THE CONCEPT BROWSER
A NEW FORM OF KNOWLEDGE MANAGEMENT TOOL

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ABSTRACT

This paper discusses conceptual organization and exploration in the context of a *Knowledge Manifold*.[1] It introduces a new kind of knowledge management tool called a *concept browser* and discusses a set of design principles for such browsers. These principles include a strict separation of *context* and *content*, contextual descriptions in terms of a collection of semantically visual context maps, which can be navigated by moving through *contextual neighborhoods*, presentation of the content components through context-dependent *aspect-filters*, and *contextualization* of content components that are themselves context maps.

KEYWORDS

Knowledge manifold, context map, contextual neighborhood, contextual topology, content component, aspect-filtration, visual semantics, Conzilla, UML, ULM, IMS, RDF, semantic web, conceptual web, PADLR, Edutella, ECIMF.

1. INTRODUCTION

Due to the rapidly increasing use of information and communication technology, the amount of information that we have to deal with in our everyday lives has become much greater than only a few years ago, and this process has led to new ways of

[1] See [6], [7], [9].

structuring information. Knowledge Management is a rapidly growing field of research, which studies these issues in order to create efficient methods and tools to help us filter the overwhelming flow of information and extract the knowledge that we need. Of course, the most complex information structure that we are dealing with today is the Internet, with its 'linked anarchy', where anyone can connect anything with anything else. It is a well known fact that - unless these anarchical powers are balanced by careful design - they easily result in web sites that are difficult to navigate and conceptualize as a whole, which in turn makes it hard for the human recipient to organize and integrate the separate components of information that are presented into a coherent pattern of knowledge.

Wittgenstein has demonstrated that we cannot speak about things in their essence [19]. We attach names to things in order not to have to talk about whatever lies behind these verbal interfaces. Instead, we talk about the only things that we can talk about, namely the *relations* between the cognitive appearances of things. This fundamental fact forms the basis of the entire scientific project, so clearly stated by one of its most eminent proponents - Henri Poincaré: "The aim of science is not things themselves - as the dogmatists in their simplicity imagine - but the relations between things. Outside those relations there is no reality knowable"([17], p. xxiv). Hence, according to Poincaré, the conceptual relationships are fundamental to any linguistically based world model, because they represent the only things that we can talk about.

2. DICTIONARY OF TERMS

The following terms are important for the discussion of this paper and will appear in several places below. They are listed here for the sake of clarity.

• *Thing* = phenomenon or entity.
• *Concept* = representation of some thing.
• *Mental concept* = inner representation of some thing.
• *Medial concept* = communicable representation of some thing.
• *Communication* = the process of constructing and exchanging medial concepts.
• *Context* = graph containing concepts as nodes and concept-relations as arcs.
• *Context map* (or *context diagram*) = graphic representation of a context.
• *Content* (*component*) = information linked to a concept or a concept-relation.
• *Resource* = concept or concept-relation or context or content.

3. PROBLEM

Traditional paper-based information systems freeze their concepts into a single context. This imposes a fixed contextual topology, which makes it hard to navigate the information landscape and present the conceptual content in a personalized way. In the case of a hyper-linked system - such as e.g. the WWW - a concept generally appears in many different contexts, whose number and form are constantly changing by the addition and removal of pages and links. This makes it hard to maintain a clear separation of context and content, and results in the all too well-known 'surfing-sickness' on the web, that could be summarized as "within what context am I viewing this content, and how did I get here?"

4. CONTEXTUAL TOPOLOGIES

Let **S** be a set of concepts, and let *C* be a concept in **S**. A context in **S** that contains *C* is called a *contextual neighborhood* of *C* in **S**. The *contextual topology* on **S** is the set of all contextual neighborhoods (in **S**) of concepts of **S**. If a concept *C* has no contextual neighborhood involving other concepts from **S**, then *C* is called an *isolated* concept in **S**. Let us add the following terms to our dictionary:

- *Contextual neighborhood* (of a concept or a concept-relation) = context containing the concept or concept-relation.
- *Isolated concept* = concept which has no contextual neighborhood involving other concepts.
- *Contextual topology* (on a set of concepts **S**) = the collection of all contextual neighborhoods for all concepts from **S**.
- *Totally disconnected* (or *discrete*) *contextual topology* = contextual topology where each contextual neighborhood consists of an isolated concept.

4.1. Traditional contextual topologies

Presenting informational content requires some form of containing structure - or context - for the information that is to be presented. A traditional dictionary, for example, uses lexicographic ordering of the labels representing the content in order to create the structure of the presentational context. This lexicographic context has the advantage of making the content easily accessible through the corresponding label, but at the same time it has the drawback of not showing any conceptual relationships between the different dictionary entries. Hence, a dictionary creates a totally disconnected contextual topology on the set of the corresponding content components - with each separate component corresponding to an isolated concept.

A textbook, on the other hand, normally makes use of some form of *taxonomy* in order to create a suitable context for the presented information. For example, if the textbook is about animals, they might be presented as a taxonomic type-hierarchy of insects, fish, reptiles, birds, etc. on the first sublevel. Each of these types would then in turn be appropriately sub-typed according to the level of presentation and targeted reader profiles. The chosen classification scheme creates a context that gives a relational structure to the informational content, and this context reflects the corresponding taxonomic connections between the various content components. In this way a textbook creates what could be called a *taxonomically connected* contextual topology on the set of content components.

4.2. Dynamic contextual topologies

Of course, the components of a book are frozen into a single context by the order in which they are presented in relation to each other. In the case of a hyper-linked multi-mediated system - such as e.g. the WWW - the situation is very different. Here there are in general many different contexts for the components, and both their number and their form are constantly changing by the addition and removal of pages and links.

For example, a web browser maintains a dynamic contextual relationship between the page that is viewed now (= this page) and the page that was viewed the moment before (= the previous page). Using the browser buttons 'back' and 'forward' traverses the corresponding dynamic contextual neighborhood. Another (larger) example of a dynamic contextual neighborhood is given by the browser's history list.

In fact, each web page functions both as a container of its content and as a context for the contents that are reachable (by a mouse click) from it. Consider a typical web page *Q*. Each web page *P* from which *Q* is reachable forms a context for *Q*. If *Q* contains a link to another web page *R*, then *Q* forms a context for *R*, and if *R* contains a link to *Q*, then the relationship is reversed and *R* forms a context for *Q*.

In this way the underlying link structure leads to an inextricable mixture of context and content - creating what could be termed a *reachability-connected* contextual topology on the set of content components. Since these connections only have a "1-step-forward visibility", this tends to make web pages self-contained, and favors a contextual design that focuses on various forms of eye-catching techniques rather than on illuminating the conceptual relationships of the content. Of course, when designing a conceptual presentation system - as in fact when designing any kind of system - the overall aim is to use visual techniques in order to support the underlying conceptual context, and not as a substitute for this context.

4.3. Problems with these contextual topologies

The contextual topologies that were discussed above are extreme in terms of their relationship between context and content. Books are totally (= linearly) ordered and do not allow reuse of content in different contexts. The overall context of a book is fixed, and so is the relationship between its context and its content. The WWW, on the other hand, presents a totally fluid and dynamic relationship between context and content, which makes it hard to get an overview of the context within which the content is presented, which results in the web surfing sickness discussed above.

5. DESIGN PRINCIPLES FOR CONCEPT BROWSERS

Multitudes of different knowledge management tools have been proposed in order to deal with the problems mentioned above. Although this paper makes no attempt to survey this field, we mention *Merz* [5], *Mondeca* [20], *OntoBroker* [21], *OntoLingua* [22], *Protegé* [23] and *Tadzebao* [24]. They usually display the connections of the different content components in terms of text-based trees or labeled connectivity maps - such as *concept maps* [2], [15] or *Topic Maps* [25] - and they all attempt to highlight the conceptual relationships in different ways in order to support the overview of the information landscape. However, since none of them is based on contextual topologies, the capability of *contextual navigation* (by traversing contextual neighborhoods) is not supported by any of these systems. Neither is the capability of context-dependent aspect filtering of content components, which is discussed below.

A *concept browser* is a knowledge management tool that conforms to the eight major design principles listed below:

(i) Separate the *content* of a concept or a concept-relation from its *contexts*. This supports the reuse of conceptual content across different contexts.

(ii) Describe each separate context in terms of a *context map*, preferably expressed in the Unified Modeling Language [18], which is an international industry standard for this purpose.

(iii) Allow neighborhood-based contextual navigation on each concept and concept-relation by enabling the direct switch from its presently displayed context into any one of its contextual neighborhoods.

(iv) Assign an appropriate set of resources as the content components of each appropriate concept and/or concept-relation.
(v) Label each resource (concept, concept relation, context or content component) by making use of a standardized data description (= metadata) scheme.
(vi) Allow metadata based filtering of the content components through context-dependent aspect-filters. This enables the presentation of content in a way that depends on the context.
(vii) Allow the transformation of a content component, which is also a context map, into a context (henceforth called *contextualization*).
(viii) Support lateral thinking by introducing a *concept bookmaker*, which allows concepts as well as contexts to be interactively constructed from content according to a menu of different *content-gathering principles.*

6. MERITS OF THESE DESIGN PRINCIPLES

6.1. Principle (i)

The principle of separation between context and content is a design feature that is applied with varying degree of rigor by different knowledge management, including the ones mentioned above. The strict adherence to this principle introduces two different modes of the conceptual browsing process that are termed *surfing* respectively *viewing*. You *surf* the contexts (= context maps) and *view* their respective content (= resources). Note that this usage of the term 'surfing' is consistent with standard web terminology. When you surf the web in the normal mode, you have direct access only to the next level of forward links, a process that could be termed surfing with forward-single-depth link visibility. In contrast, when you surf/view the web according to the principles of conceptual browsing, you have direct access to the content of all the concepts and concept relations without losing the overview of the context. This could be described as conceptual browsing with multiple-depth link visibility.

6.2. Principle (ii)

A context map with visually defined semantics breaks up the linear order of any verbal presentation of the depicted conceptual relations. It shows them all at the same time, as opposed to a verbal presentation that is forced to describe them in a certain order by creating a journey (= navigated path) between the different concepts on the map. In terms of supporting the contextual overview, a context map has a fundamental advantage in comparison to a verbal presentation. The reason behind this advantage lies in the fact that our capacity to visually survey conceptual relationships in different directions is considerably greater than our capacity to change the directions of the corresponding verbal descriptions. Hence, it is much easier to cognitively integrate the contextual information visually than verbally. In fact, this is the very reason why we use the term 'overview' (instead of something like 'overwords') for the description of such a contextual survey.

Since its introduction in 1997, the Unified Modeling Language has emerged as "the Esperanto of object-oriented modeling". Over the last decade, the author has developed a more concept-oriented modeling technique [6], [7], which is designed to visually depict how we speak about things. This technique has been adapted to UML under the name of Unified Language Modeling[2] (ULM), the basis of which is depicted in Figure 1.

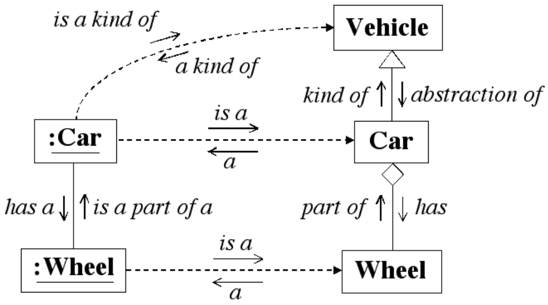

Figure 1. The basic visual-to-verbal semantic mappings of ULM.

Making use of ULM for the graphical representation of each context introduces clearly defined (and verbally coherent) visual semantics for the concept relations, which makes it easy to visually convey the meaning of the underlying contextual model. This standardized overview support is a crucial advantage in comparison with other contextual representation techniques, such as *concept maps* or the related *Topic Maps*, which rely on verbally defined semantics in order to convey their contextual models.

6.3. Principle (iii)

This feature enables contextual navigation in a way that naturally corresponds to the underlying contextual topology of the presented information. As a concrete example, if we think of the context maps as an atlas, and consider e.g. the concept of Paris, then we can easily switch between all the different maps in the atlas where Paris appears.

Contextual navigation by "neighborhood switching" is one of the characteristics of a concept browser, which (to the author's knowledge) distinguishes it from any other knowledge management tool that is available today. A concept browser is fundamentally important for the construction, exploration and presentation of information that is structured in the form of a *Knowledge Manifold*, which is a learner-centric educational architecture that supports customizable forms of inquiry-based learning. For more information see [6], [7], as well as a separate article [9] in these proceedings.

6.4. Principle (iv)

Both the concepts as well as the relationships of a context map can be assigned a multitude of different content components. These components can then be displayed in different ways, e.g. through an ordinary web browser, in a way that is controlled by the concept browser. Highlighting a concept and simultaneously displaying both its content and its present context provides an effective cure for the "web surfing sickness" mentioned above.

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[2] This name was suggested by Mikael Nilsson of the KMR group at CID.

6.5. Principle (v)

This principle allows for a third mode of concept browsing, called *inspecting*, which is a "metadata mode" that enables the study of the labeling of the resource components, or the automated search for such components based on their respective labels. These labels include such information as author, coverage, description, granularity, interactivity level, platform requirements, pedagogy, use rights, use support etc. - all of which are part of the IMS metadata scheme [14], [35].

6.6. Principle (vi)

Since a concept browser should support the reuse of concepts and concept relations in different contexts, some of these concepts and concept relations will eventually become associated with very large sets of content components. This suggests a variety of filtering and sorting features, where filtering means hiding inappropriate content components, and sorting means arranging the displayed components in some form of structure (e.g. a tree of maps). In order to support a context-dependent presentation of content, each combination of a concept and a context (or a concept-relation and a context) should allow the definition of its own separate filtering and sorting layer, which can narrow the scope of the presentation of all content components of this concept (or concept-relation) in the corresponding context. The presentational structure (sorted order) can be thought of as different aspects [16], which need not be exclusive. In a longer perspective, users may have locally defined filters working as a part of their own personal profiles. Since the filtering and the sorting should be based on metadata only, the content components themselves should not affected. This is a novel (and very powerful) kind of information interface technique.

6.7. Principle (vii)

No information presentation system can claim an absolute distinction between content and context. As we have seen above in the case of a hyper-linked information system, the content of a concept may well form the context of a set of other concepts. Hence it is important for the flexibility of a concept browser to allow a content component to be a context map in itself. However, it is of fundamental importance to maintain the separation between context and content. Therefore, when a context map appears in the form of conceptual content, it should not at the same time be treatable as a context. In order to be able to treat it in this way, we should first *contextualize* it, which transforms the content component into a context map and displays it in the context window of the browser, where it can be treated exactly as any other context map.

6.8. Principle (viii)

The importance of lateral thinking to web browser use in not fully recognized. Often people do not follow a logical path when browsing. They start with one concept in mind, follow that for a couple of links, then spot something that is peripheral but interesting. What is needed is a "concept graph" that allows people to identify sets of resources that they have visited that were related to a particular concept. For example, if a user visits three resources about Topic Maps, then the *concept bookmarker* will add Topic Maps to her list of recently browsed concepts. If she then goes off and reads a series of resources that contain critiques of Wittgenstein, then he should get added to the concept bookmark list.

Often we don't know what we want. We start somewhere in the hope of getting to some unarticulated goal. What we need is a record of how we got there so we can find other matching patterns. For example, say a user looks at a web site on mathematics to find out something about lattices and comes across a particular person who has produced an important theorem on the subject. What the user then wants to do is to look for other sites where there are resources that reference the same theorem, but only if they are linked to other resources that are about lattices and related to mathematics, rather than the use of lattices in computer applications. In this case it is the *context* that is important, and which needs to be reused, not the single concept. Such context-based searching will be made possible by the Edutella system [4] discussed below. These "contextual queries" will be phrased in a graphical query-language based on the ULM technique mentioned above.

7. CONZILLA - A FIRST PROTOTYPE

A first prototype of a concept browser, called *Conzilla* [12] has been developed during the past 3 years within the knowledge management research group at CID [26]. Conzilla is written in Java and uses XML as the underlying format for exchanging information. Since the program is carefully designed [13] with a clear object-oriented structure that separates the underlying logic from the presentational graphics, it can easily be adapted to different presentational styles and cognitive profiles. Conzilla is presently being developed as an open source project at SourceForge [27] and can be downloaded from that site. Several Conzilla-based knowledge manifolds are presently under construction at CID, e.g. within the fields of mathematics [8], IT standardization and interoperability between different systems for e-commerce [40].

8. ONGOING RESEARCH PROJECTS

8.1. The Conceptual Web - our overall research vision

Within the knowledge management research group at CID we are working to extend the emerging semantic web [1], [37] into what we call the *Conceptual Web* [10], where the semantics is not only machine-readable, but also available for the user in an appealing form. We are using the visual semantics of ULM combined with conceptual browsing to present the conceptual web to the user in a way that creates substantial benefits in terms of overview and clarity. This is especially important within the emerging field of e-learning, because in a learning context, the conceptual structure of the content is an essential part of the learning material. Losing the contextual information of the content means more than just surfing-sickness - it means that you will be unable to "contextually integrate" the concepts that you are trying to learn, which is vitally important in order to achieve an understanding of any specific subject area.

The conceptual web lives on top of the ordinary semantic web, which provides machine-readable semantics based on RDF [36]. However, it is not at all evident that machine-readable semantics will be clear and effective for human interpretation. Combining the semantics of RDF with the human-understandable semantics of UML [3] is vital in order to enable more intelligent forms of human-computer interaction.

A concept browser is a very powerful tool with a multitude of potential applications, and Conzilla is attracting increased attention both on the national and the international level. Within the framework of the conceptual web, we are aiming to develop Conzilla into a combined knowledge-, economy- and management-tool by participating in collaborative projects that will expand the capabilities of the program within the areas of e-learning, e-commerce and e-administration[3]. Two of these projects will be briefly outlined below.

8.2. e-Learning: Personalized Access to Distributed Learning Resources

The driving vision for the PADLR [34] project[4] is a distributed learning web infrastructure which makes it possible to exchange/annotate/organize and personalize/navigate/use/reuse modular learning objects, supporting a variety of courses, disciplines and universities. Each of the PADLR sub-projects deals with a specific problem on the way towards this vision. Infrastructure, tools, courselets and archives will be designed and developed in accordance with international standards for modularization and metadata[5] and will be compatible across the PADLR project[6].

We are cooperating with research groups at the universities of Uppsala [28], Stanford [30], Hannover [31] and Karlsruhe [32] in order to develop *Edutella* [4], an infrastructure and search service for a peer-to-peer network that will facilitate the exchange of educational media. Edutella will be based on RDF and operate with IMS metadata. Hence it will make strategic use of the RDF binding of IMS metadata [14] created under the coordination of Mikael Nilsson of the KMR group at CID and recently released as a part of the IMS 1.2 metadata standard.

8.3. e-Commerce: Electronic Commerce Integration Meta-Framework

The proliferation of mutually incompatible standards and models for conducting e-commerce resulting from the isolated efforts of industry groups and standard bodies have created quite the adverse effect from what was intended, when it comes to wide acceptance of electronic commerce, especially in the SME[7] market.

The industry is looking for methods to meet the exploding demand in the "new economy" to offer increased quality of service, reduction of manual labor and cost, and to meet the requirements of nearly real-time reaction to changing market demands. However, the existing e-commerce frameworks require costly adjustments in order to fit a specific business model to that of a specific framework, with the perspective that similar costs will follow if the business party wants to participate in other frameworks as well.

In response to these concerns from the industry, CID and WebGiro AB, supported by associated partners Hewlett-Packard, Microsoft and MCI WorldCom have started the ECIMF project [40] within CEN/ISSS Electronic Commerce Workshop [39], in order to create a standardized meta-framework, which offers a modeling language, methodology, and prototype tools for describing and aligning various aspects of already existing e-commerce frameworks, with the aim of increasing their interoperability. An extended version of Conzilla will be used as a platform for this project.

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[3] We are also aiming for Conzilla to support increased e-accessibility, in accordance with the e-Europe initiative [38], by enabling the program to configure itself to different cognitive profiles.

[4] supported by the Wallenberg Global Learning Network [29], [33].

[5] especially IMS [35].

[6] The architectural issues involved in designing such Learning Management Systems are discussed in a separate article [11] in these proceedings.

[7] Small- and Medium-sized Enterprises.

The development of the ECIMF standard will build on the experiences from projects such as ebXML [41], UN/CEFACT Unified Modeling Methodology [42], RosettaNet [43], BizTalk [44], [45] and various Web Services initiatives.

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Some knowledge management tools on the web

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[21] OntoBroker: http://ka2portal.aifb.uni-karlsruhe.de.
[22] OntoLingua: www.ksl.stanford.edu/software/ontolingua.
[23] Protegé: http://protege.stanford.edu.
[24] Tadzebao: http://kmi.open.ac.uk/people/domingue/sharing-ontologies.

Other relevant web sites

[25] Topic maps: www.topicmaps.net , www.topicmaps.org.
[26] CID (Centre for user-oriented IT Design): http://cid.nada.kth.se/il.
[27] Conzilla development: http://conzilla.sourceforge.net.
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[29] SweLL (Swedish Learning Lab): www.swedishlearninglab.org.
[30] SNLPG (Stanford Natural Language Processing Group): http://nlp.stanford.edu.
[31] KBS-Hannover: www.kbs.uni-hannover.de.
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[38] e-Europe: http://europa.eu.int/information_society/eeurope/index_en.htm.
[39] CEN/ISSS Electronic Commerce Workshop: www.cenorm.be/isss.
[40] ECIMF (Electronic Commerce Integration Meta-Framework): www.ecimf.org.
[41] ebXML: www.ebxml.org.
[42] UN/CEFACT www.unece.org/cefact.
[43] RosettaNet: www.rosettanet.org.
[44] BizTalk: www.microsoft.com/biztalk/techinfo/BizTalkFramework20.doc.
[45] BizTalk repository: www.biztalk.org.