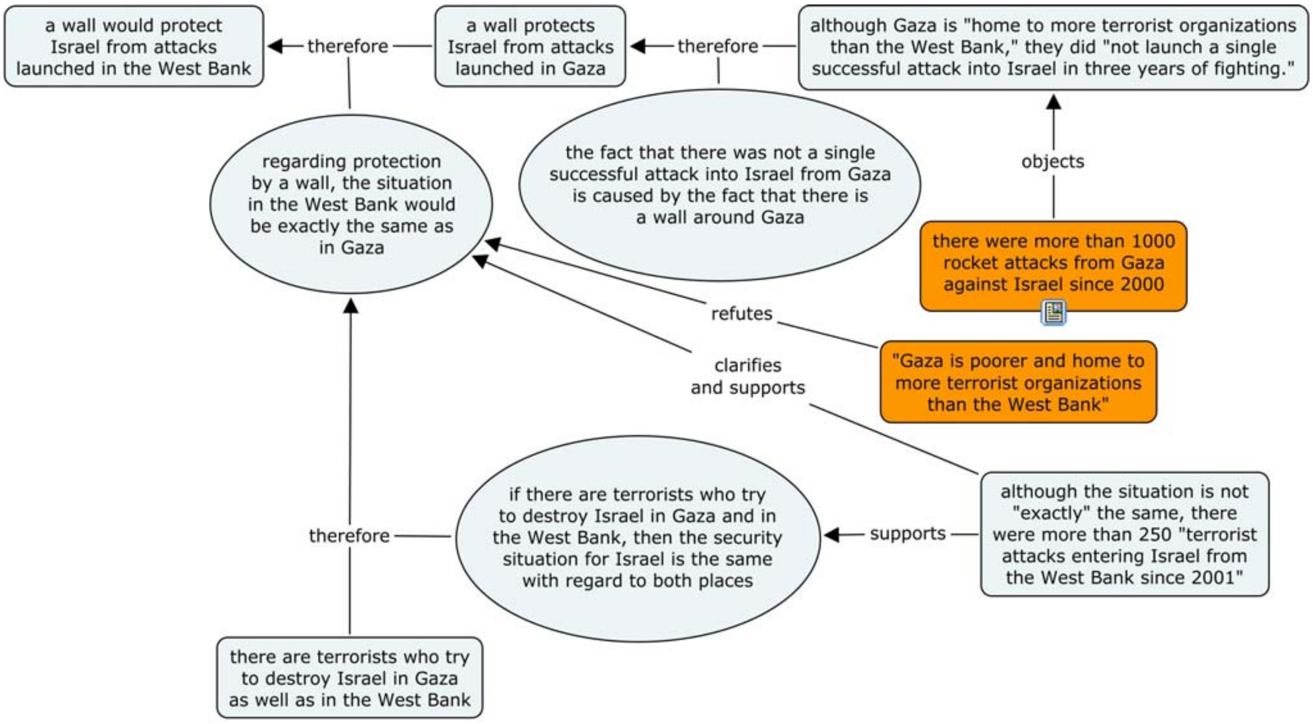

Figure 3. The transformation of the flyer in Figure 2 into a LAM map (created with Cmap, http://cmap.ihmc.us/)

its direction, but also with regard to its *function*. Arguments are identifiable through the "therefore" that links its parts.

Besides arrows, colors are used to specify a coherent position. Rule 3 regarding the consistency of premises (reasons and warrants) is only applicable to what is presented in the ground color of the argumentation; objections and other considerations are presented in different colors. The basic *elements* of arguments are statements that are presented in two different text box forms: rounded rectangles and ovals. Based on their importance for cognitive change, the *warrants* are highlighted by using oval text boxes; everything else is presented in rounded rectangles.

The *layout* of the structure of a LAM map is determined by Western reading habits that direct our attention from the top left corner of a page to the right and downwards. Since the understanding of an argument is facilitated when we know the central claim from the very beginning, this claim is located on top of the map in the left corner. Starting from there, we work to the right and downwards to reconstruct the reasons and warrants in an ongoing process of argumentation.

The map in Figure 3 represents the flyer's core argument in the top left corner as an "argument by analogy." The first warrant under the "therefore" here is formulated in a way that we get a *logical* argument. In further steps, both the reason and the warrant of this core arguments are supported by further arguments; some of the reasons are criticized, motivating a refinement of some statements.

5. CONCLUSION

Due to its foundation in Peirce's pragmatism, Logical Argument Mapping is a method that should enable us to build common ground in negotiations, in analyzing texts and narratives, and in intercultural understanding. Key is the idea that the rules of operation, that define a normative mapping standard, challenge the LAM user to represent everything that determines how she or he sets the boundaries around an issue, and frames, perceives, and interprets what is within those boundaries. Visualizing the driving forces behind our thinking and acting is the first step to reflect on necessary limitations of our perspectives, and to induce cognitive change.

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An evaluation of the pragmatics of web-based bug tracking tools

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ABSTRACT

Web-based tools are often used to support software development processes. Many of these tools are aimed toward a development process that relies implicitly on particular supported roles and activities. Developers may already understand how the tool operates; however, developers do not understand or adhere to a development process supported (or implied) by the tools. This paper proposes a preliminary formal model of roles and activities in one aspect of software development, namely the problem reporting process, and describes both a standards-based process and a well-known tool with respect to its support for their respective processes. An alternative is proposed for modeling problem status that is based on the analysis of process roles.

Categories and Subject Descriptors

K.6.3 [**Software Management**]: Software process, software development.

General Terms

Management, Documentation, Human Factors

Keywords

software issue tracking, conceptual graphs, process models

1. INTRODUCTION

Many web-based tools support software development. There are two main reasons for an organization to use these tools:

- Much of software development takes place in distributed environments, or at least where the participants might have difficulty meeting regularly face-to-face. Web-based tools allow them to collaborate in a generally cost-effective way.

- Software development processes prescribe various *activities* and *artifacts* to be created and maintained. Even when developers are able to collaborate in person, the number of artifacts can become large and therefore requires organizing tools and a central repository. Since activities are described as a set of required/allowable/prohibited actions with respect to achieving some stated goal, the features of the web-based tool can be set so that only those obligations are supported.

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As with all tools, their effectiveness is determined by how well the participants understand how to use them. There is ample evidence that mere use of tools is not sufficient to support an effective process. Even if developers understand a tool's basic operation, they often do not understand or adhere to any development process supported (or implied) by the tool. This paper examines parts of some popular web-based software engineering tools from a pragmatic role-oriented perspective. That is, we intend to focus on the roles and purposes of the participants, rather than characteristics of artifacts or products.

Our ultimate purpose in developing these models is three-fold:

1. to better characterize and describe the processes themselves

2. to formally analyze and evaluate tools with respect to generally accepted process models, and

3. to formally compare and contrast the models with each other.

This paper will only describe the models themselves (purpose 1) and begin the pursuit of purposes 2 and 3. This work continues in the spirit of previous work in modeling development processes [3] [7] and in using conceptual graphs for modeling communication [5] and software development [6] [8].

2. BACKGROUND

Two areas that will be addressed in this paper are workflow modeling and software problem tracking (sometimes called "bug tracking"). We first describe the workflow models for the tracking processes implied by an important standard and some popular Web-based bug trackers. We use conceptual graphs [17] as a convenient formalism and easily understood visual aid to represent the models. Conceptual graphs are well described elsewhere [17] [13].

2.1 Workflow modeling

This paper is intended to provide a framework for describing and evaluating software development processes, in particular the bug-tracking process. Its position is neutral with respect to being either normative or descriptive (i.e., neither "to-be" or "as-is" in the sense discussed by Scacchi [16]). While the discussion in [16] gives valuable insight into an environment (namely, open-source) where prescriptive models may not be viable or useful, this paper takes the position that one must first have a model of a process in order to effectively understand, evaluate and ultimately improve that process.

Being "informal" does not render a model incapable of being modeled; on the contrary, most formal processes have their origins as informal activities that were eventually refined. We begin with the assumption that developing a model of a process is generally more useful than not modeling it at all. That being said, this paper does not propose imposing its model on any software development environment; rather it is an attempt to establish a framework for modeling and thence understanding one's software development environment. As the range of environments widens (e.g., open source, agile methods, etc.) it becomes even more important to develop models and then of course validate them.

We will focus on the workflow involved in bug tracking. Workflow modeling, as used in this paper, is taken from the workflow specification definitions used in [4], and based on the RENISYS model of organizational roles [1]. One key feature of those models is the notion of organizational actors, each of whom has particular obligations with respect to their roles in various activities. A simple model of a workflow activity is shown in Figure 1, adapted from [2].

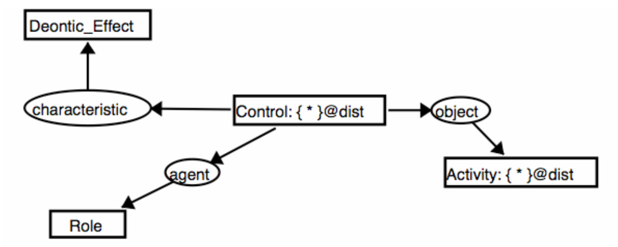

Figure 1: Workflow step represented by conceptual graphs.

The meaning of Figure 1 is as follows. There is a set of control concepts, each of which is characterized by a deontic effect (see below) and each performed by a particular role. For each control concept, there is a set of activities, each of which is operated upon by that control. The graph may appear simple; in fact, we consider this one of the strengths of conceptual graphs. This paper proposes some modifications and additions to this model, based on some shortcomings in its power to express some important pragmatic relationships in the bug tracking process.

2.2 Software problem tracking

Software problem tracking is one portion of a much large set of processes belonging to software configuration management (SCM) which has been extensively studied; for a summary, see [14]. The motivation for a controlled SCM process comes from the observation that software systems constantly change while under development, either through additional requirements or business needs, or through the natural process of successively refining artifacts from inception to deployment. Because this process has many purposes, there are often many people involved. SCM generally is composed of five tasks: identification of configuration items, version control, change control, configuration auditing, and SCM standards. One of the most visible aspects of change control is that of software bug reporting and tracking. This paper is focused on modeling the bug reporting process with respect to its pragmatic aspects: who is involved, what are stakeholders' roles in the process's success, what responsibilities do they hold with respect to the system and what are their communication needs with other stakeholders.

3. MODELING PROBLEM RESOLUTION PROCESSES

Bug-tracking can be viewed as one kind of *problem resolution process.* The software engineering community has established standards for such processes, as exemplified in ISO/IEC 12207 [11]. In this section of the paper, we first describe some generic problem resolution process steps using the workflow models developed previously, then we briefly describe the 12207 process, and summarize the bug tracking processes supported by three well known software development tool sets: **Bugzilla, Trac** and **sourceforge**. Although these are primarily known as tools (not methodologies), each of their descriptions implies a process to be followed when using the tools' bug tracking features. In the next section, formal models are shown for the ISO/IEC 12207 process and Bugzilla. Space does not permit showing the others, and in fact an argument is made that modeling Trac would not be especially useful since it is such an impoverished process model.

The first thing that one notices in studying the bug tracking capabilities of existing tools and processes is that there is generally no explicit set of roles which are defined in the process. Of course, the mere existence or use of a tool never guarantees that it will be used effectively or even correctly; however, most tools seem implicitly geared toward a particular change control process. Some of them appear to imply certain roles, while others appear role-neutral.

3.1 Generic models for software engineering processes

This section describes our model of an organizational process (including an ontology) and gives general models for three bug-tracking activities: reporting, fixing and auditing. In the next sections, we show part of the models for the other processes.

We adopt Figure 2 as a description of a general process with some pragmatic knowledge. Note the inclusion of the concept "Intention" with respect to a role in the process. This concept is lacking in previous models, which simply showed the obligations (required, allowed, prohibited) as the deontic effect assigned to a particular role. Previous models therefore did not give any indication as to *why* a particular role would be given a particular assignment.

For example, why would a program manager be required to review a change, or why would a developer be allowed (but not required) to make a change? For our future goals, if we want to reason automatically about roles and their appropriateness or legitimacy, we must start to model their purpose and relationship to the system's development as a whole.

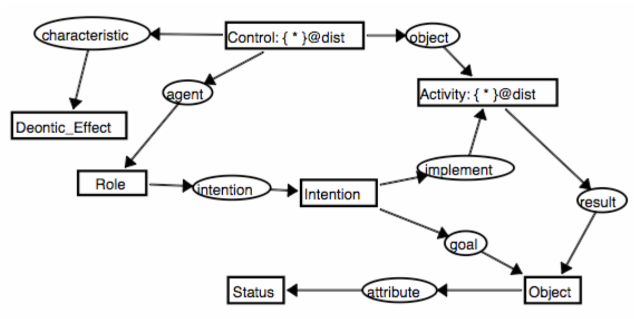

Figure 2: Workflow model incorporating intention.

The model in Figure 2 is meant to emphasize that a participant's intentions need to be captured for each activity in a process model, as well as the status intended for the result(s) of that activity. (Later, we will propose a more accurate idea of what "status" really means.)

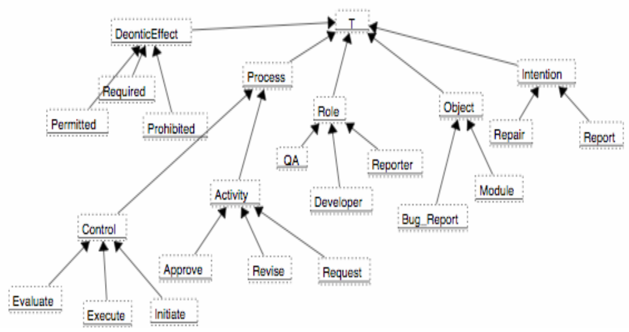

Figure 3: Ontology for a pragmatic analysis of bug tracking.

Figure 3 shows a basic ontology for the bug tracking domain. The "QA" role represents that of Quality Assurance, whose duties include (among other things) verifying that processes have been followed. This ontology is modified from [2]. The cluster under "Intention" has been added.

Figure 4 and Figure 5 illustrate how two typical bug-tracking steps would be modeled. The point here is that a formal model can help developers visualize their process, remind them of their obligations and also allow process analysts to compare different models to each other, process vs. practice models, etc.

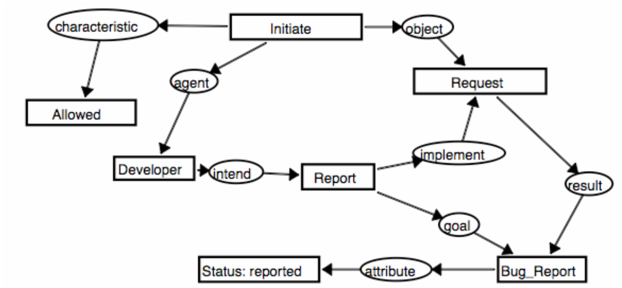

Figure 4: Generic model for reporting a bug.

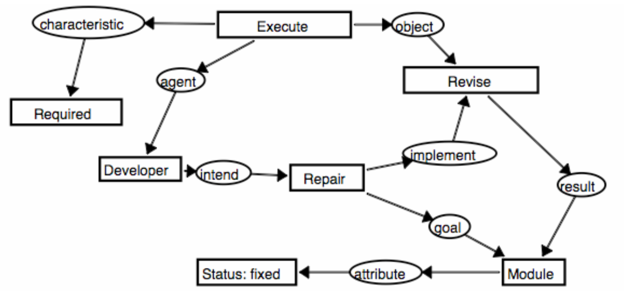

Figure 5: Generic model for fixing a bug.

Our motivation for establishing basic graph models for these processes stems from a belief (as yet untested) that they can serve as guides for identifying missing or incorrect elements in existing processes. Once the graphs are established, we of course have to validate them. One avenue of validation would be to use conceptual graph tools to scan the wealth of existing data as advocated in [15]. Examples of natural language sources are emails, forum posts, program source code comments [10], and even identifier names in programs [9]. The task of validating graphs linguistically is still daunting; the work given here constitutes some necessary first steps toward that ultimate goal.

3.2 Models of existing processes

We have already described some shortcomings of the existing process models. This section illustrates those differences by showing examples of their process models using the conceptual graph notation already introduced.

3.2.1 ISO/IEC 12207 Problem resolution process

The problem resolution process of the ISO/IEC 12207 standard is reprinted in Figure 6.

The standard's process is shown in its entirety in order to emphasize one striking omission: nowhere does it prescribe *who* is tasked with any of the steps or activities! For example, the standard says "analysis shall be performed" but it does not state who will perform the analysis. This lack of specified roles weakens an organization's ability to provide appropriate process descriptions, including who does what and also providing reasonable checks-and-balances for management.

Using the ISO/IEC 12207 problem resolution process, the general model of problem resolution is shown in Figure 7. Note that while the deontic effect of "Required" is present (meaning initiation is required), there is no role shown that is responsible for that initiation, nor is there any indication of the purpose of the problem report or the goal in "handling" it. In short, the model is clearly incomplete, in ways that would directly impact an organization's ability to understand the process and therefore to implement it in their workflow or audit its correct implementation.

6.8 Problem resolution process

The Problem Resolution Process is a process for analyzing and resolving the problems (including nonconformances), whatever their nature or source, that are discovered during the execution of development, operation, maintenance, or other processes. The objective is to provide a timely, responsible, and documented means to ensure that all discovered problems are analyzed and resolved and trends are recognized.

List of activities. This process consists of the following activities:
1) Process implementation;
2) Problem resolution.

6.8.1 Process implementation. This activity consists of the following task:

6.8.1.1 A problem resolution process shall be established for handling all problems (including nonconformances) detected in the software products and activities. The process shall comply with the following requirements:

a) The process shall be closed-loop, ensuring that: all detected problems are promptly reported and entered into the Problem Resolution Process; action is initiated on them; relevant parties are advised of the existence of the problem as appropriate; causes are identified, analyzed, and, where possible, eliminated; resolution and disposition are achieved; status is tracked and reported; and records of the problems are maintained as stipulated in the contract.

b) The process should contain a scheme for categorizing and prioritizing the problems. Each problem should be classified by the category and priority to facilitate trend analysis and problem resolution.

c) Analysis shall be performed to detect trends in the problems reported.

d) Problem resolutions and dispositions shall be evaluated: to evaluate that problems have been resolved, adverse trends have been reversed, and changes have been correctly implemented in the appropriate software products and activities; and to determine whether additional problems have been introduced.

6.8.2 Problem resolution. This activity consists of the following task:

6.8.2.1 When problems (including nonconformances) have been detected in a software product or an activity, a problem report shall be prepared to describe each problem detected. The problem report shall be used as part of the closed-loop process described above: from detection of the problem, through investigation, analysis and resolution of the problem and its cause, and onto trend detection across problems.

Figure 6: ISO/IEC 12207 problem resolution process.

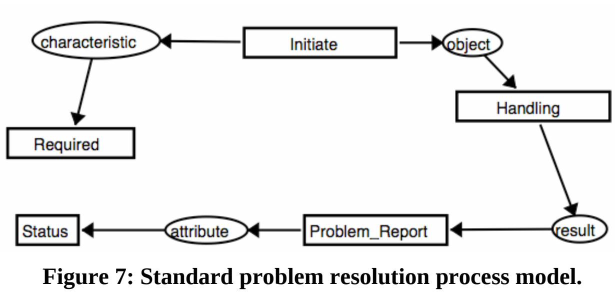

Figure 7: Standard problem resolution process model.

3.2.2 Bugzilla

The Bugzilla bug tracking process is described in Figure 8 (taken from Figure 6-1 of the Bugzilla Guide at http://www.bugzilla.org/docs/3.0/html/). Note that several of the transitions have no labels, indicating that while it is possible for a bug to follow that transition, there are no constraints on when or how that transition is permitted. As in most other descriptions of these kinds of processes, there is little guidance as to *who* is authorized to change the status of a bug. One might assume that the "owner" of a bug is authorized to change its state, but even in that case there is little organizational support for the reasons or circumstances under which which the change is legitimate. For example, what does "unconfirmed" mean? The owner could simply mark a bug as "unconfirmed" if they did not want to deal with it at the moment, or the owner could engage in a detailed exploration and be unable to reproduce the bug, or perhaps the owner just hasn't had time to check out the bug yet.

In short, participants in a given software development process needs a set of guidelines, constraints, operating procedures, etc. that govern what these status values mean. In a more sophisticated process, there would be procedures for changing/augmenting the set of status values as the team gains more experience.

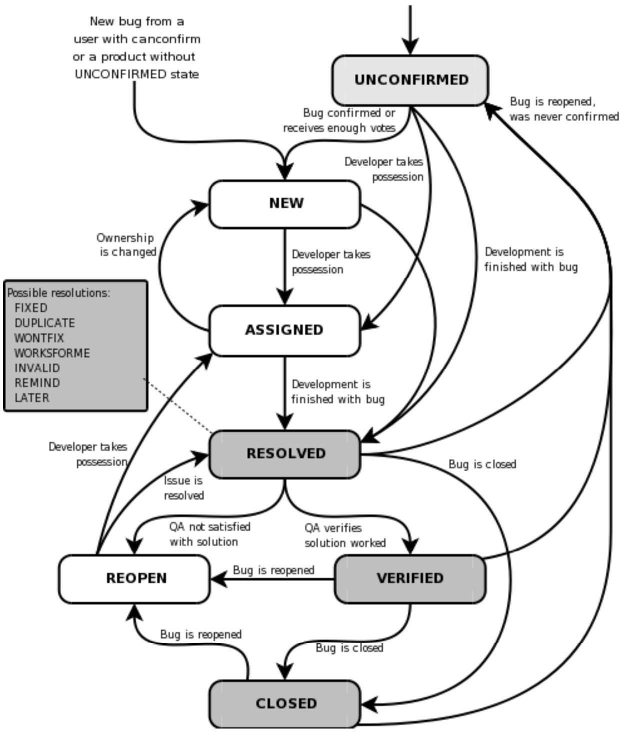

Figure 8: Bugzilla bug tracking process.

The Bugzilla process is somewhat more completely defined than in the ISO/IEC 12207 process. Using Figure 8 as a basis, we can describe the model formally as shown in Figure 9.

Note that the Bugzilla model, while still rather informal, does in fact include much of the vital pragmatic knowledge needed for an organization to implement the process. Roles are shown in several places, and verbs indicated processes are also shown. "Ownership" and "possession" are not specifically represented in the process models, but does seem to suggest a "required" obligation of some sort. In summary, Bugzilla's process appears more complete than the ISO/IEC one in section 3.2.1.

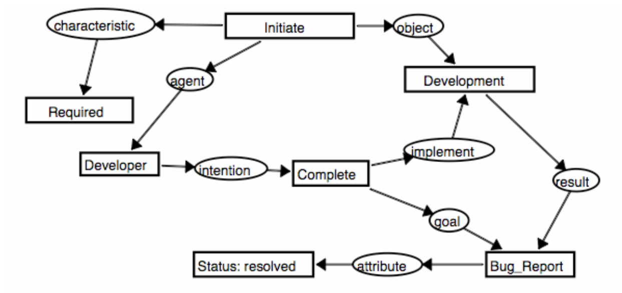

Figure 9: Bugzilla bug tracking process model.

3.2.3 *The Trac reporting system*

The description of the Trac system is given as an additional description of a process that is clearly incomplete (perhaps intentionally). The Trac system is a full-featured software support system that is aimed at being simple and easy to use. It therefore has more compact processes, which have fewer constraints as a result. The state diagram in Figure 10 shows Trac's bug tracking process, as illustrated in figure taken from http://trac.edgewall.org/wiki/TracTickets.

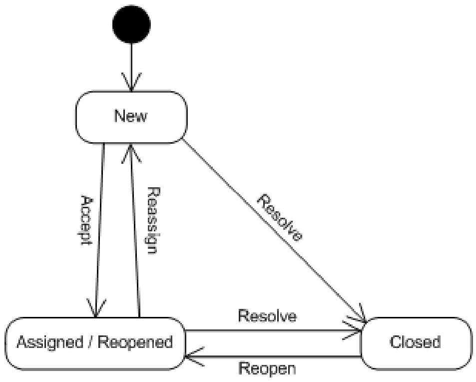

Figure 10: The Trac problem tracking process.

The Trac system shows no particular actors or roles. A bug has only four possible status values, although there is no distinction made between "assigned" and "reopened". Since there is no real detail on the process itself, beyond mere names for operations (e.g., "resolve") many of its deficiencies are already obvious (although perhaps not all of them). In this case, our formal model would not be especially useful because the model itself is so "lightweight".

3.2.4 *Sourceforge*

A tracked bug using sourceforge's tracker has the following attributes: assignee, status, category, group and description. It is important to note that few of the attributes have any reference to persons or roles' responsibilities in software development.

- **Assignee** - The project administrator to which a tracker item is assigned. Can be chosen from one of the administrators registered in this project.
- **Status** - This is the (potentially changing) current status of a bug. The online help says: *You can set the status to 'Pending' if you are waiting for a response from the tracker item author. When the author responds the status is automatically reset to that of 'Open'. Otherwise, if the author doesn't respond within an admin-defined amount of time (default is 14 days) then the item is given a status of 'Deleted'.* This provides the beginnings of a primitive set of definitions for the possible status values, and even suggests the process being supported.
- **Priority** – a nine-level scale.
- **Category** – project-specific.
- **Group** – project-specific.

The list of sourceforge's bug attributes clearly illustrate one of the major hurdles in developing systems using existing tools: there is no structure or process guidance provided! To be sure, sourceforge's organizational goal is not to develop or impose processes, so one of its goals is to ensure as much flexibility as possible. Thus it may be unfair or even irrelevant to use these as a starting point for analysis, but our main purpose is to show that we can use the approach to compare different specified processes.

The attributes of "category" and "group" are good examples of this: each project administrator can choose them based on their own preferences. The downside of this approach is that the automated bug tracker has no capability to relate them to each other, to accommodate constraints between particular categories, groups or values of the other attributes (except for the ability to search the bug list by value). For example, are "category" and "group" orthogonal to each other, or is a group a sub-category, etc.?

Completing the model of sourceforge (not shown here) would aid in identifying additional process features that need to be included and described in order to support the process.

3.3 Summary

The advantages of using conceptual graphs to represent the processes are (i) they have the potential to be formally manipulated and compared, and (ii) they provide an easily understood visual description of the process for developers and analysts. In the case of Trac, the effort involved in modeling is probably not worth it, since the process itself is so limited. A model of sourceforge might reveal some interesting inadequacies; that work is ongoing.

4. MODELING A BUG'S STATUS

The notion of a bug's status is an interesting one. As one educator reports using the sourceforge tools, "if the phrases describing subtask status are not defined, different student teams often give different meanings to the same phrase. Even worse, sometimes, different members in the same team would interpret the same phrase differently." [12]. They identified the need to define status phrases indicating which role and process are involved; e.g., the status "Ready for Review" meant ready to be reviewed by the quality assurance (QA) role on the team. A better way to name this would be an explicit "Ready for Review by QA" status.

Another way to envision status as a working concept is to approach it from a process perspective: an item's status reflects the process that produced it, not some arbitrary choice from a pull-down menu. So a more accurate and useful definition of status would look something like Figure 11.

The meaning of the conceptual graph in Figure 11 is that a bug report with status "reported" is defined to be a bug report where a developer has imitated a request for the bug report, and that same developer intends that request to report a bug. This makes *status* not an independent attribute but instead it is a dependent attribute – dependent on the process that produced it. A similar definition can also be constructed for the status shown in Figure 5. This may be a promising direction in more precisely describing details of bug reporting.

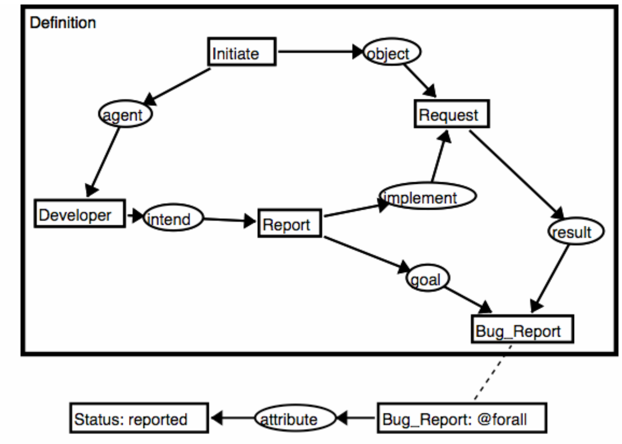

Figure 11: Status as a derived concept.

5. CONCLUSION AND FUTURE WORK

This paper is intended to be an exploratory exercise in using pragmatic concepts to model some bug tracking processes in software development. Because most process definitions provide only vague (or absent) roles, responsibilities and managerial duties are also vague. Because most existing tools do not address the issues of why someone is authorized (or not) to make a change to an item's status, it is possible for the status of bugs to be inconsistent with whatever development process the software's developers are supposed to follow.

A necessary next step is some empirical validation of the approach. One promising avenue would be to compare the performance and experience of software engineering project teams, with some teams using conventional approaches and others using the pragmatically supported approach. Another way would be to incorporate the ideas into an existing production-level software organization (assuming they already perform sufficient metrics on their process) and see how the approach affects their outcomes. This second avenue would permit some comparison to not only gauge whether the approach improves software process quality but (if it does indeed improve) also give a quantitative indication for the degree of improvement. A final long-term approach (as alluded to previously) would be to perform some linguistic analyses of various natural language used or produced in software development, especially in distributed communities where a large portion of the interaction takes place through electronic means.

The subsequent process of actually correcting the bugs identified during the process, with duties and responsibilities assigned to appropriate roles, would be an interesting area to study further, since it involves a superset of the same roles involved in problem tracking. Obviously it will be useful to compare different organizations' processes to find common elements, and (likely) missing elements; this is a natural next step. It will also be useful to identify where the procsses actually conflict with each other. This last issue becomes quite relevant as companies' products and staff are merged with other companies' products and staff.

6. ACKNOWLEDGMENTS

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A Practical Method for Courseware Evaluation

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ABSTRACT

As more courseware becomes available, choosing the right functionality for a particular e-learning community is becoming more problematic. Systematic methods for evaluating courseware functionality components in their context of use are required. Of many general methods for ICT evaluation it is unclear how to assess their applicability in the context of courseware. We outline a practical method for courseware evaluation. We experiment with the method by evaluating the courseware functionality used in one core e-learning activity: the making of group assignments. One interesting finding is that the usefulness of an application to a large degree depends on the particular activity being supported, much less on the particular functionality used.

Categories and Subject Descriptors

D.2.8 [**Software Engineering**]: Metrics – *performance measures, product metrics, software science.*

General Terms

Measurement, Performance, Design, Economics, Experimentation, Human Factors

Keywords

Courseware, evaluation, method, information systems quality.

1. INTRODUCTION

E-learning is an increasingly important application of the Internet. Ubiquitous computing and life-long education is rapidly making electronic learning more feasible and accepted. In the educational field, courseware has become an essential means of supporting course-based e-learning, much of it Web-based. A plethora of tools and environments is available. Two main types of courseware applications exist: commercial platforms like WebCT and Blackboard, and open platforms which can be completely or partially open source. A related development is the development of online open content, such as the ambitious Open Courseware initiative in which MIT makes much of its course material available online to the world for free[1].

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Courseware offers many functionalities which can be used to support communities of users in their individual and especially collaborative needs. Much information systems research concentrates on developing ever more advanced components for knowledge sharing and learning [4]. However, many design problems arise:

- *Too much (costly) functionality*: functionality goes unused, wasting resources and confusing users. Many sophisticated group file management options are never used, for instance.
- *Gaps between required and available functionality*: some needs go unsatisfied. For example, originally Blackboard permitted only lecturers to remove students from a course, whereas empowering students to manage their own accounts saves everybody much work.
- *Conflicting functionality requirements between different categories of stakeholders*: a prime example is the different requirements of students who want user-friendly and powerful functionality, and computer centers, which need to ensure security and maintainability.

The basic question is: how to make sense of the jumble of requirements, technologies and interests typical of courseware decision making in large, complex institutions like universities? In other words, how to evaluate web functionalities in their context of use? Such context-sensitive evaluation methods that work are important building blocks of the Pragmatic Web.

To answer this question, we first summarize our definitions. *E-learning* is any process of computer-mediated learning. We define *courseware* as technological environments consisting of multiple functionality components, together offering a complete system of information and communication services required for supporting course needs[2]. A functionality is a set of functions and their specified properties that satisfy stated or implied needs[3].

[1] UNESCO's free software portal gives an overview of some typical open educational software, much of it open source: http://tinyurl.com/2roukq/. The MIT Open Courseware portal: http://ocw.mit.edu.

[2] A comparison of the functionalities of many well-known courseware tools: http://www.edutools.info/course/compare/all.jsp

[3] http://www.sei.cmu.edu/opensystems/glossary.html

Functionalities can be studied at different levels of granularity: at the lowest level, we distinguish *systems* of tools or services. The next level consists of the *tools* or services themselves. The next level consists of the *modules* of which the tools or services are composed. Finally, we distinguish the particular *functions* combined in a module [7]. Depending on the particular community in which they are applied, almost identical functionalities are often selected and configured very differently in practice [14]. In making strategic decisions on which courseware to select, the value of its functionality to the users thus needs to be assessed carefully.

Much research on ICT evaluation has focused on exploring the dimensions of evaluation which such methods can take into account, such as trees of quality aspects to be used in the evaluation process [5, 6]. Applying such dimensions, a wide range of methods has been developed to systematically evaluate the quality of information technologies, e.g. [3, 16]. However, these methods vary widely in their evaluation scope, outcomes, and techniques. These generic methods, although useful in theory, are not very applicable in practice, since they do not take into account the *situatedness* of courseware evaluation, determined by the context of use of the tools.

In this article, we examine some of the specific characteristics of courseware evaluation methods in Sect 2. In Sect. 3, we outline our practical method for courseware evaluation, which combines simple indicators assessing the value of the combined ICTs for particular workflow activities with the value of a particular tool functionality for the combined activities. We show how the method was validated in practice by applying it in a group assignment making experiment in Sect 4. We discuss some implications of our approach and end the article with conclusions.

2. COURSEWARE EVALUATION METHODS

A new paradigm of market-based information systems development is emerging. In this model, vendors focus on developing products, not systems. New forms of analysis, roles in software development, and the meaning of use and maintenance therefore need to evolve [20]. To design useful information systems by selecting the right components, available functionalities in the form of modules and services need to be evaluated in their context of use by their communities of use. Choosing the right courseware is not simply a technological decision, however, but a strategic IS development choice. Since the choice of courseware has far-reaching implications for the primary process of an educational institution, its selection requires a careful balancing of the multiple educational, political, and social requirements with the affordances and constraints inherent in the technology [21, 23]. If proper analysis does not take place, the socio-technical gap between work practices and supporting groupware may easily become too large, impeding use and collaboration [1].

When assessing the value of courseware in the e-learning process, we are especially interested in the role that these technologies play in supporting work activities, in other words, finding out whether they are used effectively. Effective use is the capacity and opportunity to successfully integrate ICTs into the accomplishment of self or collaboratively identified goals [10]. Evaluating the usefulness of a functionality can be defined as the evaluation of the extent to which users can translate their intentions into effective actions to access the functionality [8]. Such evaluation should ultimately contribute the purpose of the community of use [18], so that somehow individual assessments must be aggregated and interpreted by relevant stakeholders.

Courseware selection is still too often seen as only a process of software selection based on some simple list of technical features. Many software evaluation methods outline the order of process steps to be taken, such as defining software requirements, investigating the options provided by the various tools, making a shortlist and selecting the final candidate [11]. However, these methods do not provide much help in providing material criteria and procedures for the communal, systemic evaluation of the usefulness of software. In other words, how to assess whether the courseware-in-use serves the purposes of the community?

An interesting class of evaluation methods are so-called portfolio approaches. These take into account the existing infrastructure and architecture of the organization in their weighing and scoring of aspects. One prime example is Bedell's method for ICT investment selection [3]. In this method, ICT functionalities are scored on both their effectiveness and importance for the activities they are to support. The activities themselves are also scored on their importance to the organization. The importance scores act as weights for the effectiveness scores. Several higher-level indicators can be calculated, such as for making decisions on whether the organization should invest in ICT at all. Thus, Bedell’s method provides a powerful instrument for aggregating many diffuse evaluations and preparing for decision making

Summing up: courseware evaluation requires evaluation criteria of the right scope and granularity, procedures to calculate more complex metrics out of simpler ones, and approaches to allow for human interpretation to play its appropriate role in the evaluation process. However, most generic methods, such as multi-criteria and portfolio approaches, do not pay enough attention to the larger evaluation process and context in which the (human) decision makers interact with the data [2]. In Figure 1, we present a context model of courseware evaluation, which is at the heart of our evaluation method. Space is lacking here to discuss the model in detail. The reader is referred to [7] for an extended version of this model and the method it informs, which we outline next.

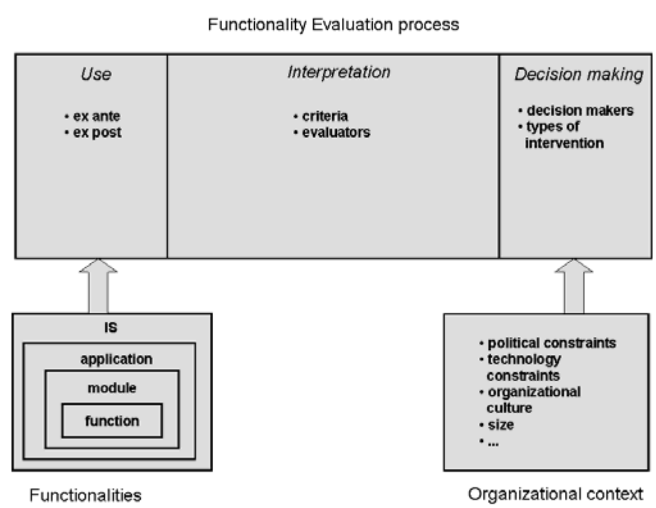

Figure 1. A context model of courseware evaluation

3. A PRACTICAL METHOD FOR COURSEWARE EVALUATION

Our main objective was to design a practical method that - with a minimum of intrusion and effort – could assess the usefulness of functionality modules to courseware users. It should allow various stakeholders to weigh and reach agreement on possibly conflicting evaluations. One application of this method is performing an initial analysis of which functionality modules to acquire, develop or divest from in building a comprehensive courseware information system.

We used Bedell's method [3] as the basis of our own courseware evaluation method. However, we simplified it in that we did not perform some of the higher-order analyses on, for instance, the effect of all tools on the organization level, as such interpretations can be quite complex and abstract to first-time evaluators. Instead, we focused on developing simple measures for the usefulness of courseware.

We were interested in two basic questions: (1) how well are our course activities supported by the various courseware functionality components? (2) how much are the various functionality modules used? To this purpose, we developed two indicators: *activity* and *functionality scores*.

3.1 Activity and Functionality Scores

Activity scores show how useful the combined functionality components are for the support of a particular activity. Functionality scores represent the usefulness of a particular functionality component in supporting the combined activities of a community.

The basic elements to be scored by the users are:

- *I(a)* = importance of an activity
- *I(f,a)* = importance of a functionality in supporting a particular activity
- *Q(f,a)* = quality of a functionality in supporting a particular activity. This measure can include aspects such as efficiency, user-friendliness, to look-and-feel, etc.

The elements are scored on a ten point scale, with 10 being highest. Examples of these indicators could be, respectively, I(Information Collection) = 9, meaning that Information Collection is very important to the group, I(Virtual Chat, Information Collection) = 4, implying that chat support is not so important to the users for collecting information, and Q(File Transfer, Submission of Results) = 8, which suggests that the particular file transfer module used works well for result submission.

Activity scores

$$\text{A-Score} = \Sigma\ I(f_i,a) * Q(f_i,a), \text{ for all functionalities } 1..i.$$

For all functionality components f_i supporting a particular activity *a*, the experienced quality of the support they provide is multiplied by their importance in supporting this activity. The sum of these values measures the usefulness of the combined technologies for a particular activity to the scoring user. This measure is especially useful for technology users, such as lecturers and students.

Functionality scores

$$\text{F-Score} = \Sigma\ I(a_j) * I(f,a_j) * Q(f,a_j), \text{ for all activities } 1..j.$$

For all activities a_i supported by a particular functionality component *f*, the quality of support provided is multiplied by its importance for this activity *and* by the importance of the activity. This last multiplication is necessary, as support provided by the component to more important activities should weigh more than to less relevant activities. The sum of these values measures the usefulness of a particular functionality component for the combined activities of the scoring user(s). This is especially useful for technology maintainers and developers, such as computer centers and software vendors, in order to determine which components to acquire, develop, or to remove.

4. AN EXPERIMENT: THE EVALUATION OF GROUP ASSIGNMENT FUNCTIONALITY

Tilburg University heavily promotes the use of Blackboard: almost all courses are mandatorily supported by this software. However, a few years ago, the university computer center received many complaints about the functionality from students and lecturers, ranging from awkward interfaces to very low performance. Furthermore, given the rapidly increasing prices of commercial courseware software, the center was investigating the possibilities of (partially) open source courseware at the time. Moreover, one of their strategic objectives was to find better ways to collect, classify, and handle user requirements. The computer center was therefore very interested in experimenting with a practical evaluation method.

4.1 The Design of the Experiment

An initial experiment was set up in which students taking the 2002 course Quality of Information Systems would use the method to evaluate the quality of Blackboard for the making of group assignments. This experiment was repeated in the 2003 course, to compare results and see if discovered patterns would hold over time with different groups of students. In 2003, a new version of Blackboard was used, but most of the new functionality was for better course management by the lecturer and did not affect the functionality experienced by students. Furthermore, to compare not just the usefulness of one tool over time, but also the similarities and differences between tools, in the 2003 course another courseware tool, CourseFlow, was analyzed as well. CourseFlow was custom-developed earlier by one of the students for another institute of higher education and contained most of the basic functionalities provided by Blackboard. To ensure a valid comparison, the functionality modules evaluated in the 2002 experiment were also tested in the 2003 experiment, both in Blackboard and CourseFlow. To allow students to develop sufficient experience with CourseFlow, this tool was used as the only courseware in the 2nd half of the course, prior to the evaluation assignment.

The population consisted of 2nd year Information Management students, most of whom had at least one year experience using Blackboard prior to this course. Information management students are good candidates for such an evaluation experiment, as they are used to thinking in terms of assessing the organizational usefulness of technical functionality. For these future architects of information systems, it was motivating that their assessments were taken seriously in strategic software acquisition and development planning. At the beginning of each course, the students were divided into groups of 4 persons each (2 groups in each year consisted of 3 students. This, however, should not significantly have affected the quality of group judgment, as the students in all groups had a similar background and experience). The groups had to do several assignments during the course, one of which was this evaluation experiment. The 2002 experiment counted 62 students in 16 groups, the 2003 course 46 students in 12 groups. In the 2002 course, all 16 groups had to score Blackboard, in the 2003 course, 6 of the randomly assigned groups analyzed Blackboard, the other 6 evaluated CourseFlow. The software manager of the computer center was involved from the start. He promoted the importance of the project to the students, gave feedback on the results, and promised to use the results in strategic software planning.

One of the main – and complex - workflows to be supported by the courseware, was the making of group assignments. The purpose of the experiment was to find out (1) how well the various activities that comprise the group assignment making process were supported by the technical system as a whole, and (2) how useful the various functionality components were considered to be.

The group assignment making process was subdivided into four *activities*:

- *Information collection*: the retrieval of the assignment, relevant literature, and the standard answer sheet.
- *Group discussion*: the communication within the group about the planning of the assignment and the division of tasks.
- *Submission of results*: the submission of the finished assignment, including notification of teaching assistant.
- *Feedback from peers*: the review of each submitted assignment by at least one other group and related comments obtained from other students.

The following 11 *functionality modules* were scored:

- *General communication*: Send E-Mail, Discussion Board, Virtual Chat, Student Roster
- *General information*: Announcements, Course Information, Course Documents, Assignments
- *Group*: Discussion Board, Virtual Chat, File Transfer

Student groups had to score the importance of the various activities, and both the importance and quality of a particular module in supporting a particular activity. Additionally, they were to give short textual motivations (given their diversity and the lack of space, these are not included here, but have been used in the interpretation of the quantitative data by the software manager). Participation by students was high, and resulted in detailed responses. Informal feedback showed that many students thought it was a useful and valuable exercise.

4.2 Results

The data obtained from the evaluation are summarized in Figures 1-4. Note that the 2003 scores in Figure 2 and 3 are averaged over both tools. The comparison between Blackboard and CourseFlow in 2003 is given in Figures 4 and 5. The scores for both years and tools are remarkably similar. An explanation of interesting differences will be given below.

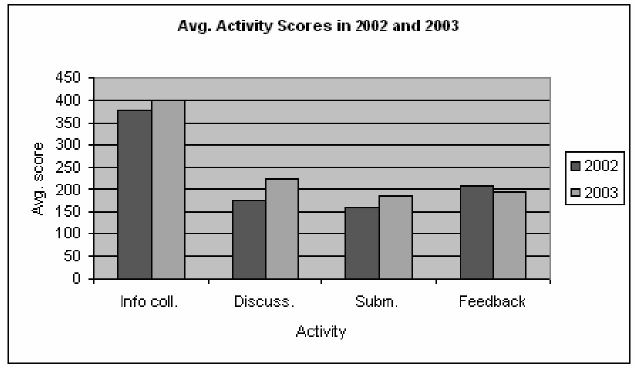

Figure 2. Average activity scores for the group assignment making process in 2002 and 2003

Figure 2 shows the average activity scores for the 2002 and 2003 experiments. These activity scores indicate that both cases, overall functionality was perceived as most useful for information collection. In their textual explanations, most student groups indicate that easy, portal-style, access to the various materials needed to properly make the assignment was most important to them. This was also advertised by the vendor as one the key strengths of the Blackboard functionality. The relative usefulness of Blackboard for information collection can further be explained by discussion and feedback being relatively unimportant in the process model of group assignment making used, and the fact that assignment submission could also easily be done by ordinary e-mail.

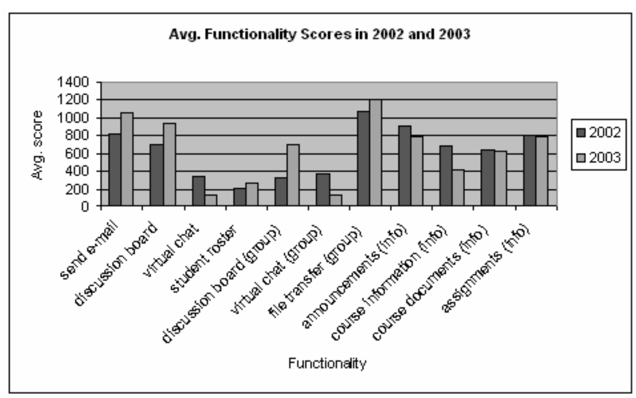

Figure 3. Average functionality scores for the group assignment making process in 2002 and 2003

The functionality scores for 2002 and 2003 are summarized in Figure 3. In 2002, these scores and their textual motivations were interpreted by the software manager of the university computer center in the following way:

- Especially the basic functionality of Blackboard (File Transfer, Announcements, and Send E-mail) was considered important by students.
- File Transfer, however, was not implemented well (according to textual comments. Its high score is thus due to importance, not quality). An alternative would be looked for by the computer center. The E-Mail functionality provided by Blackboard was only very basic, external e-mail applications were better suited, but not (yet) integrated in the platform.
- The Student Roster and Virtual Chat components were not considered important at all. Explanations were, respectively, that there already was an electronic study guide with better functionality, and that external chat-tools such as MSN were much preferred by students as chat functionality.
- Applications like Blackboard and external chat tools should be more open in their integration of functionality modules.
- Open source courseware could be a valuable addition in the future. Given that the university already made a large investment in Blackboard licenses and training, a major transition was not likely to take place soon. Still, experimenting with specific components in order to allow a possible partial migration in the future was supported. For example, Tilburg University was developing its own suite of survey-tools, called UvTLAB, as the survey-module provided by Blackboard was considered insufficient.
- The software manager made a similar interpretation of the 2003 results. Two relatively large differences can be seen in the scores for the virtual chat and the group discussion board. The virtual chat scored even lower in usefulness in 2003 than in 2002, probably because the use of chat tools had become even more widespread in the meantime. The group discussion board, on the other hand, scored significantly higher in 2003. One reason was that students perceived the quality of the group discussion board functionality of CourseFlow to be much higher than that of Blackboard. This was in line with the development goals of CourseFlow, which stated offering advanced and user-friendly discussion functionality as one of its prime objectives.

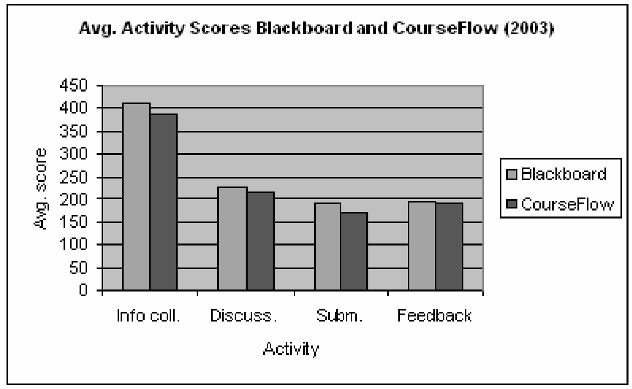

Figure 4. Average activity scores for the group assignment making process for Blackboard and CourseFlow (2003)

When comparing the 2003 data by the applications Blackboard and CourseFlow, we see a very close similarity between both tools. The activity scores (Figure 4) are almost similar and follow the same overall pattern as the comparison between the 2002 and 2003 results, with information collection by far being the activity for which the provided support is considered to be most useful. The similarity in scores suggests that activity is a much more important determinant of usefulness than the specific version or tool used to support it.

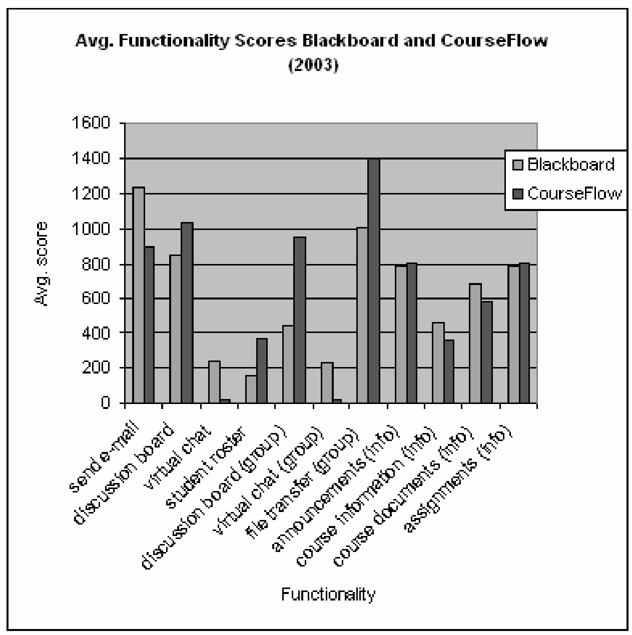

Figure 5. Average functionality scores for the group assignment making process for Blackboard and CourseFlow (2003)

The functionality scores of both tools show somewhat more variation than the activity scores (Figure 5). As mentioned before, CourseFlow scored considerably higher on the group discussion board functionality. It also scored considerably higher on student roster and file transfer functionalities, which were other design goals of CourseFlow, as it included more advanced knowledge management functionalities than Blackboard. Only on the virtual chat, CourseFlow scored even lower than Blackboard.

5. DISCUSSION

Courseware is a key technological infrastructure for enabling e-learning. However, much courseware functionality does not satisfy user requirements. One solution are component methodologies, in which tailored educational applications are constructed out of many small components of functionality [19]. Still, to make a relevant composition of modular applications, one must assess their experienced usefulness [12].

Our approach can be seen as a form of context-bound evaluation. Many traditional evaluation approaches are based on standard checklists of features that have little to do with the particular characteristics of courseware-in-use. Furthermore, such approaches make unreasonable assumptions about the level of detail at which decision makers are able to make their preferences explicit in practice [15]. Only context-bound evaluation, in which the experiences of the audience with the system in actual use are assessed *in toto*, can do full justice to the complexity of interactions of learners and their courseware [13]. Thus, for example, students can be asked to discuss in their group their joint overall experience with a particular functionality for a particular activity, giving them the freedom to define (or keep implicit) and weigh their own criteria, instead of having to check off an artificial list of characteristics that may not be relevant to their own subtle and complex work practices.

A combined use of quantitative (i.e. the scores) and qualitative indicators (i.e. the textual comments) aids complex decision making processes [17]. We found that simple measures are more insightful for initial quick scan and discussion purposes than the sophisticated measures proposed by Bedell [3].

E-learning being such a complex and core activity requires the organization itself to become adaptive, and to develop not only its technical skills, but also aim for increasing its *process learning* capabilities [22]. Such a learning organization is never finished, but continuously improves its way of working [9]. Practical courseware evaluation can be instrumental in assessing the value of learning environments, identifying functionality usefulness issues, developing solutions across applications, and helping to align the evaluation and decision making positions of the various stakeholders. Courseware evaluation can thus become a powerful catalyst in the creation of a true 'e-learning organization'.

6. CONCLUSIONS

We proposed a practical method for evaluating the usefulness of functionality components by various groups of stakeholders. An experiment was done by evaluating a core course process, the making of group assignments. The obtained activity and functionality scores were useful for initial courseware functionality selection.

One interesting finding is that the usefulness of a courseware application heavily depends on the particular activity being supported, although by which specific version or tool hardly seems to matter. This suggests that, contrary to the claims of commercial courseware providers, open source software might do just as well (or badly), but at a fraction of the cost. Also, there is great variation in the perceived usefulness of individual functionality components, so that a precise selection of which components to acquire or develop should be possible.

In sum, practical courseware evaluation is important, but not trivial. In this article, we have explored some of the many design choices to be made in developing simple methods for complex evaluations. We ignored many of the evaluation complexities and methodological tradeoffs still to be made, but have tried to make a case for methods that matter.

7. ACKNOWLEDGMENTS

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Towards Pragmatic Patterns for Clinical Knowledge Management

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ABSTRACT
We present a research program for identifying, modeling, and making use of generic pragmatic patterns for clinical knowledge management that support evidence-based medicine (EBM). Part of this program is SOMWeb, a system based on Semantic Web technologies, which is used for knowledge sharing and dissemination within an oral medicine community. A study of the use of SOMWeb has been conducted as the first step in the elicitation of important contextual factors and communicative activities involved in knowledge sharing processes in oral medicine. One such activity, community discussion activation, is described using consultation patterns together with the collaboration patterns of [5]. The general need for context-aware health information systems and the prospective use of approaches within Pragmatic Web in the pursuit of EBM are also discussed.

Categories and Subject Descriptors
H.5.3 [**Information Interfaces and Presentation**]: Group and Organization Interfaces – *computer supported collaborative work, web-based interaction*. H.4.3 [**Information Systems Applications**]: Communication Applications – *computer conferencing, information browsers*. J.3 [**Life and Medical Science**]: *medical information systems*.

Keywords
Pragmatic Web, community of practice, context, Semantic Web, ontologies, OWL, medical informatics, evidence-based medicine.

1. INTRODUCTION
An increasingly overarching goal of health care is providing optimal care, with maximized patient and societal benefits and with the use of the least possible resources. Many hold that optimal care should be evidence-based, meaning that care should be based on identifying, validating, and using the latest research results as a basis for clinical decisions [20]. To practice evidence-based medicine (EBM) entails integrating the expertise of the individual clinician with the best medical evidence obtainable from different knowledge sources.

One part in promoting EBM is to provide IT-support for the *communities of practice* [28] that are formed by practitioners of a medical domain, taking advantage of the practitioners' passion for their profession, their ambition of learning how to do it better, and their mutual interest of advancing the level of knowledge within their domain.

The oral cavity is sometimes referred to as the mirror of the body. This expression was coined to emphasize that the oral mucosa may mirror internal diseases. Diseases of the oral mucosa may therefore require consultations from different medical disciplines. Even the opposite may occur, i.e., various medical disciplines may benefit from consultation of oral medicine specialists when patients, in addition to general diseases, show signs of oral mucosal lesions. Thus, an oral mucosal disease, which is easy to examine, may through the contact with an oral medicine specialist lead to the establishment of correct diagnosis. The Swedish Oral Medicine Network (SOMNet) functions as a community of practice within oral medicine in Sweden. In this, SOMNet is an important platform in the interaction between the oral medicine and general medicine specialists. For example, when a patient with both skin lesions and oral mucosal lesions is submitted to one of the regularly held SOMNet meetings, the chairman of the meeting may invite a dermatologist. The specialists from the two disciplines will then get the opportunity to discuss the reaction patterns of the lesions observed on the skin as well as in the oral mucosa. As a consequence, this interaction may result in a correct diagnosis and treatment plan that had not been possible without the discussion between the dermatologist and oral medicine specialist. The interaction between specialists may also convey new knowledge to other participants of the meeting, e.g., general practitioners in dentistry, listening to the discussion.

It has been noted that the lack of platforms that support multi-disciplinary teamwork, as described above, limits the exploitation of IT in dental care and research [21]. The overall research question of the work presented in this paper therefore concerns the design, implementation, and adoption of web-based tools that support communities of practice within oral medicine and especially tools supporting the interactive dialog between

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geographically dispersed participants of consultation meetings, exemplified by the SOMNet meeting outlined above.

Pervasive in the above is the modeling, representation, and use of *context*, both at the level of the individual clinician, at the community level, and at an organizational level. However, there seems to be no consensus regarding the role of context within the health care domain [2]. This calls for research that can lead to a greater understanding of which aspects of context are important in developing more context-aware health information systems (HIS). Thus, a first step in our investigation of the general research question is the identification of contextual factors involved in communities of practice within oral medicine.

Central to EBM is the externalization of clinical practice knowledge of the individual clinician into diffused knowledge (e.g., evidence, protocols or clinical guidelines), together with the possibility to exploit explicit knowledge sources, all during daily clinical work [25]. In this, emphasis is put on what clinicians actually *do* with knowledge and on how the underlying *practices of clinicians* can be aligned with knowledge management processes, making *activity* a crucial attribute to be modeled in health care contexts [2]. Although social communication is essential for both the externalization and exploitation of knowledge, communicative actions are often neglected in HIS design [3]. The long-term objectives of this research are therefore to identify, represent, and make use of recurring *pragmatic patterns* of interaction and communicative actions in clinical knowledge processes within oral medicine, patterns that could inform the design of systems supporting communities of practice.

In this paper, we present an ongoing research program for identifying, modeling, and making use of pragmatic patterns for clinical knowledge management that support evidence-based health care, with focus on knowledge sharing and dissemination processes. We describe SOMWeb, a community collaboration system presently in use within a Swedish oral medicine community, a system that is based on Semantic Web technologies. A study of the clinicians' use of SOMWeb has been conducted as the first step in the elicitation of important contextual factors and communicative activities involved in knowledge sharing processes in oral medicine. An identified activity, community discussion activation, is described conceptually using consultation patterns together with the collaboration patterns in [5]. A preliminary analysis of the study suggests improvements to the system based on taking contextual elements related to the users, their activity, and their environment into consideration. The preliminary results of the study and the use of consultation patterns are discussed in terms of the general need for context-aware HIS and the prospective use of approaches within Pragmatic Web in the pursuit of realizing EBM.

1.1 Overview of the Paper

In the next section, the Pragmatic Patterns for Clinical Knowledge Management research program is described. The program aims at providing a web-based infrastructure for knowledge management that is necessary for achieving evidence-based oral medicine. The basic assumptions are presented together with the project's aims and objectives. In Section 3, MedView and SOMWeb, two earlier projects that provide the foundation and starting point, respectively, for the Pragmatic Patterns research program, are introduced. An outline of the ontological basis of SOMWeb is given, and then the web-based system for knowledge sharing and dissemination is described. In Section 4, the collaboration within SOMNet is described in terms of a typical SOMNet meeting, followed by the results of a first study of to which extent SOMWeb supports this collaboration, and a first example of a pragmatic pattern – a consultation pattern – is given. After a general discussion in Section 5, we conclude the paper in Section 6 by staking out directions for future work within the research program.

2. THE PRAGMATIC PATTERNS FOR CLINICAL KNOWLEDGE MANAGEMENT RESEARCH PROGRAM

Our modern IT-society provides the prerequisites for developing HIS that can contribute to high quality and effective care. Thus far, HIS have mainly been designed to provide more efficient handling of electronic patient records (EHRs) and administration. However, the global, net-based, and digital infrastructure of today offers the possibility of extending the use of HIS to include clinical research and optimization of health care strategies.

Several prerequisites for reaching this goal have been identified: (1) Access to relevant data. Without quality assured evidence, almost no decisions regarding diagnosis, medications, or other care procedures can be made [10]; (2) Support for the creation, harmonization, and dissemination of new knowledge that can be used in new improved care strategies, which over time provide new evidence [1]; (3) Methods and techniques that enable clinicians to define shared meanings of medical knowledge, across the boundaries of the individual HIS and the particulars of different EHRs [3]. (4) Knowledge management computer support that is easy to use, that can be adopted to different disciplines and groups of users, and that can be integrated with existing health care processes and work flows [16][12][19]; (5) Methods for handling differences between different HIS with regard to the usage of clinical information, which, compared to differences in fundamental health care strategies, is a larger impeding factor when it comes to the possibilities for communication and information exchange between today's HIS [17].

To come closer to the goal of HIS with better support for EBM, the Pragmatic Patterns for Clinical Knowledge Management research program was initiated in 2006. The research program is based on the following:

- Computer support should be based on the *practical use of knowledge*, with the knowledge process context in focus. From the previous section, it's clear that HIS must be designed to support the users' knowledge management tasks in different situations. For example, the entering and discussion of clinical data are two entirely separate activities that must be supported by appropriate tools. This should provide tools with better potential for integration in clinical practice and therefore with greater possibilities for long-term use and increased patient benefit.
- The developed models for clinical decision making and knowledge creation and dissemination should be generalizable so that *reusable patterns of knowledge management* can be identified, which can be turned into improved strategies for evidence-based health care.

- Standards for the Semantic Web[1] and approaches within Pragmatic Web [24][22] should be used to ease reuse and use of external information sources. By modeling clinical knowledge in accordance with proposed standards, the possibility of information exchange between HIS and use of third party applications is increased.
- To increase user acceptance, methods and computer support should be user-centered and user-controllable. Tools for computer support should be simple and adaptable to the individual user's preferences and context [26].
- Iterative testing and validation of the computer support in daily clinical work. Development in collaboration between user and developer, where prototypes and applications are tested in the daily clinical activity, has been identified as a key success factor in the development and adoption of HIS [29][11].

2.1 Aims and Objectives

The overall goal of the project is to obtain further knowledge of how pragmatic patterns for clinical knowledge management that support evidence-based health care should be modeled, implemented, and introduced into clinical practice. More specifically, the project addresses the question of how to design clinical computer-supported tools in which the use of information and the context of knowledge processes are in focus, while a solid foundation in formal knowledge representation and reasoning is maintained. In this, we seek to answer the following:

- What patterns for knowledge management can be identified in clinical decision-making and knowledge sharing and dissemination and how can these patterns be modeled and put to practical use?
- How should clinical knowledge processes be modeled and computer support be designed so that the knowledge's use and the processes' context are in focus while maintaining the foundations in formal knowledge representation and reasoning?
- How should computer support for clinical knowledge management be designed to be in alignment with existing health care processes and clinical workflows?

The hypothesis is that use of suggested standards and methods of the Semantic Web, computer-supported co-operative work (CSCW), and ideas from the Pragmatic Web are advantageous in answering these questions. In the project, oral medicine will serve as an example discipline from which more general results will be extracted.

MedView [13] and SOMWeb [9] are information systems in oral medicine that provide the foundation of the research program, in the form of an elaborated content when it comes to formalized clinical knowledge, web-based tools for the entering and analysis of clinical data, an online community for clinicians, and an established user base. With MedView and SOMWeb as starting points, the above hypothesis is investigated by setting up the following objectives:

[1] http://www.w3.org/2001/sw/

- **Formalizing clinical examination data**: Using the current formalization of clinical examination data in SOMWeb, initiatives for standardization of EHRs and of Semantic Web technologies should be applied to get a more standardized knowledge model.
- **Formalizing the context of clinical knowledge processes**: Based on results from previous steps, the context of a typical clinical decision process and a typical knowledge sharing process should be described at a suitable level of abstraction.
- **Web-based knowledge sharing and dissemination**: Based on the results of previous steps, SOMWeb's system for community collaboration should be made more context-aware, to better support the knowledge sharing processes within the community.
- **Decision-support**: Based on the results of previous steps, a context-aware decision-support system for oral medicine should be developed.
- **Pragmatic patterns for clinical knowledge management**: From the results of previous steps, generic, reusable patterns for clinical knowledge management should be identified and described at a suitable level of abstraction.

Expected results include improved strategies for evidence-based health care in oral medicine, the identification, and implementation of generic patterns for knowledge management, more specifically, knowledge sharing, knowledge dissemination, and decision-making, as well as contributions to open standards for representing patient data and to the Pragmatic Web.

The above objectives are met through the parallel development of a web-based system for knowledge sharing and dissemination and a decision-support system for use in oral medicine.

3. SOMWEB

The Swedish Oral Medicine Network has together with Chalmers University of Technology, Göteborg University, and University of Skövde developed the MedView application suite, to aggregate and analyze clinical information in the form of text and images. MedView contains components for the formalization, collection, and visual analysis of clinical data. The system is in daily use and has for the past couple of years been integrated with the commercial health record system T4[2] at the clinic for oral medicine in Gothenburg. MedView is also used outside of the SOMNet context.

One of the MedView applications, SOMWeb, is regularly used for distance consultations, follow-up of treatment strategies, and continuing education, and has contributed to a national harmonization of treatment strategies in oral medicine. SOMWeb is an online community for communication and knowledge sharing and dissemination within oral medicine. Members can add cases, with associated pictures, that are discussed at regular telephone conferences. SOMWeb is based on a formalization of information in oral medicine, where examination data and user definable templates for examination descriptions are represented

[2] http://www.kodakdental.com/sv/productsForDentists/T4/index.html?pID=7521

using the Semantic Web technologies of the Resource Description Framework (RDF) and the Web Ontology Language (OWL).

Development of MedView and SOMWeb has been carried out in a continuous dialogue between users and developers taking a user-centered design approach [27]. Cornerstones of user-centered design are an active involvement of end-users, iteration of design solutions, and the use of multi-disciplinary design teams. Central is an iterative process involving: (1) understanding and describing the context of use; (2) specifying requirements; (3) producing design solutions; and (4) evaluating designs against requirements. The process is repeated until a sufficiently good result is reached.

3.1 The Ontological Basis of SOMWeb

A formal representation of the information of SOMWeb is necessary, as we need the possibility of reasoning with the information that is collected and handled by the system. OWL has a basis in Description Logics, which has a well-explored complexity-tractability landscape. Further, OWL is a recommendation of the World Wide Web Consortium, which has spurred much activity in developing reasoners, tools for ontology authoring, visualization, and browsing, as well as application programming frameworks.

SOMWeb includes ontologies related to medical examinations and terminologies, as well as to community aspects. We begin by describing the ontologies related to examinations, and then describe the one related to the community.

The design of the SOMWeb ontologies [8] takes the MedView knowledge representation and content as a starting point, which includes (1) examination templates describing the pattern from which the individual records are created and which are used in constructing graphic input forms; (2) value lists, from which values can be chosen when filling out the forms; (3) aggregates of values; and (4) individual examination records. An examination is composed of categories (roughly corresponding to different headings of an examination, such as general anamnesis and mucos anamnesis), and each of the categories is composed of a set of inputs (questions to be answered, such as whether the patient has any allergies or not and the color of a mucos membrane) for which the class(es) of values that these inputs can take are given.

In the SOMWeb system, each examination template is stored in a separate OWL file. There is also one OWL file defining classes and properties common to all examination templates. A template OWL file contains definitions of the categories that may or need to be included in an examination constructed from that template. These categories are represented as OWL classes, which are subclasses of the class `ExaminationCategory`, found in the common OWL file. Examples of such subclasses are `PatientData` and `MucosAnamnesis`. Each category class in a template has inputs (or properties) associated with it. There are different kinds of input, such as whether they take data types, values from a class in the value list, or free text as values. Inputs can also have a description and an instruction (to be displayed on screen when filling out the form generated from the template).

For the value lists, all clinical terms, e.g., `Allergy`, are represented as OWL classes, with their values as instances, e.g., `PeanutAllergy`. For each instance, its name can be specified in different languages (in our case Swedish and English are of interest). The instances of some classes, such as diagnoses, may contain extra information about its code in the International Classification of Diseases (ICD)[3]. Currently, there is very little structuring of the instances within a class. In the previous MedView representation, such structuring was mainly done through creating value aggregates when analyzing collected data. For example, one may want to group allergies into different categories to investigate relations between these categories and certain mucous membrane changes in the mouth. Aggregates are mainly formed by sub-classing the values in the value list ontology, and by making the appropriate individual values instances of this subclass. Thus we can get more structure to the value lists by using the tools already in place for creating value aggregates.

Information related to the community is also described using OWL. This includes information about users and meetings, case metadata, and news. Some of the user-descriptions are related to relevant classes and properties of the Friend of a Friend (FOAF) vocabulary. Data related to these community elements is stored in RDF, as are individual examinations.

3.2 The SOMWeb System for Community Collaboration

The initial version of SOMWeb is centered on supporting the sharing of cases in oral medicine. The members of SOMNet hold regular telephone conferences (usually once a month) where shared cases are discussed. SOMWeb provides support for the organization, administration, and general structure of these meetings.

Clinicians who participate in the SOMNet meetings are of two different main types. One group comprises of specialists in oral medicine who exploit SOMWeb to consult other specialists, with the objective of getting different opinions on diagnosis and treatment planning. The other group involves general practitioners in dentistry who gain knowledge from an active discussion between the specialists. The specialist may also convey new knowledge to the general practitioners by reporting on a case with a previously established diagnosis and management.

Depending on what kind of member is using the system, the activities of a SOMWeb user can be:

- browsing cases, meetings, and members of the system,
- looking at presentations of individual cases,
- adding and administering the cases one owns,
- looking at presentations of individual meetings (past, current, or future),
- administering meetings (only certain members of SOMNet have privileges to administer meetings),
- reading news, or
- using the discussion forum, with threads both associated with individual cases and more general topics.

Some of these activities are also performed during the teleconference meeting, as described in Section 4.1. We will now go through some of the activities in the list above in more detail.

[3] http://www.who.int/classifications/apps/icd/icd10online/

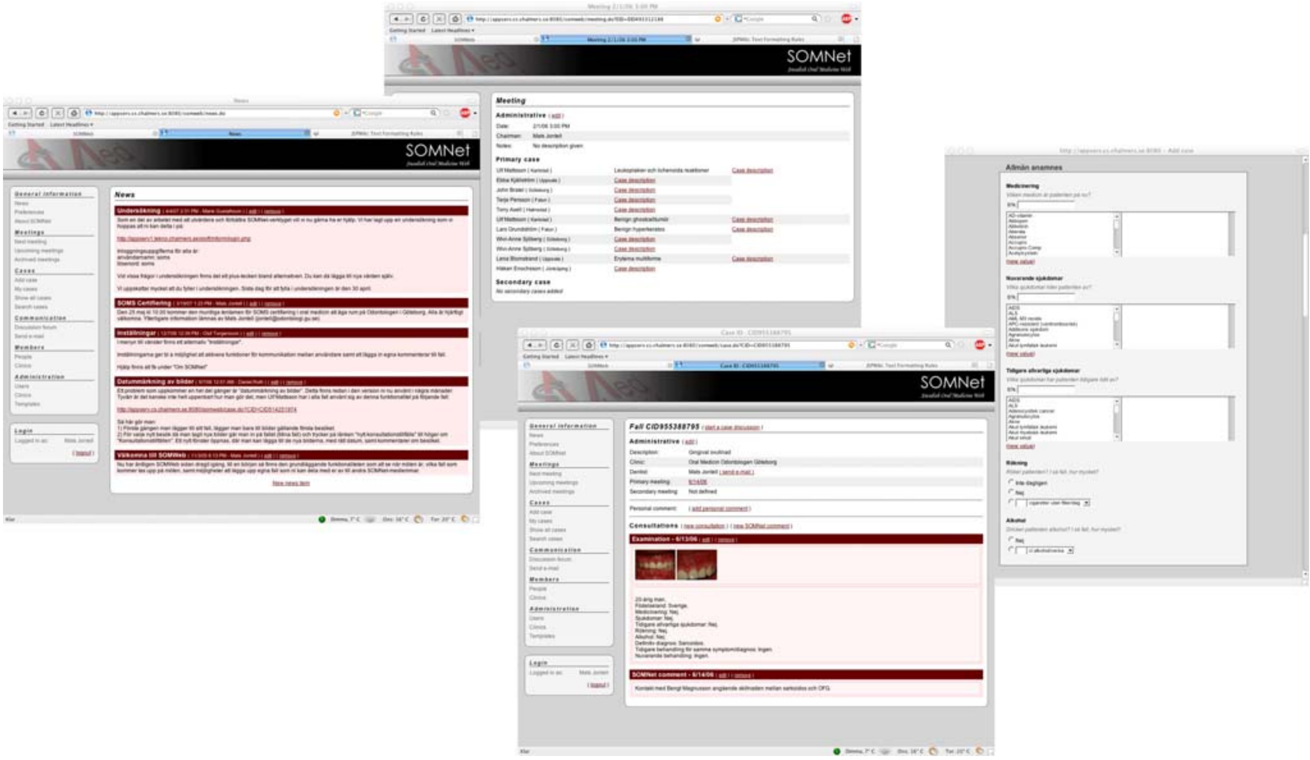

Figure 1. The SOMWeb Community Collaboration System: News page (left); Meeting page, with administrative details and list of cases to be discussed (top); Case page, with consultation details, pictures and comments (bottom); Page for adding a case using a form generated from a user-developed template (right).

When a clinician wishes to add a case to the system, he or she is presented with a blank form, which is generated from an OWL description of the examination (an examination template). This structured case entry is shown in the right-most screenshot of Figure 1 (above). The types of questions posed and the allowed values are determined by the underlying OWL description. After submission of a case, the case data is stored as RDF. In addition to templates for the first time a case is entered, there are also templates for entering the suggestions of the SOMNet telephone conference and for when the clinician has more information to add about the case. The templates all describe different types of consultation occasions, the type of which is specified on the case presentation page (more on this below). The users create templates in a separate editor for specifying the content of examinations, and they never interact with the underlying OWL representation.

When a case is added to the system, the user also has the option of assigning it to one of the upcoming telephone conferences, where it will be brought up for discussion. A meeting can also be assigned for when the case will be followed up, usually a few months after the initial discussion. In addition to the case owner, a user with administrative privileges can assign a case to a meeting.

Users with administrative privileges also update the meeting pages, where meetings can be added and details of date, time, and chairperson are provided. For each meeting, a page is created which displays these details, as well as links to any cases that have been assigned to it. The list of associated cases is divided into those brought up for the first time and those that are followed up from previous meetings. A meeting page is shown in the top screenshot of Figure 1. The navigation provides easy access to list of past and upcoming meetings, and the users can quickly navigate to the next meeting.

To browse the cases of the system, the user can look at the cases presented at meetings, at the cases of individual members, a list of all cases added to the system, or search the examination data using free text search. When the user clicks on a link to a case, a case presentation page is displayed. First, some administrative data connected to the case is given: a short description entered by the case owner, the clinic of the owner, the name of the owner, and any meetings the case has been assigned to. Then any consultation occasions are displayed. For each of these consultations, case data is presented in natural language generated from the RDF data, along with any associated images. A case presentation is shown in the bottom screenshot of Figure 1. The thumbnail images can be clicked to get a window where larger images are shown. Users can also add private notes to cases. They can also generate a discussion thread about the case in the discussion forum, if such does not exist, or get a link to the existing discussion thread.

It is to be noted that the contents of the SOMNet collaboration tool can be influenced by the user community, regarding both storage and presentation of cases. First, the case templates deciding what parameters to collect for submitted cases are the result of an agreement between the members of the community concerning what information to collect. As the needs of the community change, users can, by themselves, edit the case templates using the provided editor. Second, case summaries are generated from stored data through the use of presentation templates and natural language generation. Like the templates forming the basis for input, the generation templates may also be edited and controlled by the members of the community. The possibility to modify all parts of the contents regarding collecting data and presenting cases can be seen as a form of end user development [15], similar to what can be found in web authoring tools, which allow users to create web sites without knowing the technical details. However, in the SOMNet tool, the end user is the community rather than the individual user, since the templates used is the result of a harmonization process within the community regarding what data is important and how it is best interacted with.

4. SOMWEB IN USE

4.1 Collaboration within SOMNet

Before and during the development of the SOMWeb community collaboration system, several telephone conferences within SOMNet were observed. Now that the system had been used for several meetings, we have studied its use at four meetings. Three of these meetings were observed at the clinic of oral medicine, at the Sahlgrenska hospital in Gothenburg. At the meetings, there were between 10 and 16 remote clinics participating, and between five and ten clinicians located at Sahlgrenska. The remote clinics do not have as many clinicians per clinic, usually between one and three. One meeting has been observed so far at a remote clinic.

Each meeting, which lasts about one hour, has about three to six cases that are presented for the first time, and zero to three cases that are followed up from previous meetings. Each meeting also has a chairperson assigned, who leads the meetings, by e.g., transitioning between case presentations and summing up discussions. The cases are listed online in the order in which they were entered, but at the meetings the actual presentation order is often established based on the time and availability of the presenters.

When a case is brought up, the presenting clinician usually tells the story of his or her encounters with the patient, what treatments have been tried, and what the results have been. After, and sometimes during, this short presentation, the other participants ask questions of clarification. Depending on the nature of the case presented and the clinician’s purpose for bringing it up, the participants start suggesting possible diagnosis and treatments. These suggestions are sometimes accompanied by recounts of similar cases or general treatment strategies at one of the participating clinics. Sometimes more general discussions of the reporting of side effects for medications or the virtues or vices of different treatments ensue. Once several options have been considered, the chairperson usually starts summarizing these and one or two suggestions are given to the presenter. At the meetings observed, very few of the participants, apart from the chairperson, took notes. After each meeting, the chairperson is expected to make a note for the case in the system on what was decided and enter a date for a follow-up presentation, if that was decided upon at the meeting.

4.2 Community Collaboration Supported by SOMWeb

To further investigate the use and perceived usefulness of the SOMWeb community collaboration system, an online questionnaire was provided to the members of the SOMNet. The purpose was to evaluate the current system, identify possibilities for adopting the system further to the users needs and as a first step in the elicitation of important contextual factors and communicative activities. The questionnaire was announced at the telephone conference, on the news page of the system, and by e-mail to the around 60 registered members. The questionnaire was available for answering for about a month. The questions of the survey were about what goals they see with their collaboration as a whole (not just the system), self-reported details of how they use the system (for example, whether they only use it in association with telephone conferences), and how they assess the ease of use of the system. They were also asked whether or not they had added cases for discussion at the telephone conferences, and their reasons for doing or not doing this. A total of 24 clinicians completed the questionnaire. Selected results of the questionnaire are summarized in Table 1–3 below.

Table 1. Gender, position, computer familiarity, and location of workplace of respondents.

Gender	Male/female	46/54 %
Position	Specialist/general practitioner	57/43 %
Computer familiarity	Very good/good/average	13/58/29 %
Workplace	Private/hospital/specialist clinic/public dental care	8/54/25/13 %

The average age of the respondents was 51 years. Seventy-five percent of the respondents had more than 20 years of professional experience, 17 % 10–20 years of experience, 4 % had 5–10 years of experience, and the same percentage had 0–5 years of experience.

Table 2. Purpose of use of the system and how the system supports continuing education, discussion of cases, distance consultation, and the needs of the respondents in general.

Purpose of use	Continuing education/ discussion of cases/ distance consultation	29/63/8 %
Suits continuing education	Very good/good/neutral	33/46/21 %
Suits discussion of cases	Very good/good/neutral	50/33/17 %
Suits distance consultation	Very good/good/neutral/ bad/very bad	38/54/4/0/4 %
Suits user’s needs	Very good/good/neutral	30/61/9 %

As for reasons of using the system outside the SOMNet meetings, respondents state to acquaint oneself with the system, to check

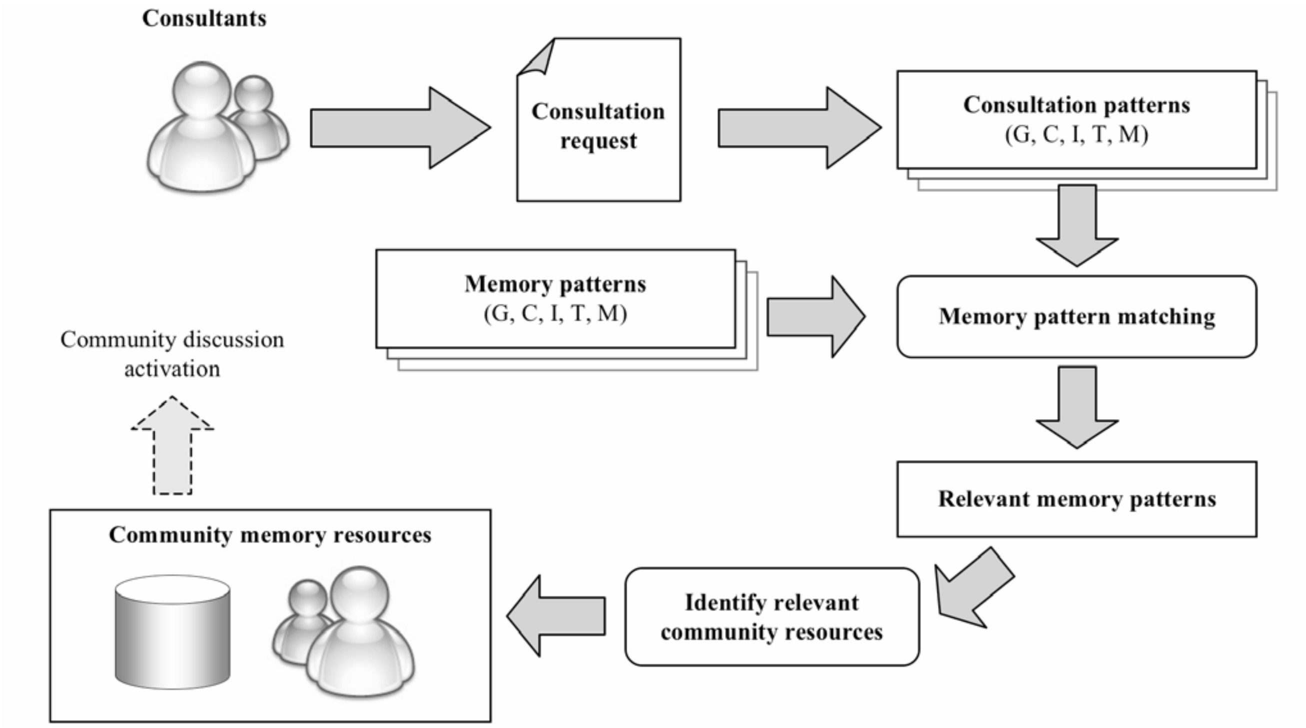

Figure 2. Using consultation patterns and the collaboration patterns (*G*oal, *C*ommunication, *I*nformation, *T*ask, and *M*eta-patterns) from [5] for community discussion activation in SOMWeb.

who's a member of the community, and to look at cases discussed at meetings not attended by the respondent.

Table 3. Percentage of users having added cases to the online repository and user's experience of the system's functionality regarding cases compared to the previous, non-web-based form of collaboration.

Has added cases to the repository	Yes/no	29/71 %
Using the case repository	Better/neutral/worse	78/22/0 %
Adding cases to the repository	Better/neutral/worse	87/13/0 %
Viewing old cases	Better/neutral/worse	88/12/0 %

For those that answered that they had added cases to the repository, we also inquired about their purpose in adding cases, giving three alternatives (of which several could be chosen): wanting advice in a specific case, to create a discussion about treatment strategies, and sharing a rare or interesting case. Of the seven respondents who had added cases, all wanted advice, five wanted to share a rare case, and four wanted to create a discussion on treatment strategies. Those who replied that they had not added any cases were instead asked whether they had considered adding a case, but decided not to. If this was the case, they were asked to give free text reasons for why not. Here to most common answer was a lack of time. Other reasons were that they did not have all the information about the case and an apprehension about whether the case was of general interest.

The case repository currently has 67 cases, added by twenty clinicians. Of those that have added cases, nine clinicians have added only one case, and one clinician has added 14 cases.

4.3 Pragmatic Patterns in SOMWeb

In the following we will adopt the terminology of *collaboration patterns* from [5].

Conceptually, the most common pragmatic pattern in SOMWeb is initiated when a *consultation request* is issued by a specialist requesting consultation about a case from the community regarding diagnosis or treatment planning (Figure 2 above). The consultation request is translated into a *consultation pattern,* in which the relevant *goal pattern* is either establishing a diagnosis or a treatment plan, supported by the best medical evidence available, as soon as possible; *communication patterns* include getting approval of the submitted case from the designated chairman and requesting case details from the consultant; *information patterns* define what data that have to be extracted from the case description and how the data should be presented (based on the chosen system templates, see Section 3.2); *task patterns* include setting the date of the meeting when the consultant's case is scheduled and creating a summary of the case (as generated by the current natural language generation template); and the relevant *meta-patterns* include an assessment of if the data extracted from the case using an information pattern is 'interesting' enough for the community as a whole and checking if all required data about the case (as defined by the template) can be extracted by an information pattern.

A pattern matching process then identifies the relevant *memory patterns*, of which the goal patterns include finding a community member that is a specialist within the field of the case and finding a community memory resource that is relevant for the case and is of as high credibility as possible (e.g., a published work); notifying the identified specialists by email and assigning them to the meeting in question is part of the relevant communication patterns; an example of an information pattern is how to search for relevant external medical evidence (e.g., in MEDLINE) and assess its quality; task patterns include creating lists of relevant specialists, previous cases, and (external) medical evidence; and typical meta-patterns describe what to do if no specialist and/or no medical evidence supporting the case can be found and what to do if a selected specialist cannot attend the meeting in question.

The identified memory patterns are then used to identify relevant *community memory resources*. As in [5], community memory resources consist mainly of computerized knowledge sources and community members. In the subsequent consultation meeting that is the result of community discussion activation, these resources are used as cues. For example, after presenting the case in question, the chairman of the meeting can give a summary of the identified medical evidence and then call on the identified specialists to address the meeting. Before the actual meetings take place, a discussion thread can automatically be set up in one of the discussion forums provided by SOMWeb, with the consultant as the moderator.

The description of the discussion within the community that then follows (as outlined in Section 1) in terms of pragmatic patterns is the subject of future research.

4.4 Context in SOMWeb

Our preliminary analysis of the use of SOMWeb leads us to consider improvements to the system, e.g., so that users are motivated to contribute cases, use the system when they need information, and to further their learning from each other. Adding context would aid in presenting the user with information and services better suited to their needs, as well as adding context to cases, which can be used in retrieval and matching of relevant patterns and community resources.

Thus far, identified contextual elements related to the users, their activity, and their environment are:

- Relating to the user: Whether the user is a specialist or a general practitioner, experience (e.g., years working), the location of employment (both geographically and the kind of clinic), previously added cases, and professional interests.
- Relating to the activity of the user: Time of use (whether it is a meeting time or not) and what actions are performed in the system (adding a case, browsing, looking for specific information).
- Relating to the environment: Whether the clinician is at work or at home, the number of possible distractors, and the time available to the user. However, contextual elements relating to the environment are probably few, as our system is only accessed from a web-browser and there are no features relating to pervasive computing.

There are also contextual elements that are related to the content of the system, such as the user's purpose of adding a case. This may be used both in organizing the SOMNet meetings to better suit the participants and for browsing the case repository.

5. DISCUSSION

The long-term objectives of the research presented in this paper are to identify, represent, and make use of recurring pragmatic patterns of interaction and communicative actions in clinical knowledge processes within oral medicine, patterns that could inform the design of HIS aimed at supporting EBM, and especially systems supporting communities of practice. In order to meet these objectives, the following questions must be addressed: What are the important aspects of the context of a typical knowledge process within oral medicine and how can the context be described at a suitable level of abstraction? Similarly, what pragmatic patterns can be identified in a typical knowledge process within oral medicine and how can these patterns be described at a suitable level of abstraction?

5.1 Context

During the past five years, both public and private dental health care in Sweden has undergone an extensive computerization, with more efficient handling of patient records as the driving factor. However, there is little insight or ambition to use the collected clinical data for knowledge creation. There are no tools for analysis of treatments and clinical guidelines for use by the individual caregiver, even though there is a demand for such tools. Thus, there is no explicit strategy to bridge the gap between collected data and the creation and dissemination of knowledge that could be realized as a result of integration between a modified clinical work process and the development of adequate analysis applications based on the EHR [25]. Taken together with the clinical care process's lack of natural elements and time for reflection and knowledge creation based on collected clinical data, this means that the full potential of today's HIS is not exploited.

Byrne and Gregory [3] put forward that, in order to create an enabling environment in which people can participate in debate on equal terms, issues concerned with lack of time, with social pressure and tradition, poor participation, history of top-down government, and insufficient knowledge of rights have to be resolved. Kane and Luz [14] make similar observations and conclude that lack of time and coordination are serious threats to the dependability of multidisciplinary medical team meetings (MDTMs). These challenges are confirmed by our study of the use of SOMWeb: lack of time is a recurring reason for not getting more involved in SOMNet activities; the apprehension that a case is not "interesting enough" for senior members of the community, that "I'm not an expert", are obstacles for some members to participate in the community's work; and one respondent listed the uncertainty of copyright status of the uploaded material (case descriptions and images) as one unresolved issue.

According to de Moor [4], modern approaches to knowledge management are based on users' agreement on a common perspective of the content, in the form of data and processes, of a given domain. The basis for this consensus is the interaction between users and between users and systems, in the form of a conversation about meaning, purpose, and goals of data and processes. The idea is that individual and common pragmatic contexts are represented, with the goal of providing better support for the actual individual and organizational processes. This is in line with recent research in community-based information systems within the health care domain, in which the establishment of a codetermined vision – of a "shared ground" – and the negotiation between local meanings are emphasized [3]. However, within the health care domain, socio-technical/-economic factors have so far been overshadowed by purely scientific factors (i.e., hard evidence) [25].

5.2 Patterns

Our description of community discussion activation using consultation and memory patterns is essentially an instance of the description of community memory activation in [5]. Apart from the identified consultation patterns, differences are at the level of collaboration patterns. While we find the approach of [5] to be a good starting point, we have found that applying the community memory activation description to the knowledge sharing activities that we have observed is not straightforward. One way forward is to add more structure to the process of identifying and describing the elements of community memory activation, which could be done by connecting these with an ontology over organizational elements. Such an ontology would aid in considering the context of the patterns involved in community memory activation. For example, in identifying and describing the goal patterns in [5], the *normative structure* of the relationships that exist among members of an organization (e.g., values, norms, and role expectations) [25] could be useful. Further, the *behavioral structure* of an organization can be described in terms of activities and interactions between members, and could, thus, be used for identifying relevant communication patterns. Finally, when identifying and describing communication and information patterns, the *technologies* (material resources as well as technical knowledge and skills of members) available to an organization are a factor to consider.

A SOMNet meeting, as described in Section 1, is an example of a MDTM, in that it is a forum where the team members, specialists from different clinical disciplines and general practitioners, meet to review patient cases, establish a diagnosis, and decide on the most appropriate treatment plan for the patient. According to [14], the processes associated with a MDTM system are: (1) pre-meeting activities; (2) case presentation (narrative in style); (3) case discussion, including negotiation and reinterpretation of findings; (4) deciding on the diagnosis and treatment; and (5) recording of the outcome. The same processes can be discerned in a SOMNet meeting, as described in Section 4.1. The different processes of a MDTM could be used for finding the appropriate level of abstraction (or granularity) for identifying and defining pragmatic patterns within SOMNet.

5.3 Communities of Practice

To develop computer support for the conversion of tacit manifest clinical knowledge (knowledge that is referred to by an individual or a group during their daily clinical work) into explicit and diffused knowledge (a repository of medical knowledge that has been proven valuable to a larger community) [25], a prerequisite is to represent the knowledge in a computer-processable manner. Within the area of knowledge representation, there has during the past ten years been much focus on ontologies [7]. The biomedical domain has shown much interest for the use of ontologies and ontology-based solutions, as one sees possibilities for integrating heterogeneous data, simplifying the identification of relevant data and tools, using inference for discovering new relationships, and creating well-defined models of biological systems [18].

However, the process of creating biomedical ontologies is more difficult than many had hoped [30][6]. One problem is how knowledge is formalized. How a group agrees on how a concept should be represented and how an ontology of the individual can be reconciled with an ontology of the community are other open questions. Another question is to what degree knowledge should be formalized. The formalization can be rigorous to different extents and different levels of formality can be needed for different subsets of the collected information. Shipman and Marshall [23] discuss difficulties associated with degrees of formalization and suggests that reasons for these difficulties are cognitive overload, tacit knowledge, and negative effects of prematurely imposing structure and that different formal structures are needed to support different situations requiring different user support. In dealing with explicit medical knowledge, it has been argued that an emphasis on context (temporal, spatial, cultural, and social) is needed [25], and we believe that representing context can be used to alleviate some of the difficulties of formalization for knowledge sharing within a community of practice, such as SOMNet.

6. CONCLUSIONS AND FUTURE WORK

We have argued for the need to apply the modeling and use of context and ideas from the Pragmatic Web on EBM, and have presented a project that intends to study how pragmatic patterns for clinical knowledge management that support evidence-based health care should be modeled, implemented, and introduced into clinical practice. Preliminary studies have been conducted as a first step in the elicitation of important contextual factors and communicative activities involved in knowledge sharing and dissemination processes in oral medicine. An example of a pragmatic pattern for requesting consultation of the SOMNet specialists was presented as part of community discussion activation. A preliminary analysis of the study suggests improvements to the system based on taking contextual elements related to the users, their activity, and their environment into account.

In the short term, we intend to continue studying the use of the SOMNet system by observing meetings at other locations and by interviewing the users, as well as further investigating existing models and techniques that support interaction and conversation in knowledge processes. Given that there is room for improvement in supporting the work in SOMNet (as reported in Section 4.2 and Section 4.4), we intend to take the current forms of co-operation as starting points in identifying contextual elements that can refine the model of knowledge sharing in SOMNet. For example, we want to investigate how contextual aspects should be added to the value list ontology (see Section 3.1), so that diverse views of the users and different levels of granularity can be represented. As for pragmatic patterns, the next step is to refine and formalize the conceptual model in Section 4.3 using identified models and techniques.

The long-term objectives of this research are to formulate a theoretical framework for supporting interaction and communicative actions in clinical knowledge processes and to develop methods, techniques, and computer tools for such support. We believe that identifying pragmatic patterns is a step towards EBM. If the care-givers' interests and needs are not provided for and support for the contexts and processes in which different evidence occurs are not realized, it is difficult to give the clinicians the experience that EBM-services are beneficial. As our research on pragmatic patterns is in an early stage, it is of value to continue to examine how patterns can be identified, represented, and used within the domain of clinical knowledge processes.

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Mind the Gap!
Transcending the Tunnel View on Ontology Engineering

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ABSTRACT
The key objective of communal knowledge sharing at the scale of the World Wide Web is the ability to collaborate and integrate within and between communities. Ontologies, being formal, computer-based specifications of shared conceptualisations of the worlds under discussion, are instrumental in this process by providing shared semantic resources. To this end, the pragmatic aspects of the exchange of knowledge and information are crucial. Pragmatics represent the intentions, motivations and methodologies of the persons involved and need to become formalised and unambiguous for effective exchange to occur. On the one hand, this is something that humans manage fluently in their daily face-to-face social discourses. On the other hand, as contemporary knowledge engineering methods consider only the non-human system parts, they usually focus on mere syntactic aspects of concept modelling. The elicitation (semantics) and application (pragmatics) context are often weak or even ignored. This paper aims to bridge this gap between "reality" and its modelling concepts by (i) transcending knowledge engineering methods to a semiotics view on contextualised communal knowledge engineering and sharing; and (ii) by presenting the DOGMA ontology framework and how it provides extension points to this semiotics engineering.

Categories and Subject Descriptors
I.2.4 [**Knowledge Representation Formalisms and Methods**]: *representation languages, semantic networks*

General Terms
Management, Experimentation, Human Factors, Languages, Theory

Keywords
ontology, knowledge sharing, DOGMA, semiotics, context dependency management

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1. INTRODUCTION
The key objective of communal knowledge sharing at the scale of the World Wide Web is the ability to collaborate and integrate within and between different and diverse communities. A community constitutes a social system, where action and discourse is performed within more or less well-established goals, norms, and behaviour [10]. Communication is the primary basis for coordinated action, hence in order to collaborate and integrate between different and diverse communities, it is important to capture and agree on the semantics of the concepts being communicated.

In order to fulfil the rapidly evolving community requirements, the concepts being communicated must continuously be adapted to the actual collaborative situation, and the meaning of new concepts should be incrementally negotiated by all participating stakeholders. Therefore, knowledge creation becomes the ultimate red-thread action transcending communities to develop consensus for communication in order to accomplish their goals.

Ontologies, being formal, computer-based specifications of shared conceptualisations of the worlds under discussion, are instrumental in this process by providing shared resources of syntax and semantics [7]. Such formal semantics are evidently fundamental in the development of any collaborative, knowledge-intensive services, methodologies or systems that claim to capture and evolve, in real time, relevant commonalities and differences in the way communities conceptualise their world and communicate about it.

To this end, the pragmatic aspects of the exchange of knowledge and information are crucial. Pragmatics represent the intentions, motivations and methodologies of the persons involved and need to become formalised and unambiguous for effective exchange to occur. This is something that humans manage fluently in their daily face-to-face discourses. However, in current practice, knowledge engineering methods usually focus on mere syntactic aspects of concept modelling, and the context of elicitation (semantics) and application (pragmatics) is often weak or even completely ignored. Furthermore, systems are usually reduced to only the non-human parts, with the possible exception of the field of organisational semiotics [16,25] that already involved a few socio-technical aspects of communities such as norms and behaviour in information system specification. Semiotics [4,9,19] is a science of signs and their syntax, semantics and pragmatics that, by giving an interdisciplinary, socio-technical view on an information system specification, aims to bridge this gap between "reality" and its modelling concepts [10].

Similarly, this paper wants to bridge the gap in a knowledge-intensive system between its social/human part (where knowledge is socialised in daily face-to-face discourses), and its technical part (where knowledge is engineered as pure mathematical objects) (Sect. 2). Doing so, it contributes to state-of-the-art in knowledge engineering methods by (i) transcending these methods to a semiotics view on system engineering for communal knowledge sharing by introducing requirements for semiotics engineering (Sect. 3); and (ii) by presenting the DOGMA ontology framework and how it provides extension points to this semiotics engineering (Sect. 4). Section 5 gives a real-world case study excerpt from engineering semiotics for competency modelling. Finally, we end with a discussion and conclusion.

2. COMMUNITIES AND KNOWLEDGE

In order to illustrate the gap we mentioned between the social/human knowledge-sharing system and its technical "mirror", we adopt Nonaka's well-known four modes of knowledge conversion [18] (Fig. 1). Critics have argued that Nonaka and Takeuchi's distinction between tacit and explicit knowledge is oversimplified and that the notion of explicit knowledge is self-contradictory [12]. Specifically, for knowledge to be made explicit, it must be translated into information (i.e., symbols outside of our heads) and knowledge, which is what semiotics engineering is all about.

Communication is the primary basis for coordinated action for accomplishing community goals. Through **socialisation,** people naturally *utter* and *share* experience and expertise in face-to-face discourses, and thereby create *tacit* knowledge such as mental models of ontological concepts and new technical skills. The current application context is about the concept Deliver.

Through **externalisation**, this tacit knowledge is *partly* articulated (publicly or privately) into explicit formal knowledge *artefacts*, taking the shape of e.g., a concept type, a contributed taxonomy, an interface, a workflow definition, etc. This is illustrated by the curved arrows that take a selection from the mental models that is relevant to explicate the concept Deliver in this application context. Note that although externalisation is an incremental process using language of variable expressivity (as we will explain below), there will inevitably remain an important part of tacit knowledge in the utterer's mental model on which the correct interpretation of the articulated part is dependent [20,21]. Externalisation is done by domain experts, as they have the tacit knowledge about the domain and can sufficiently assess the real impact of the conceptualisations and derived collaborative services on their organization.

Once they are published, **combination** involves semantic analysis and integration (for an excellent survey, see [15]) of published contextualised knowledge artefacts in order to adapt to new collaborative requirements. This process might be further constrained by community-shared models such as running application tools that commit to certain published consensus, by pre-existing organisational sub-ontologies, and by inflexible data schemas interfacing to legacy data. Furthermore, participating stakeholders usually have strong individual interests, inherent business rules, and entrenched work practices that influence decisions in meaning negotiation rounds. These may be tacit, or externalised in workflows that are strongly interdependent, hence further complicate the conceptual combination. Sometimes it is not necessary (or even possible) to reach for context-independent ontological knowledge, as most ontologies used in practice assume a certain context and perspective of some community [23]. Wenger [26] supported this by stating *"Peace, happiness, and harmony are therefore not necessary properties of a community of practice"*. Hence pragmatically, combination processes need to support human experts to focus on these "community-grounded" processes of realising the appropriate amount of consensus on *relevant* conceptual definitions through *effective* meaning negotiation in an *efficient* manner [7].

Internalisation concerns the appropriate operationalisation and embodiment of explicit knowledge consensus in the current communication actions. For example, for ontological knowledge, the most widely used recommendations on the Semantic Web are XML, RDF(S) and OWL.

The four modes of knowledge conversion engender an upward knowledge spiral, where individual knowledge opinions become commonly accepted, through an iterative interplay between externalisation and internalisation. This interplay illustrates how knowledge artefacts co-evolve with their communities of use. In socialisation, knowledge is communicated as abstract entities, and humans can easily grasp the context of interpretation. However, when applying formal knowledge engineering methods for the other knowledge conversion modes, we have to emphasize the semiotic dimensions, in order to bridge the gap between socialisation processes in the social system on the one hand, and the other conversion processes (externalisation, internalisation, and combination) in the technical system on the other hand.

In the next section, we bootstrap some requirements for semiotics engineering that address the context of elicitation (semantics) and application (pragmatics).

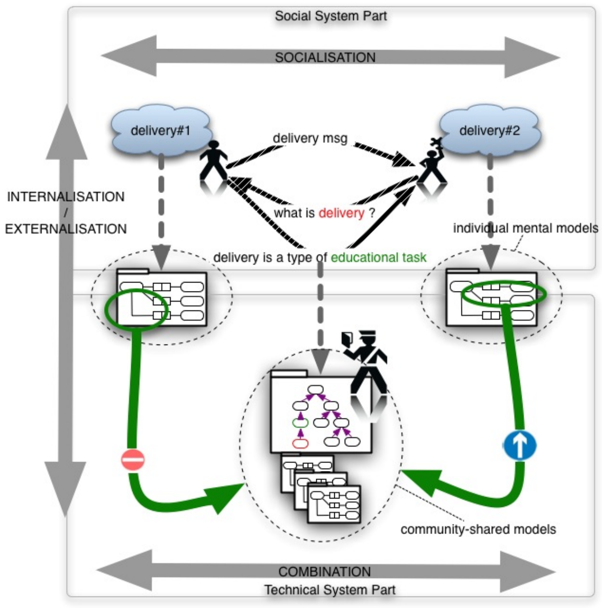

Figure 1: The gap between the social/human knowledge-sharing system and its technical "mirror".

3. REQUIREMENTS FOR SEMIOTICS ENGINEERING

Semiotics engineering (as introduced by Zhao [27]) concerns the process of engineering a symbolic system that formalises models of data, processes, and ontological knowledge in well-formed symbolics. Similarly to ontology engineering, we distinguish two directions of semiotics engineering: *elicitation* and *application* [6].

Knowledge elicitation is related to Nonaka's processes of externalisation and combination. Guidance for elicitation is triggered and influenced by composition norms that hold in the community [8]. Elicitation concerns the syntactic and semantic dimensions of semiotics. Knowledge application is related to combination and internalisation, and concerns the pragmatic dimensions of semiotics.

From a pragmatic point of view, *scalable* elicitation should on the one hand be driven by the intended purpose or application, but should on the other hand result in reusable knowledge artefacts. In [6], we identified a set of context-driven ontology engineering processes that govern this trade-off. Considering the literature, these processes differ widely in their implementation. The only constraint we stress here is that their user interfaces should be accommodated for ease of use in communities.

3.1 Constructivism

Constructivism rejects the existence of a unique objective reality, hence its reflecting "transcendent" conceptualisation. Therefore, the *constructivist* approach supports multiple domain experts in the gradual and continuous externalisation of their subjective realities contingent on their ever-evolving social and cultural background, and professional experience. Technically this requires a knowledge engineering methodology that supports the building and managing of increasingly mature versions of ontological artefacts (conceptualising their divergent subject realities), and of their converging interrelationships, achieved through careful negotiation.

Wittgenstein and Putnam also consider the meaning of a concept to be the set of all its uses (read: application contexts) [22, pp.128]. Pragmatics boils down to converging to that subject conceptualisation that maximally fits the intended application context.

3.2 Variability and Reusability

All meaning (semantics) is for communication purposes about a universe of discourse. It is represented independent of language but necessarily must be entirely rooted and described in (natural) language. Linguistic "grounding" of meaning is achieved through elicitation contexts, which can be mappings from identifiers to source documents such as generalised glosses, often in natural language [6,14].

Thousands of shared vocabularies or so-called *folksonomies* emerge, are sold and advertised, prosper or wither in a self-organising manner on Web 2.0, through reuse and adaptation of natural language labels for tagging their resources, such as process and work flow models. Natural language labels for concepts and relationships bring along their inherent *ambiguity* and *variability* in interpretation [2], which on the one hand provides an *unbounded reusability* potential for specific reference in a given application context, which is important for *scalable* semiotics engineering [27]. On the other hand, however, it requires an analysis of multiple contexts to conduct successful *lexical disambiguation* on the labels [1,5].

3.3 Application-specific Contextualisation

Tagging resources and thereby externalizing a cloud of lexically disambiguated concept labels is not enough. From a pragmatic point of view, elicitation must anticipate on the intended application by eliciting and combining the relevant artefacts insofar necessary in an effective way. In Section 3.2, we stressed the unbounded potential for vocabulary reusability and scalability, however true knowledge creation for the benefit of the community involves further externalisation of specific concept semantics such as attributes and axioms, uniformly agreed, but properly contextualised for a particular application context.

3.4 Flexible Operationalisation

Once (a version of) an artefact or ontology has been agreed on and validated, it can be translated into an operational language that is in accordance with the actual collaborative application pool and internalised in the tacit mental models. For example, the most widely used recommendations on the Semantic Web are XML, RDF(S) and OWL. However, as community goals tend to shift depending on the changing shared business interests, an operationalised ontology version (or even its operational language) will soon become obsolete. An ontology (language) should capture these changes continuously in order to co-evolve driven by the ontology engineering activities described so far.

To formalise the semiotics engineering framework we circumscribed above, we adopt and extend the DOGMA[1] ontology engineering approach.

4. DOGMA ONTOLOGY ENGINEERING

Ontology is an approximate shared semiotic representation of a subject matter. To fulfil the requirements mentioned in previous section, the DOGMA [6,13,17,24] ontology approach and framework is adopted with the intention to create flexible, reusable bounded semiotics for very diverse computational needs in communities for an unlimited range of pragmatic purposes [27].

The DOGMA approach has some distinguishing characteristics that make it different from traditional ontology approaches such as (i) its groundings in the linguistic representations of knowledge, (ii) the explicit separation of the *conceptualisation* (i.e., lexical representation of concepts and their inter-relationships, materialised by so-called *lexons*) from its *axiomatisation* (i.e., semantic constraints) and (iii) its

[1] acronym for Developing Ontology-Grounded Methods and Applications

independence from a particular representation language. The goal of this separation, referred to as the *double articulation* principle [24], is to enhance the potential for re-use and design scalability. Lexons are initially uninterpreted binary fact types, hence underspecified, which increases their potential for reusability across community perspectives or goals [2]. The axiomatisation of lexons guarantees the specification needed for semantic consistency and well-formedness in a particular collaborative context (see further).

Lexons are collected in the Lexon Base, a reusable pool of possible vocabularies. A lexon is a 5-tuple declaring either (in some *elicitation context* G) [6]:

1. taxonomical relationship (genus): e.g., < G, manager, is a, subsumes, person >;
2. non-taxonomical relationship (differentia): e.g., < G, manager, directing, directed by, company >.

Lexons could be approximately considered as a combination of an RDF/OWL triple and its inverse, or as a conceptual graph style relation [22].

Next, we will elaborate more on the notions of elicitation context (Sect. 4.1) and application context (Sect. 4.2).

4.1 Language versus Conceptual Level

Another distinguishing characteristic of DOGMA is the explicit *duality* (orthogonal to double articulation) in interpretation between the language level and conceptual level. The goal of this separation is primarily to disambiguate the lexical representation of terms in a lexon (on the language level) into concept definitions (on the conceptual level), which are word senses taken from lexical resources such as WordNet [11]. The meaning of the terms in a lexon is dependent on the context of elicitation [5].

For example, consider a term "capital". If this term was elicited from a typewriter manual (read: context *G*), it has a different meaning (read: concept definition) than when elicited from a book on marketing. The intuition that a context provides here is: a context is an abstract identifier that refers to implicit and tacit assumptions in a Universe of Discourse (UoD), and that maps a term to its intended meaning (i.e. concept identifier) within these assumptions [6]. Notice that a context in our approach is not explicit formal knowledge. In practice, we externalise an elicitation context by referring to a source (e.g., a set of documents, laws and regulations, informal description of best practice, etc.), which, by *human understanding*, is assumed to "contain" the necessary assumptions [13].

Hence, within a context of elicitation, a lexon is not merely syntactic by nature. They are just underspecified, what makes them reusable for being applied in specific collaborative application contexts within a UoD. The formal account for *application context* is manifested through the selection and interpretation of lexons in *ontological commitments*, and the *context dependencies* between them [6].

4.2 Ontological Commitments

The pragmatic account for knowledge artefacts is formalised in ontological commitments. Committing to the Lexon Base in the *context of an application* means selecting a meaningful set *S* of lexons from the Lexon Base that approximates well the intended vocabulary, followed by the addition of a set of semantic constraints, or rules, to this subset. The result (i.e., *S* plus a set of constraints), called an ontological commitment, is a logical theory of which the models are first-order interpretations that correspond to the intended task(s) for achieving a particular goal with a certain level of trust and quality. An important difference with the underlying Lexon Base is that commitments are internally unambiguous and semantically consistent[2]. Though ontologies can differ in syntax, semantics, and pragmatics, they all are built on this shared vocabulary, called the Lexon Base. Examples of ontological commitments are business rules, database constraints, or norms.

4.3 Context Dependency Management

The motivation to regard context dependencies as a facet of an elicitation or application context comes from classical literature, where context is adopted for packaging, disambiguating, linking, and nesting knowledge artefacts [6]. Doing so, two formal artefacts might be mutually inconsistent, and at the same be dependent on the same upper core artefact. When the latter changes, the dependencies will force the dependents to evolve along. Context dependencies provide additional information on the pragmatic context of the dependent.

5. COMPETENCY MODEL BUILDING

In this section we demonstrate how the requirements for semiotics engineering are facilitated by our DOGMA approach, with an example from the Human Resource domain.

5.1 Reusable Competence Definitions

The Lexon Base provides possible vocabularies that can be reused as building blocks for integration. We consider three stakeholding communities: the Superb Actors School (SAS), the Public Employment Agency (PEA), and the RCD Vocabulary Advisory (RVA). All of them commit to the Lexon Base, of which a sample is given in Table 1. This means that their ontological commitments use a vocabulary in which all terms are linguistically grounded and lexically disambiguated[3]. RVA is

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[2] Although it is outside the scope of this article, we find it valuable to note that in the research community it is debated that consistency is not necessarily a requirement for an ontology to be useful.

[3] E.g., the term "action" is disambiguated as in [10]:

An action is a transition involving a non-empty set of actors in its pre-state, and, if not "destroyed" or "consumed" by the action, in its post-state as well, and involving a nonempty or empty set of other things (actands) as part of its pre-state, and having a nonempty or empty set of other things (actands) in its post-state. Examples:

responsible for maintaining reusable vocabularies for competence definitions. Note that some lexons such as "speech clarity is_a /subsumes competence" imply a taxonomy.

Table 1: a sample Lexon Base

G[4]	Head term	Role	Co-role	Tail term
RVA_vocabulary_20060410	Competence	consists_of	part_of	Action
RVA_vocabulary_20060410	Competence	belongs_to	has_competence	Actor
…	…	…	…	…
Actor_School_20070514	Speech_Clarity	has_quality	quality_of	Very_good
Actor_School_20070514	Speech_Clarity	consists_of	part_of	Speak
Actor_School_20070514	Speech_Clarity	results_in	result_of	Understand
Actor_School_20070514	Speech_Clarity	is_a	subsumes	Competence
…	…	…	…	…
Public_Employment_20070514	Person_Actor	is_a	subsumes	Actor
Public_Employment_20070514	Speech_Clarity	belongs_to	has_competence	Person_Actor
Public_Employment_20070514	Speech_Clarity	belongs_to	has_competence	Politician
…	…	…	…	…

5.2 Contextualised Competency Building

An important collaborative goal of both communities is to enhance job matching for actors. Knowledge workers, including domain experts and (middle) managers are responsible for detecting and reporting flaws in the job matching processes caused by a lack of consensus about the structure, meaning and use of concepts. The knowledge engineer interprets then these reports and formulates them in concrete externalisation tasks, which are after initiation delegated to the relevant participants for execution. To this end, communities can externalise their knowledge and combine it with RVA vocabulary insofar necessary and relevant for the communication context at stake.

For example, consider the elicitation of a competency model for a key competence "Speech_Clarity" in job matching. Before this concept is elicited from scratch or by making uncontrolled subjective selections from the Lexon Base, Ontology Server is queried for existing ontological commitments that already formalise the concepts "Competence" and/or "Speech_Clarity" for some application context both stakeholding communities share.

In general, the Ontology Server hosts the different knowledge repertoires of collaborating communities. Each repertoire is contextualised: it stores different kinds of knowledge artefacts, and sometimes multiple structures or semantics for the same artefact can exist.

In this case, if the artefacts already exist, they can be reused as the context for the current elicitation tasks in this new application context between SAS and PEA. However, it turns out that:

1. "Speech_Clarity" was not yet formalised so far, but for "Competence", it appears that SAS and PEA share a minimal but unambiguous commitment, consisting of one axiomatised lexon formalising following business rule *BR*:

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Competence belongs_to AT LEAST ONE Actor.
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2. "Speech_Clarity" is a sub-type of "Competence", hence the (diverging) educational and employment commitments for "Speech_Clarity" from SAS and PEA respectively, will be context-dependent on this shared commitment.

SAS' speech clarity The concepts in the SAS community are more detailed when it comes to competence descriptions. Since they are responsible for making sure their students obtain the competences, they need a clear view on what the competences *mean*. Figure 2 shows their ontological commitment (to the Lexon Base) on "Speech_Clarity".

PEA's speech clarity The PEA community is focused on matching competences with jobs. For them, it is less relevant to have a detailed view on the competences themselves, but rather on the link between competences and possible job types. Figure 3 displays their commitment on "Speech_Clarity".

It is clear that SAS and PEA have a different use of the concept "Speech_Clarity", though both are based on the same business rule *BR*. However, the focus in this paper was not to force both stakeholders to merge to one objective concept of "Speech_Clarity", but to eamphasise the importance of dependencies that exist between different contexts of use of the same or taxonomically related concepts "Competence" and "Speech_Clarity".

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1. Stock-taking (action) by a warehouse-clerk (actor) checking current stock, and producing a stockinventory;
2. Issuing a stock item (action) by a stock supervisor (actor), resulting in a change of stock level;
3. Writing (action) a report by an author (actor);
4. Expressing (action) a conception by a person (actor), in the form of a representation.

[4] The elicitation context identifier G in our example is derived from space-time dimensions: (1) the community that elicited the lexon, and (2) the date on which this version was created.

5.3 Context Dependencies

As already mentioned both PEA's and SAS' commitments are context-dependent on the shared business rule *BR.* Suppose the administrator of *BR* decides to change the lexical representation or alter the semantics of the concepts (read: lexons) involved, then this change must be propagated to all its dependent contexts of use.

Furthermore, as part of its ontological commitment, the PEA also creates a context dependency between its ontology and the ontology from the SAS. This dependency states that the PEA system should be updated whenever there are changes related to the concepts "Person_Actor" and "Speech_Clarity" in the SAS system. When the SAS ontology administrators update their world view (e.g., by changing "Speech_Clarity" to "On_Stage_Speech_Clarity"), the technical system *triggers* the social system between the two communities. Based on norms the appropriate knowledge workers in the PEA community receive a request for a knowledge change, stating that they should check and update their ontology (e.g. by taking over "On_Stage_Speech_Clarity" which they link to "Person_Actor", but not to "Operator").

In this example, we showed an application of some of the processes depicted in Fig. 1. We demonstrated combination by merging a part of the SAS context with the PEA context ("Speech_Clarity" belongs_to "Person_Actor"). In the social part, the *socialisation* was demonstrated through the evolutionary trigger stated by the context dependency, where the PEA administrators had to understand and reflect the change in the SAS context. This change also showed *internalisation* as the administrators analysed this external knowledge, studied and understood the change. They *externalised* this by formalising the change in their own context.

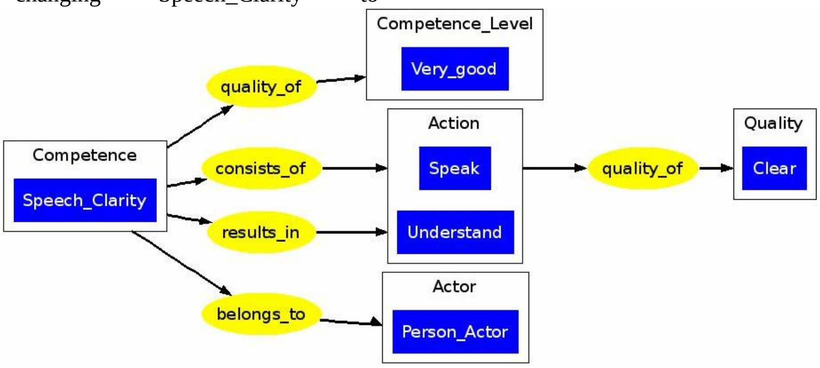

Figure 2: SAS' educational commitment

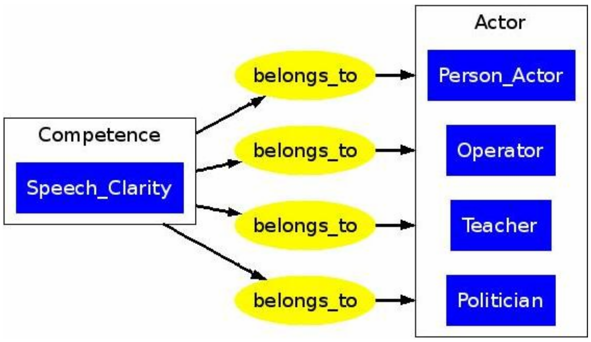

Figure 3: PEA's employment commitment

6. IMPLEMENTATION

DOGMA[5] Studio is the tool suite behind the DOGMA ontology engineering approach. It contains both a Workbench and a Server. The Workbench is constructed according to the plug-in architecture in Eclipse. There, plug-ins, being loosely coupled ontology viewing, querying or editing modules support the different semiotics engineering activities and new plug-ins continuously emerge. This loose coupling allows any arbitrary knowledge engineering community to support its own ontology engineering method in DOGMA Studio by combining these plug-ins arbitrarily. Such a meaningful combination of view/edit/query plug-ins is called a "perspective" in Eclipse. The DOGMA Server is an advanced J2EE application running in a JBoss server, which efficiently stores Lexons and Commitments in a PostgreSQL Database. DOGMA Studio is complemented by a community layer, in which the DOGMA collaborative ontology engineering processes are grounded in communities of use. This layer is implemented by the DOGMA-MESS[6] methodology and system. For an in-depth elaboration on DOGMA Studio and –MESS in the context of a business use case, we refer to [3].

7. DISCUSSION AND CONCLUSION

Successful virtual communities and communities of stakeholders are usually self-organising knowledge-intensive systems. The knowledge creation and sharing process is driven by implicit

[5] http://starlab.vub.ac.be/website/dogmastudio

[6] http://www.dogma-mess.org

community goals such as mutual concerns and interests. Current knowledge engineering methods usually focus merely on the syntactic dimension of semiotics engineering, thereby ignoring these pragmatic aspects. In order to better capture relevant knowledge in a community-goal-driven way, these community goals must be externalised appropriately. In this paper we considered a knowledge-intensive system as a true semiotic system, consisting of a social/human part and a non-human technical part. We proposed an initial, non-exhaustive list of requirements for semiotics engineering where:

1. underspecified vocabularies promote unbounded reusability potential for specific ontological reference in a given application context. In our example, the linguistic grounding and disambiguation of these vocabularies are authored by a designated stakeholder in the community;
2. stakeholders agree on and commit to concepts insofar necessary and relevant for their communication, hence knowledge socialisation in a particular application context;
3. context dependencies between knowledge artefacts provide additional context information between these knowledge artefacts. If a knowledge artefact changes, a change request must be triggered to the authors of all knowledge artefacts that are dependent on it.

The current community goals and norms may be linked to relevant strategies underlying the legitimate collaborative knowledge conversion processes and its support. This requires us to model communities completely (i.e. establish their formal semantics) in terms of their intrinsic aspects such as goals, actors, roles, strategies, workflows, norms, and behaviour, and to so integrate the concept of community as first-class citizen in the knowledge structures of the evolving system. This holistic approach is breaking with current practice, where systems are usually reduced to only the non-human parts, with the possible exception of the field of organisational semiotics that already involved a few socio-technical aspects of communities such as norms and behaviour in (legitimate) information system specification.

8. ACKNOWLEDGMENTS

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A Pragmatic Structure for Research Articles

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ABSTRACT
Our goal is to develop a new format for scientific research articles, which will facilitate their use in a computer-assisted environment. By explicitly marking up rhetorical and knowledge elements in the text, an attempt is made to optimally represent the argumentation contained within the article. To this end, a structure of discourse segments and their relations is proposed. Applying this structure to a set of research articles could enable the creation or population of a system to visualize and access scientific argumentation within a corpus of research articles.

Categories and Subject Descriptors
H.3.1 [Content Analysis and Indexing]: Indexing methods, Linguistic processing.

General Terms
Design, Experimentation, Theory, Verification.

Keywords
Pragmatic Web, Science publishing, Research Articles, Discourse Analysis

1. INTRODUCTION
The exponential growth of scientific literature prevents scientists from reading all relevant articles appearing in their field. First, it is difficult to know whether all relevant publications are found; once found, it is impossible for an individual researcher to read all those that are interesting. Although the advent of powerful search engines such as Google and Pubmed, and the near-ubiquitous availability in PDF format of articles on authors', universities' or publisher's websites means that the majority of scientific articles are available in an electronic form, the structure of 'paper' itself, with its traditional IMRaD (Introduction, Method, Results and Discussion) set-up, has survived, largely unchanged, into the digital age. But the knowledge contained within a paper is embedded within its exact linguistic representation, and cannot easily be extracted by computational means. Therefore, this discourse structure itself prohibits finding a more efficient way of locating and comprehending the bulk of scientific information. In the end, scientists still have to read every article, more or less in its entirety, to know what the authors have done and argue to have contributed to the canon of scientific knowledge.

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To address this problem, a large corpus of work ongoing in Bioinformatics aims to allow access to large collections of articles by identifying entities such as organisms, proteins, genes, drugs or disorders from their ambiguous textual representations. The current focus in this field lies in identifying such entities and, if possible, their relationships (such as protein-protein relationships; gene-disorder relationships, and so on); for overviews of this field see e.g. [4] and [14]. Other initiatives to channel the flood of information in the life sciences such as the 'Structured Digital Abstract' propose that authors and editors add a list of entities and relationships to an article [7]. The main assumption underlying these efforts is that a research articles can be fully represented by a set of facts, which can then be collected and transformed into knowledge bases. However, science is not merely the statement of facts. To model the content of a research article, pragmatic considerations, i.e. the *reasons why* the author mentions entities and their relationships, need to be taken into account. A representation of the argumentation (including non-textual elements such as figures, and references to other work) is crucial to see precisely *which* statements are proposed to be facts, and how these are motivated. We therefore need to identify not only the *semantic* information transmitted, but also the *interpersonal*, *stylistic* and *interpretational* aspects of the text (categories taken from [13]).

The goal of this research is to model this argumentation. To do so, we propose a structure for the Research Article, consisting of typed discourse segments, connected by relationships. The proposed structure is called 'pragmatic', for three reasons: first of all, it is 'pragmatic', in the common use of the term, i.e. aimed to provide a practical solution to a pressing problem, rather than merely an academic exercise. Secondly, by taking the rhetorical, persuasive and interpersonal roles of the text into account it uses concepts from Pragmatics, 'the branch of linguistics which seeks to explain the meaning of linguistic messages in terms of their context of use' [19]. Thirdly, it aims to work on and support the concept of the Pragmatic Web, as outlined in the Pragmatic Manifesto [25]: 'the Pragmatic Web complements the Semantic Web by improving the quality and legitimacy of collaborative, goal-oriented discourses in communities.'

The purpose of this article is to provide a first-order model of such a discourse structure. This work focuses on research articles in Cell Biology, for several reasons. First, the community is very large and widely distributed, the number of publications enormous, and therefore the need for integrative technologies is quite urgent. Next, a lot of research is done in this area on text mining and entity extraction. Also, probably partly due to the competitiveness of the field, the format of the Research Article in Cell Biology is quite tightly defined, which can help identify common structures. The model might also prove to be useful in other fields; if the results in Cell Biology are promising, this will be investigated in a later stage of the project.

2. A PRAGMATIC STRUCTURE FOR RESEARCH ARTICLES

2.1 Discourse Segments

Discourse consists of “discourse segments and [...] the relationship[s] that can hold between them” [9]. A rhetorical step or move is defined by Swales [26] as ‘*a discoursal or rhetorical unit that performs a coherent communicative function in a [...] discourse*’. (Swales, in fact, uses the two concepts ‘step’ and ‘move’ interchangeably – a step is a part of a move, but no exact definition of the difference is given.) In various text analytics models, this is the level chosen for analysis; Grosz and Sidner [9] refer to these elements as ‘Discourse Segments’; in Rhetorical Structure Theory, it corresponds to the concept of ‘span’, defined (with comfortable vagueness) as: ‘A text span is an uninterrupted linear interval of text’ [20]; Polyani [23] refers to these as discourse constituent units (dcu’s) and Marcu [21] as elementary discourse units or edu’s.

An empirical evaluation of a corpus of cell biology articles (validated by a user study where 85% of the elements were found to overlap between 9 users) identified the following moves within cell biology articles (examples taken from [30]):

1) **Facts** – i.e. statements which are presumed to accepted as true by the community:
‘Cellular transformation requires the expression of oncogenic RASV12, but in primary cells, its expression provokes a stress response that arrests the cells (Serrano et al., 1997)’
2) **Problems** – describing discrepancies or unknown aspects of the known fact corpus:
‘the small number of miRNAs with a known function stresses the need for a systematic screening approach to identify more miRNA functions.’
3) **Research Goals** – which can contain an implicit hypothesis, and an implicit problem:
‘To identify miRNAs that can interfere with this process and thus might contribute to the development of tumor cells,’
4) **Methods** – the way in which the experiment was performed:
‘We inserted 500 bp fragments spanning a given miRNA-genomic region in a modified pMSCV-Blasticidin vector’’
5) **Results** – the direct results of the measurements:
‘we observed an approximately 4-fold increase in miR-311 signal’,
6) **Implications** – offering an interpretation of the results, in light of the known facts and the research goal:
‘indicating that our procedure is sensitive enough to detect mild growth differences’
7) **Hypotheses**– offering a possible explanation for a set of phenomena:
‘This suggests possible roles for APC in G1 and G0 phases of the cell cycle’
Here, I have used ‘Implication’ when a direct interpretation of a result is provided (‘*This indicates that miRNA-372 and 3 do not block RASV12 signals’*) and ‘Hypothesis’ when a model is being presumed without empirical evidence (‘*we suggest that suppression of LATS2 is an important factor*’); admittedly, the boundary is blurry.

Table 1: Verb tenses for segments in two articles – bold indicates most used

	Fact		Problem		Goal		Method		Result		Implication		Hypothesis		*Total*
Present active	72	46%	27	60%	15	23%	7	7%	37	16%	69	51%	38	55%	*265*
Present passive	5	3%	2	4%	2	3%	1	1%	1	0%	11	8%	1	1%	*23*
Past active	18	11%	5	11%	11	17%	48	47%	122	54%	16	12%	8	12%	*228*
Past passive	25	16%	2	4%	1	2%	17	17%	21	9%	1	1%	5	7%	*72*
Future	2	1%	3	7%	0	0%	0	0%	1	0%	0	0%	0	0%	*6*
Imperfect: "to"	13	8%	2	4%	32	50%	2	2%	20	9%	14	10%	7	10%	*90*
Gerund ("ing")	22	14%	4	9%	3	5%	28	27%	23	10%	24	18%	10	14%	*114*
Total	*157*	*100%*	*45*	*100%*	*64*	*100%*	*103*	*100%*	*225*	*100%*	*135*	*100%*	*69*	*100%*	*798*

These segment types are marked up using an XML DTD, see http://people.cs.uu.nl/anita/XML for a copy of the DTD and a small corpus of marked-up articles. As an example, a portion of a marked-up text from [30] looks like this:

<*Goal*> To investigate the possibility that miR-372 and miR-373 suppress the expression of LATS2, </*Goal*>

<*Method*> we performed immunoblot analysis of cells expressing wt and mutant miR-372 and 3, the cluster and the controls p53kd and empty vector. </*Method*>

<*Result*> Both in the absence of RASV12 and in its presence, a significant reduction in LATS2 protein level was observed upon miR-372 and 3 expression (Figure 5B). </*Result*>

<*Method*> Using quantitative RT-PCR and immunoblot analysis, <*Method*>

<*Result*> we observed a 2-fold effect on LATS2 RNA levels and 4- to 5-fold on protein levels by the miR-371-3 cluster (Figure 5C). </*Result*>

<*Method*> As a control, we used a LATS2 knockdown construct (Figure 5F). </*Method*>

<*Implication*> These results show that a combined effect of RNA destruction and translation inhibition is used by miR-372 and 3 to silence LATS2. </*Implication*>

Table 2: Segment order in four Research Articles– from {column headers} to {row headers}; start/end indicates first/last segment in a (sub)section; bold corresponds to arrows in fig. 1

	Fact	Hypothesis	Problem	Goal	Method	Result	Implication	End	*Total*
Start	18	3	1	8	2	2	4	0	*38*
Fact	*83*	22	13	17	9	31	12	1	*188*
Hypothesis	20	*5*	3	7	6	2	6	3	*52*
Problem	9	7	*7*	2	3	5	3	3	*39*
Goal	7	0	2	*4*	46	6	0	0	*65*
Method	13	2	3	10	*25*	54	3	0	*110*
Result	23	9	4	6	16	*85*	78	6	*227*
Implication	13	6	4	12	11	30	*12*	25	*113*
Total	*186*	*54*	*37*	*61*	*118*	*215*	*118*	*38*	*827*

We can identify these rhetorical segments using different linguistic markers, including verb tense, aspect and modality; cue phrases, or specific syntax structures or word order [21]. Preliminary investigations of the tenses in two cell biology articles ([30] and [18]) shown in Table 1 indicate that a first identification of the segments listed above can be done using *verb tense*: in 516 segments, 72% of the Facts and 69% of the Implications were stated in the active present tense, whereas 47% of the Methods and 54% of the Results were stated in the active past tense. Also, we find quantitative indicators of the preferred order in which segments occur. The order of segments in set of four cell biology research articles ([30], [18], [33] and [16]) is shown in Table 2. This shows that, for example, Goals are often followed by Methods, and Results by Implications.

These results suggest a model of the reasoning in Research Articles, depicted in Figure 1. From the use of tenses, it appears that research occurs in two distinct 'realms': the realm of Models, including Theories, Hypotheses and Facts, which is timeless, and generally shared; and the realm of Experiments (Results and Methods), which lies in personal (past) experience of the researcher. In fact, most persuasive moves occur on the boundaries of the two realms. Moving from the Model realm to the Experiment realm, a proposal for an experiment is made, which forms the research Goal. Moving from Result to Implication, a researcher tries to substantiate his or her model by experimental results: this is where the core of the argumentation takes place. Most hedging (see e.g. [15] for definition and examples) occurs on the model-experiment boundary; phrases such as '*our results suggest that*', '*this could for instance be a result of*', and '*these results point to'* are common here.

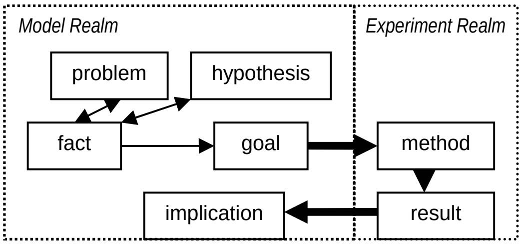

Figure 1: Schema of Discourse Segments and relations

From the segment order (specifically, the order 'Fact' → 'Goal' → 'Method' → 'Result' → 'Implication') we can identify a linguistic representation of the scientific method as used in biology: a Problem is identified in the canon of Facts, appropriated by the author, and subjected to Methods of experimental probing. Based on the Results of this probing, the author resubmits the Implications to the shared canon of Facts, addressing the Problem posed at the beginning. In making the Implications fit within the fact corpus, the researcher is justifying his model, and making his claim. Fact creation happens here, where the implications are seen to fit with the world of facts as described in the Introduction, and hopefully address the Problem. Latour et. al. in [17] describe science as 'a fact factory'. Seen in these terms, the schema of moves depicted in Figure 1 represent a 'fact machine'; its churning can be seen in each experimental article. What I refer to as 'Facts' represent Latour et. al.'s Statements of categories 4 and 5 - Implications refer to their Statements of category 1 or 2.

2.2 Segments versus Sections

The basic outline of a Research Article is provided by the sections and subsections, that are of the order of several paragraphs or more and are identified by section headings (such as 'Introduction', or subsection headings, such as: 'Segments vs. Sections'). Traditionally, and very explicitly in Cell Biology, the section headings used are Introduction, Results, Discussion and Experimental Methods. Comparing these sections to the elements in a story grammar as defined by Thorndyke [28] or the elements of classic rhetoric, as defined by Aristotle, we see great overlap (see also [32]). In a Research Article, just as in these genres, the basic elements are (elements in brackets are optional):

a. *Introduction*:
  - Setting the stage, and positioning the present topic
  - Posing the central (research) question
  - (Providing an outline of what follows)

b. *Experimental Method*:
  - (Describing the methods used)

c. *Experimental Results*:

- Providing proof of the main claim(s)
- Interpreting the implications of the work

d. *Discussion*:
- Evaluating the claims in the light of related work
- (Summarizing the current work)
- (Discussing next steps)

To make a story, sections need to be read in sequence; however, as with a story schema, expert readers can skim through them to portions of interest. This does not contradict the fact that articles are often not read in sequence ([2], [5]). Precisely because the order of sections conventional, readers can ignore it.

Table 3: Nr. of segments (rows) in each section (columns)

	Introduction	Method	Results	Discussion	*Total*
Fact	63	0	104	37	*204*
Problem	20	0	10	15	*45*
Goal	2	0	72	6	*80*
Method	2	all	129	6	*137*
Result	10	0	230	44	*284*
Implication	14	0	100	36	*150*
Hypothesis	10	0	33	26	*69*
Total	*121*	*0*	*678*	*170*	*969*

The segments discussed in Section 2.1 are generally at the level of a sentence, or a sentence fragment, so there are many segments to a section. If we look to see which segments are contained in which sections, we find that in Cell Biology, there is a not a one-to-one overlap between the two: see Table 3 for results on four cell biology articles ([30], [18], [33] and [16]). For instance, the Results Section does not consist only of Results segments, but also contains many other segments. There is one exception: in the Experimental Methods section, only Methods segments are given. However, since Methods Sections generally fall outside the line of reasoning of a RA (as their frequent setting in small type indicates), I have omitted them from the rest of this study.

In Table 3, we see the 'story grammar' or 'rhetorical schema' reflected in the segment types as distributed over the sections: in the Introduction, the focus lies on the stating Facts and Problems (and sometimes, Hypotheses); in the Results, the focus lies more on Methods, Results, and Implications; in the Discussion, the main focus is on Implications and Hypotheses, as embedded in the realm of Facts, and addressing the Problem. It is clear that the argumentation is built up throughout the document, and sets of moves (e.g. Fact -> Goal-> Method-> Result) repeated throughout the sections of the article.

2.3 Relationships between Segments

Coherence in discourse is created by relationships that hold between discourse segments [9]. To model an appropriate set of relations between segments in Research Articles we believe we need to augment existing relationship taxonomies in two ways. (see section 3.1 for discussion of a number of existing taxonomies). First, it seems we need to allow for segment-type specific transitions. Segment-segment transitions are usually indicated by cue phrases or verb tense changes [21]. See Table 4 for the full set of explicit transitions between segments for one of the articles studied [33]. We see, for example, that the transition to a Method segment is typically indicated by use of the word 'We', and the transition from Results to Implications is almost always marked by use of a phrase such as *'These [results] suggest/show/demonstrate/indicate/implicate/validate that...'*. Change of verb tense, even within sentences, also reflects segment transitions. For instance, the Goal -> Method transition is usually marked by an infinitive form (e.g., 'To investigate ...') followed by a 3rd person plural, active past tense (e.g., '…, we performed/measured etc.'). To accurately model segment-segment relationships, we need to make a careful analysis of such transitions, and identify the role they play in the

Table 4: Explicit segment-segment boundaries in (Westbrook, 2006)

	Fact	Problem	Goal	Method	Results	Implication	Hypothesis
Fact	in animals	however (3x)	to, we examined (2x)	we fused, we utilised	in contrast, we found (5x), though, on average, under our conditions	our data suggest, we propose that, consistent with	suggesting that (2x)
Problem				we fused	in this paper		
Goal				we isolated	we showed		
Method					we found (2x), while, as seen	but suggests	we predicted
Results	in addition, in contrast			we utilised, we used	interestingly (2x), since (3x), also (2x), while (2x), second (2x), third (2x), finally (2x), subsequent, thereafter, in our study	(strongly) suggests/suggesting that (8x), implicating (2x), consistent with (2x), demonstrating that (3x)	we propose, suggesting that
Implication			to verify, to confirm	we replaced, we fused, we tried	however, first (2x), interestingly (2x), consistent with, in our analysis, strikingly, neither	also	in theory
Hypothesis	in animals, in support of this, indeed		to test (2x)			however, our results provide evidence that	

persuasive/argumentative structure of the text.

Secondly, when modeling relationships between segments we need to incorporate some of the specific properties of the genre of Research Articles:

- The text is greatly structured, both in explicitly named (IMRaD) sections, sometimes in explicitly named subsections which contain section headers defining their content, and in the Discourse Segments described above.
- The text contains bibliographic references to other papers, which are essential to argumentation;
- The text contains non-textual elements such as images and tables, which are also essential to argumentation.

These results suggest that we need to allow for the inclusion of inter-medium (links to figures and tables) and intertextual relations (links to references), by adding the relationship types 'link to figure/table' and 'link to reference'. These links are specific for the segment type in which they appear. For instance, in a Fact segment, references are usually used to other facts; in Methods segments, they refer to similar methods used, and in Implication or Hypothesis segments, they refer to papers that are being challenged or confirmed. Also, it would be useful to allow for references to specific *segments* in other documents – enabling relations between two methods, for example, or a result and a competing result. This implies that segments need to be marked up in such a way that they can be accessed from outside the article directly (e.g. by using XPath tags).

3. DISCUSSION

3.1 Related work

We identify three categories of related work: concerning segment types, concerning segment relations, and concerning the use and creation of rhetorically parsed texts.

Several studies within discourse linguistics focus on identifying types of rhetorical moves, such Grosz et. al's theory of Discourse Segment Purposes [9], for an overview see [1]. The work of Swales [26, 27] looks at various genres within scientific communication. Swales' work focuses on the Introduction section of Research Articles and has largely inspired our more fine-grained analysis of segment types. Teufel et. al. [28] also identify discourse segments within the body of the article, so-called 'argumentative zones'. The difference between our work and Teufel's is the size of the segments (hers are longer) and the type of segments. For example, by using the catch-all category 'Fact', we do not distinguish between 'Own' and 'Other', and 'Own' and 'Background', which was found to be difficult to identify by human annotators [28]. Also, our segment identification (using verb tense and cue phrases) is different. Interestingly, Mituza and Collier computationally modelled Teufel's zones in a corpus of biology articles [22] and identified the categories *background*, *problem setting*, *method*, *result*. These correspond in very well to our empirically identified set.

Work concerning segment relationships includes Rhetorical Structure Theory (RST) and Discourse Structure Theory (DST); for an overview, see [1]. Building on this, several taxonomies of coherence relationships have been created, including [11 -13] and [24]. Two sets of taxonomies that have been developed for specific use in science. First, the ClaiMaker suite of tools, which were matched with Sanders' taxonomy [3], and second that by Harmsze and Kircz [10]. We aim to develop a set of relationships using input from all of these taxonomies with the addition of the features discussed in section 2.3: non-textual relations and segment-specific relations (which were also suggested by Harmsze and Kircz).

The system Harmzse and Kircz [10] propose is to let the author write modular components (on the order of one or more paragraphs) with a single segment type, which are then combined (through a very rich set of relations) to form a 'modular' document. The main difference with our proposal is that we do not assume that the author will write in a modular way, but instead assume that we can parse the existing article format to allow for the population of (small) modules.

To use rhetorically parsed texts, several systems of relating scientific claims have been developed, such as the Hypothesis Editor created by Gao et. al [6] and the suite of ClaiMaker tools [3]. These systems enable the visualization and manipulation of scientific claims. In both cases, an externally edited set of hypotheses or claims are added to a text, and relationships within and between texts are created in the system to provide insight in the argumentation of a research area. Both these systems rely on author- or editor annotation of the main claims of the article. A semantic authoring tool for papers in computer science is SALT [8]. Here, the author identifies claims and relationships (using a subset of RST relations) using LaTeX commands, akin to the abcde-model we proposed earlier [31]. A good test of our structure would be to see if they could easily be imported into any of these systems.

3.2 Next Steps

We are creating a corpus of research articles in cell biology marked up as described (http://people.cs.uu.nl/anita/xml). A more detailed taxonomy of coherence markers is planned, and will be modeled within this corpus. Once this is done, we wish to develop this work in two directions: first, by enabling the creation of the markup of discourse segments and relationship identification, and second, by using this corpus to populate existing 'sensemaking systems' or knowledgebases.

Concerning the creation of the markup, we first wish to attempt to automatically identify segments and relationship types through computational means, using our preliminary thoughts on verb tense and cue phrases for segment identification. If automatic parsing is feasible, we will apply our work to a large corpus of full-text biology articles. If it isn't, we will investigate creating the markup in an automatically-assisted way within an authoring or (copy-)editing environment.

Concerning the use of the markup, we hope identification of discourse segments and their relations will allow access to the argumentation structure within a research article, and between a connected set of articles. In the future, we wish to investigate connections to existing sensemaking systems (such as [3] and [6]). Another interesting direction would be to investigate authoring/editing tools based on this analysis, which could allow for a 'rhetoric check' during the article submission process.

Lastly, if creation and usage work in biology, we would like to investigate the use of this model in other domains of science.

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Information Seeking in a "Socio-Semantic Web" Application

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ABSTRACT

Information Seeking gives users a wider range of access methods when retrieving business items (e.g. projects, products, skills, people, deliverables …) using (intra-)Web applications. The Information Seeking approach we propose is based on the concept of the "Item", as defined in the Hypertopic model that we propose for mediating various "socio-semantic Web" applications. We show on an example, in the case of a sustainable development projects cooperative e-catalogue, how items can be viewed "semiotically", depending on various tags, topics and points of view.

Categories and subject descriptors

H.3.3. [Information search and retrieval]: retrieval models, search process

Keywords

Socio-semantic Web, cooperation, folksonomy. Web2.0, Information seeking

1. INTRODUCTION

"Socio-semantic Web" applications make it possible for communities to co-produce and use symbolic organizational artefacts, such as "maps", "tag clouds" or shared indexes making the collective knowledge and actions/activities both more visible and more reflexive. Projects of this kind generally involve the use of Web 2.0 collaborative applications such as the Open Directory Project, Del.icio.us or FlickR and end-user "folksonomies", which have been defined as means of cooperative classification and communication based on shared metadata [8].

These applications open various opportunities for more accurate activities of Information Seeking [6][7] or more generally, activities of *inquiry* as defined by John Dewey [4]) based nowadays on variably well formalized documentary and informational resources accessible via Internet or the intranet environment.

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In this paper, we will start (§2) by shortly defining what the "socio-semantic Web" applications are. Then (§3), we will outline the Information Seeking conceptual model - contrasted with Information retrieval (IR) model - and we will suggest some lines on which infrastructure assisting those searching for information in the context of their occupational activities might be designed. Item-based Hypertopic maps and tag clouds can be used to collectively organize knowledge, thus facilitating users' search efforts.

For this purpose, we illustrate (§4.1) Information Seeking in the field of electronic cooperative e-catalogues: we examine complex features which could be proposed on such e-catalogues and marketplaces to describe/seek items such as "projects" or "products" proposed by multiple contributors.

In our opinion, the hypotheses on which the socio-semantic Web and the HyperTopic standard project [11][12][14] were based provide a useful starting-point for this purpose, as we will see when describing (§4.2) an *example* implemented with the Agoræ software platform, based on Hypertopic. In this example, the Information Seeking approach is shown in the context of a catalogue of projects that we are developing[1] using Agoræ in the field of the Sustainable Development (SD-projects).

2. SOCIO-SEMANTIC WEB

Socio-semantic Web, which is an extension of the Semantic Web, seems to provide a promising approach to developing tools and applications [11]. [9] has proposed a similar approach called the Pragmatic Web. The Socio-semantic Web does not involve a high level of automation of meaning, based on the processing of formal ontologies by automated inferences. The Socio-semantic Web focuses rather on situations where semantic require the semi-formal support of Information Technologies, but where human beings are also necessarily involved, interacting during the whole lifecycle of applications, for both cognitive and cooperative reasons.

From the knowledge management point of view, the Socio-semantic Web is intended to support communities needing to continuously and collectively elicit information about the "local" semantic structure of business objects and the ongoing collective work. In the case of business objects, this information can be

[1] This experimental Web portal is developed for the french-speaking community of SD-projects owners, in partnership with the www.blueinitiative.org. Demo based on the Agoræ software, is available on http://tech-web-n2.utt.fr/dd/.

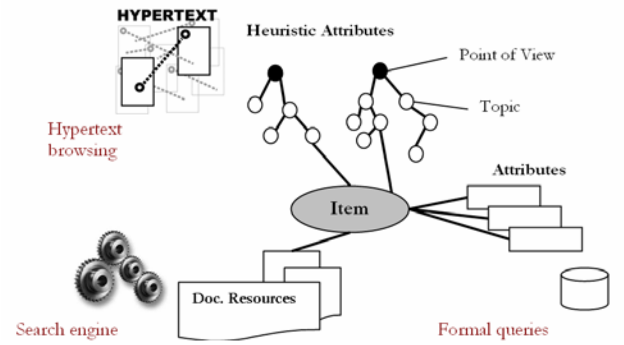

Figure 1. Hypertopic model and Information Seeking

obtained by consulting artefacts such as thesauruses, topic maps, semi-formal or semiotic ontologies [2, 11], yellow pages or catalogue directories.

At the Community level (or the inter-Community level, such as that where Clients and Sellers co-operate), the local semantic system is continuously and collectively constructed by the actors as they perform their activities. In this "autopoietic" process, users are not only passive consumers of externally-designed semantic resources, but they are users and creators of local semantic resources that they are able to manage by themselves, using Web standards, for example. This applies especially to situations where the underlying semantic resources which need to be elicited and updated are particularly voluminous, in evolution, and even conflictual (as in cases where metadata are shared by competitors working together on a common marketplace).

New approaches are required nowadays for to co-building large shared indexes and collective socio-semantic Web artefacts. In many case, the construction requires Hypertopic maps (see§3) including multiple points of view, and the use of methods which can be finely adapted [13] to the case of each focused Community. Organizational rules have to be chosen, depending on whether the semantic decision-making process takes place under centralized or distributed conditions: i.e., on whether it is a top-down, bottom-up (or mixed) process, whether (or not) a moderator or facilitator is involved, etc.

Since 2002, several communities have been using Hypertopic-based groupware tools (such as "Agoræ", "Argos-Viewpoint", "Porphyry" and "Cassandre", which are Open Source software developed by the Tech-CICO team) to co-build socio-semantic Web applications. In these experiments, many pragmatic methods have been used to "bootstrap" Hypertopic maps including multiple points of view. For instance, to build the e-catalogue of projects in the very conflictuous field of sustainable development projects (see § 4), a "conflicting co-construction method" has been used, resulting into several actors' points of view in competitition. In such a case [13], groups attempting to share knowledge are liable to experience cognitive conflicts [10] due to the existence of differences between various points of view, semantic heterogeneity and interpretative disagreement.

3. IR *VS* INFORMATION SEEKING IN THE CONTEXT OF SOCIO-SEMANTIC WEB

The IR (Information Retrieval) always fits the context of a finalized activity (one with a goal) [7]. In the example we will give here, the aim of the information-seeker is to choose a project in the field of sustainable development in order to support it or to join it. In many cases, this situation involves making investigations and acquiring knowledge both about the project itself and about the subjects (i.e. the scientific topics, the arguments and opinions...) associated with the project or justifying the project.

In this situation, the IR corresponds to the user who already knows which project he wants and what for. All he wants to do is to find the project, to contact the project owner and to support the project. This situation does not require much serendipity, since any attempt to deviate this user from his focused research will be brushed/drawn aside.

In the case of the Information Seeking, on the contrary, the actor does not know *a priori* which complex item is liable to best meet his needs, and he does not even know whether any such item exists. His aim in this case will be to discover and to build a picture or representation of this complex item.

User may resort alternatively to the various modes of access to information mentioned above. We assume that these various modes of access to the item correspond to various types of descriptions of this item, which can be variably constrained, formalized, contextualized, and consensual. These modes of definition of the item sought for actually reflect the social conditions under which it was produced and/or exchanged, *i.e.*, they indicate the degree of standardization of the communicational transactions whereby it was formatted at the symbolic level [11].

In the context of a projects e-catalogue, for instance, we can distinguish between the tangible criteria relating to given project (the name or the e-mail of a project owner, the date or the total cost of a project) and the more immaterial criteria related to the usefulness, the difficulty, the priority... of the project. These criteria themselves are expressed in the potentially conflictual negotiations between the various categories of actors and stakeholder (sponsors, people working in NGO, final recipients, etc.) and the various occupations and roles (engineers, scientists, experts,, etc.) involved.

To identify the various modes of definition and access to complex items, we will use the HyperTopic representation language which we have developed in the context of the socio-semantic Web (Fig 1).

3.1 Standard Attributes, formatted data, and formal ontologies

The first mode used to define the item involves the use of countable, pre-defined and fixed qualifiers. These parameters or standard attributes have to be sufficiently stable for designing perennial data structures (to design request and inference systems). They are associated to many current data types.

This mode of describing items is commonly used in many different computer science contexts (data bases, object oriented design, multi-agent systems, ontologies and the semantic Web).

In the field of IR, this approach is implemented in request systems using a logical combination of standard attributes (such as the date of issue of the project, the total founding amount which is needed , the status of the project, etc., in the case of SD-Projects) in the context of “parametric” search methods.

3.2 Documentary resources

The second mode of defining an item is *via* documents based on linguistic or graphic forms of expression. Documents can include text, pictures, musical excerpts, video sequences, or all possible combinations of these means of expression and digital vehicles. We will establish here a distinction between two types of situations: (1) those in which components of the complex item are directly accessible because they are intrinsically semiotic and their digitization has made them available via the Web (books, deliverable, films, pictures, music, etc.); and (2) those in which the components of the complex item are mainly of a material, instrumental, or relational kind (vehicles, phones, travel, training, services, projects, etc.). In this case, documents provide indirect access to the components of the item.

There are two main types of access to these resources: *via* theirs card indexes when these are available, or *via* an index of the whole document, such as those existing in the case of “textual” documents. In the first case, the search corresponds to the first method. The second type of search, which is by far the most popular these days, corresponds to the use of search engines which give access to information about the item and its resources as well as to the contents in the case of documents, often without distinguishing between the two levels of information.

3.3 Topic maps, tags clouds, semiotic ontology

The third mode of definition and access involves “hypertext” navigation [3] using directories, maps, tags clouds and semi-formal and semiotic ontologies [2, 11]. These aids describe items arranged by topics, using various approaches and depend on their “logical definition”, as well as on situational, contextual (the corpora from which the topics originated) and pragmatic (situations in which the terms are used) considerations. The significance of complex items therefore depends on their type, on the distances between them, and on their respective layouts (from the graphic point of view).

In the case of semiotic ontologies, heuristic attributes or “topics” are organized according to the various ways in which the items are viewed by the actors who produce or exchange them. In the Hypertopic model, this characteristic is of particular importance.

4. A MODEL OF INFORMATION SEEKING ENVIRONMENT BASED ON AGORÆ

We have attempted to specify the characteristics of a data-processing infrastructure for Information Seeking, based on the definition of the various access modes to complex items defined in the Hypertopic model. The term infrastructure refers to the existence of various storage devices and software components which are interoperable thanks to standardization.

4.1 Review of commercial e-catalogues

We decided to work in the context of cooperative e-catalogues and e-marketplaces, since these environments seem to provide a whole range of partially interoperable features, and thus illustrate the diversity of the requirements associated with Information Seeking. The concept of the Item is clearly present in the field of E-commerce.

We have started to review a number of commercial market places (Amazon, E-Bay, Fnac, Gsmarena, Internity, Surcouf, Rue du commerce, Rue-montgallet, Pixmania.com, Worldgsm, Buzzillions.com) present on the Web. In two of these examples, several retailers are working together; the others correspond to a model with a single retailer. In line with a current trend, the links provided by the market places studied – include a full text search engine and a generally rather perfunctory map arranged by products and then by brands, and also (in some cases) by the use of the product. There are often multi-criteria search engines. The most original devices which we noted include a “located” search engine which reduces retrieval to selected branches and other search engines which explore the textual contents of books.

To look for an item in an e-catalogue, after defining the type of item required (in this case, a SD-project), the user has three possible means of inquiry, which correspond to the three modes of definition and generic access to complex items defined above: (1) a full text search engine (Google-like); (2) a multi-criteria search engine depending on the importance given to the standard attributes of the telephone (its weight, the compatible networks, the price range, the type of subscription proposed, etc); (3) a tree structure presenting the product from various points of view (although the presentation of the points of view is not as detailed as in the directories of the “Yahoo” type).

Various modes of description of the complex item correspond to these research tools: (1) a technical shortlist giving stabilized and accessible standard attributes via the multi-criteria search engine; (2) several documentary resources such as pictures, sounds, attached files and textual descriptions; (3) a set of topics extracted from the directory, which are associated with the item, in particular in the form of the path recalling the series of navigation stages required to reach this point in the search process.

4.2 Explicit hybrid presentation of complex items

Although various modes of presentation and different research approaches are available on market places, these are generally not treated as complementary modes of access to the same type of complex item Few methods of switching from one presentation of the item to another have therefore developed to facilitate the activities of information-seekers.

The Hypertopic solution proposed here combines various forms of definition and access to complex items. In this model, the material and immaterial items which undergo transactions are represented in digitized data-processing environments using the three generic methods described above. The fact that the association of these forms of presentation should facilitate Information Seeking activities by multiplying the aspects of the items which user need to discover and reconstruct.

One way of organizing the relationships between the various facets of complex items would be to draw up an exhaustive formal ontology. In our example, the presentation of the SD-Projects would include links giving information, for instance about the scientific taxonomy of concepts involved in SD-projects.

We have already explained elsewhere [1][2]][11][12][13] why this approach are not suitable for use in the case of fast evolving complex objects, which have often given rise to technical and commercial controversies. In the context of the Socio-Semantic Web, some instances of the complex item are attached by weak links to its various descriptions. Only users can define the real item in which he is interested, since information systems can provide him an approximate idea of what he is looking for.

Figure 2 shows the Agoræ interface during the Information Seeking process, after reaching the web page about SD-projects related to particular topic of the semiotic ontology, or to particular tag in the tag cloud (i.e. "*recyclage*"). The interface will also include a search engine allowing a parametric searching by specifying standard attributes. The various modes of presenting complex items correspond, in Agoræ, to the three components of the HyperTopic model (Fig.1).

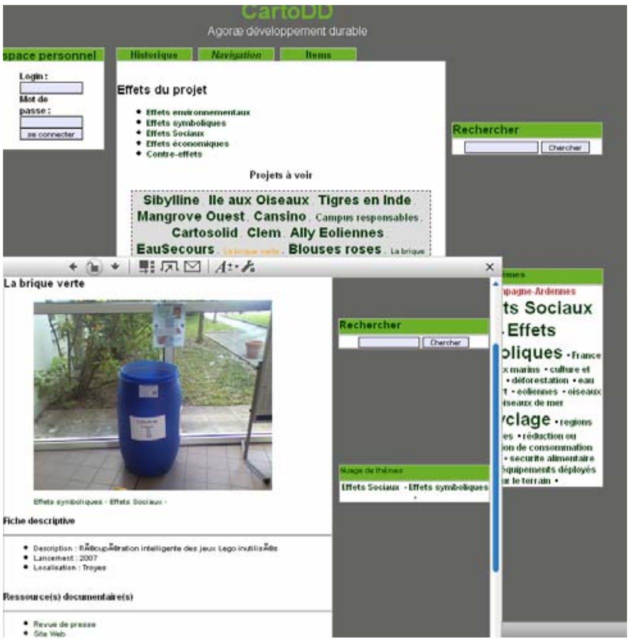

Figure 2. -augmented navigation for Information Seeking of a "sustainable developpment project" item.

5. PERSPECTIVE

The various possible combinations between different modes of presentation and access available in the Agoræ environment were intended to facilitate the work of those looking for and redefining complex items. This module was designed to facilitate comparisons between the various components of a description of complex items. No possibilities of this kind were available on any of the Web sites in our panel, apart from the original site, which restricts the field of research covered by the engine to the current branch of classification tree without memorizing previous actions.

In contexts where the items are constantly changing and where the needs of the various users are likely to evolve, it is not always possible to use standard attributes to build comparative parametric tables. The Information Seeking approach in which data, documents and semiotic ontologies are combined provides a solution which does not require indefinitely extending the lists of attributes managed in the form of data, and this will simplify the work of computer engineers. From this point of view, the Information Seeking is an approach which could be used to improve the efforts at customization already proposed by the large Customer Relationship Management systems using the Web ("e-CRM"), while integrating structured and semi-structured data.

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