Organizational Memory for Knowledge and Information Management in the Definition, Analysis and Design Phases of Civil Engineering Projects using an XML Model

Gloria Lucía Giraldo[a1], Germán Urrego-Giraldo [b]

[a] National University of Colombia - Medellín, Systems School – Faculty of Mines Medellín, Colombia.
[b]University of Antioquia, Department of Systems Engineering, Medellín, Colombia. E-mail: gaurrego@udea.edu.co

Abstract. An ontology of civil engineering services is created by combining knowledge of the phases of the life cycle of an engineering design product, the steps in the phases in an engineering service and the technical, technological, scientific, social, economic, organizational and legal aspects associated with an engineering service. The documents containing information and knowledge related to projects are tagged using ontological concepts. The annotated documents are stored in an XML-Database, and constitute an organizational memory that enables access to, and reuse of information and knowledge. A case study of an engineering service is used to illustrate the proposed approach to the construction of the organizational memory.

Keywords. Organizational memory, knowledge system, information system, ontology, XML model

1 Introduction

Organizational Memories (OM) are knowledge-based systems. Knowledge acquisition is a central aspect for developing this type of systems. In early systems knowledge was extracted from experts of domain and it was represented as a set of heuristic rules to solve problems. To find these heuristics is not easy. Reynaud in [9] argues that the difficulties arise, among others, from: the absence of a methodological guide for constructing heuristic knowledge bases, the fact that the

[1]Professor Assistant. National University of Colombia. Faculty of Mines, Systems School (Of. M8A-313). Street 80, 65 223. Tel: (+574) 4255358. Fax: (+574) 4255365. E-mail: glgiraldog@unalmed.edu.co Url: www.unal.edu.co Medellín – Colombia.

heuristics are not directly expressed by the experts and that the ability to resolve problems depends directly on the existence of these heuristics.

Active research about these difficulties began in 1980. The dynamic of research in this area has lead to approaches based on the construction of models in opposition to those centred on the knowledge extracted from the experts.

The knowledge of a study domain for developing an application, named "domain knowledge", has been differenciated from "reasoning knowledge", namely the knowledge obtained by reasoning, It describes abstractly the process of an application in terms of "task" and "methods".

Reasoning knowledge is abstract knowledge. It focus on the relationships to objects, tacking account of bject's roles in the reasoning model. The reasoning model is a frame of knowledge categories [12] supporting the interventions of the agents on the relationship between de agent and objects of the domain.

Domain knowledge is centered on objects, their associated semantic concepts, the relationship among these objects and physical interventions on domain objects. This knowledge expresses structured knowledge arising from well defined process and oriented to the communication. This characterization corresponds to the *information* concept.

The domain knowledge is currently structured in ontologies containing the domain objects and the relationships among them. Many domain ontologies are proposed in specific economical sectors. For example, [5] presents an ontology in civil engineering construction domain. Other ontologies are centered in phases or aspects of the construction work, for example, the definition phase of a project is considered in [14]. In [2] a project ontology is organized in terms of process, organization and product. We propose an enterprise ontology containing a project's ontology in the domain of studies and design in civil engineering for constructing an organizational memory, in order to store, manage, retrieve and reuse project knowledge.

In the domain of Interoperability for Enterprise Applications, the European project InterOp, www.interop-noe.org, envisions to facilitate the emergence of an interoperability research corpus through the fusion of three knowledge-components: *software architecture*, *enterprise modelling* and *Ontology*. These integration concepts are considered in that european project as requirements to interoperability. We introduce a model for integrating information and knowledge and a model of Organizational Memory for knowledge and information management related to definition, analysis and design phases of civil engineering projects.

Many definitions and interpretations of organizational memory exist in the literature. The concepts expressed, among others, in [1,6,13] are extend in [8] which considers the corporate memory as an *«explicit, disembodied, persistent representation of knowledge and information in an organization, in order to facilitate its access and reuse by members of the organization, for their tasks»*. Organizational Memory as a model for knowledge management concentrates the research work in particular domains in order to pay attention to specific knowledge and for developing an organizational culture favourable to an extended use of the Organizational Memory. In this way, recent studies in [7] and [3] highlight the

handicap between the external diffusion of Organizational Memory models and the limited impact within the enterprises.

Knowledge and Information representation, storage and retrieval are central aspects which attract important efforts from Description Logic and XML communities. Our work proposes an Organizational Memory relating knowledge to information concepts, for an enterprise of studies and designs in civil engineering domain. This memory is structured using an XML model based on an enterprise ontology containing a project ontology.

We illustrate the approach with a case study in the company AREA INGENIEROS CONSULTORES, which considers the storage, retrieval and reuse of the content of a building structural design memory.

The remainder of this paper is organized as follows. A Knowledge meta-model for Knowledge and Information Systems is presented in Section 2. Section 3 is centered on constructing an Enterprise Ontology and Organizational Memory in domain of civil engineering studies and designs. An application example of the organizational memory is the object of Section 4. A discussion of results and future works are included in Section 5. Section 6 contains the biliography.

2 Meta-model of Knowledge

A first generation of knowledge systems was centered on the knowledge obtained from domain experts, while the second one is characterized by the use of models for supporting the stages of knowledge management. We use knowledge meta-model [4], in Figure 1, intending to integrate *knowledge* and *information* concepts as well as to construct structured reasoning models and ontologies representing knowledge of different nature.

Knowledge is considered, in our work, as all that may be known, understood and imagined about a subject, considering existent or created objects, agents, means, methods and agents' interventions. Equally, we define *information* as predefined communication-oriented knowledge arising from well structured processes from systematic intervention of existent agents, means and methods on existent or created objects, considering known and created relationships among these objects. We extend the concept of knowledge involved in a Knowledge Base and in Knowledge-based Systems, in order to incorporate and differentiate *information* and *knowledge*. The Knowledge-based Systems (KBS) change to Extended Knowledge based Systems (EKBS) including *knowledge* and *information*.

Our work takes *domain* and *context* concepts of [10,11] where the *domain* is an activity field characterized by the objects, while the *context* defines a space of agents' interventions including means, methods and the circumstances that complement the description of a phenomenon.

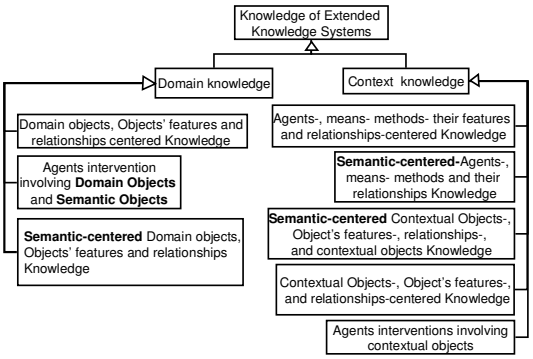

Figure 1. Meta model (domain knowledge branch)

Knowledge meta-model relates two categories of knowledge for extended knowledge-based systems: *domain knowledge* and *context knowledge*. The former involves knowledge centered on: features of existent and created domain objects and their relationships, existent and created semantic concepts of objects, and existent and created interventions (goals) of existent agents. These interventions may be physical and intellectual. *Domain knowledge* represents the three information types introduced in [4]: *predefined knowledge* corresponding to consolidated information treated by traditional information systems, *referenced knowledge* representing transitional information managed by evolving information systems, which uses knowledge techniques to manage the information, and finally, *discovered knowledge* denoting emerging information considered by prospecting information systems. Thus, *domain knowledge* is *information.* The latter considers knowledge focused on: existent and created agents, means and methods; existent and created context objects; existent and created semantic concepts of agents, means, methods and context objects and finally, existent and created interventions (goals) of existent and created agents involving features and semantic concepts of existent and created objects of the context. These concepts constitute the five sub-categories of *Context Knowledge* Category. This category is specialized according to three views. A first view presents three concepts: *Social Context Knowledge*, *Organizational Context Knowledge* and *System Context Knowledge*. A second view desegregates *Context Knowledge* in *Context Information* and *Context Expanding Knowledge*. The third view specialize *Context Knowledge* in *Specific Context Knowledge* and *Global Context Knowledge*.

Utilization Context knowledge is a hybrid concept which inherits its characteristics from *Domain Knowledge* and *Specific Context Knowledge*. In [11] *Utilization Context* delimitates the space of Intervention of system agents, the objects involved in interventions of these agents, as well as the circumstances affecting the involved objects. *Agent Intervention* represents an agent *action* or *interaction*. For sake of space we do not go ahead to explain more detailed concepts of Context knowledge.

The characterization of *Domain Information*, *Context information* and *Context Expanding Knowledge* aids to understand the interaction between Domain knowledge and Context knowledge. The proposed ontology aims to relate

knowledge and *information* in the Organization Memory. Next section explains the Ontology and the Organization Memory construction.

3 Ontology Based Knowledge Memory

Our work of knowledge engineering presents an enterprise ontology in the field of civil engineering preconstruction services [4]. In this paper we take only a part of those, corresponding to *Engineering Services Ontology*, in Figure 2. The interdisciplinary study for arranging this ontology took acount of knowledge of definition, analysis and design phases of a civil engineering product, as well as knowledge of proper processes of each phase, and knowledge of technical, technological, scientific, social, economic, organizational and legal aspects associated with an engineering service. This ontology was validated applying an alternative construction method proposed in [10], based on the concept *utilisation context*.

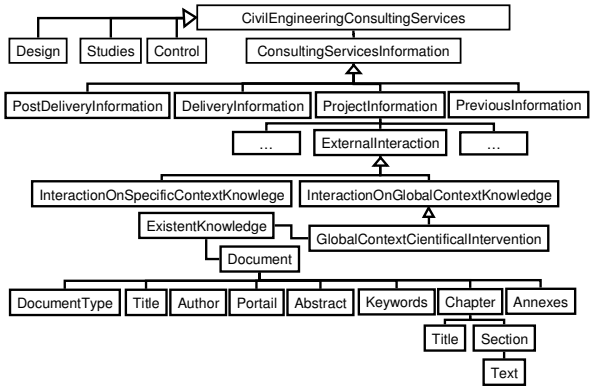

Figure 2. An ontology fragment

Offered Services as Top concept of the Engineering Service Ontology has two derived branches: *CivilEngineering*ConsultingServices and *InternalServices.* The first one generalizes the concepts *Design*, *Study* and *Control* which, in turn are specialized in particular Studies and Design Services. For example *Design* is specialized, among others in *StructuralDesign* and this last in *BridgeStructuralDesign, BuildingStructuralDesign, DamStructuralDesign, WallStructuralDesign, etc.*

The concepts *PreviousInformation*, *ProjectInformation*, *DeliveryInformation* and *PostDeliveryInformation* specialize the concept CosultingServiceInformation which is contained in *CivilEngineeringConsultingServices*.

PreviousInformation concept considers the necessary knowledge for defining, contracting and developing an engineering service and for managing the related project. *PreviousInformation* contains: *TechnicalInformation, Proposal and Contract.* This last concept is detailed in *Head, Clauses and FinalPart.*

The concept *ProjectInformation* is the central concept and covers seven concepts: *Record*, *Planning*, *Organization*, *Direction*, *Execution*, *EvaluationAndControl* and *ExternalInteraction*. The element *Execution* is desegregated in *Process*. In turn, *Process* encloses the concepts *Description*, *Activity* and *Decision*.

ExternalInteraction concept connects the domain concepts to elements of *Specific Context* and to *Global Context*. Two elements specialize *ExternalInteraction*: *InteractionWithSpecificContextKnowledge* and *InteractionWithGlobalContextKnowledge*. The former consider the interaction among Domain concepts and Specific Context concepts including the concepts: *CommercialInteraction*, *LegalInteraction*, *PersonalInteraction*, *InstitutionalInteraction*, *ClientInteraction*, *ScientificInteraction*, *TechnologicalInteraction*, *TechnicalInteraction* and *SocialInteraction.* The latter leads to relate the domain concepts to Global Context knowledge. This knowledge would be existent knowledge or created knowledge. Global Context knowledge includes:*GlobalContextScientificInteraction*, *GlobalContextTechnologicalInteraction*, *GlobalContextTechnicalInteraction* and *GlobalContextSocialInteraction*. A component of *GlobalContextScientificInteraction* is *ExistentLnowledge* having the concept *Document*, which is composed of: *DocumentType*, *Title*, *Author*, *Portal, Abstract*, *Keywords*, *Chapter* and *Annexes*. For sake of simplicity, in Figure 2, only the components Title, Section and Text of concept Chapter are depicted.

This described ontology's fragment is enough for illustrating, in next Section, the management of an ontology-based Organizational Memory.

4 Case Study of Knowledge Memory

Currently, project document repositories provide an enormous collection of engineering knowledge.

```
<GlobalContextCientificIntervention>
    <ExistentKnowledge>
        <Document>
            <DocumentType Name="Book Chapter"/>
                    <Title>Monobe-Okabe Method</Title>
                    <Author/>
                    <Portal/>
                    <Abstract/>
                    <Keywords>
                            <Keyword>earth pressure</Keyword>
                            <Keyword>Monobe-Okabe</Keyword>
                    </Keywords>
                    <Chapter>
                            <Title>EARTH PRESSURE AND HYDRAULIC PRESSURE</Title>
                            <Section Name="9.1 Overview">
                                    <Text>(1) Earth pressure and hydraulic pressure acting against structures such as exterior basement
 walls and retaining walls, which touch the soil directly, shall be considered. The buoyancy shall also be
considered for the structures below groundwater level.
(2) The earth pressure that permanently acts on exterior basement walls, etc. shall be assumed to be
the earth pressure at rest in general, and the influence the surcharge on the ground surface shall be
appropriately considered when it exists.
                                    </Text>
                            <Section Name="9.2 Earth Pressure and Hydraulic Pressure that Act on Exterior Basement Walls">
                                    <Text>The earth pressure and hydraulic pressure that permanently act on exterior
 basement walls shall be calculated according to Eq. (9.1) for above groundwater level, and shall be calculated according to Eq.(9.2) for below
Ground water level:
                                    </Text>
                            </Section>
                            …
                    </Chapter>
            …
        </Document>
    </ExistentKnowledge>
</GlobalConextCientificIntervention>
```

This knowledge refers essentially to engineering services organized as projects. Our enterprise ontology, in the field of studies and design in domain of civil

engineering, involves and deploys, among others, the concepts *civil engineering consulting service* and *projectInformation*. Thus, the ontology concepts are used to tag the documents related to the specific services and projects.
The tagged documents are incorporated in an XML file, which constitutes the Organizational Memory for the enterprise of Studies and Design. The little part of the XML file, in next paragraph, illustrates the storage and availability of the registered knowledge for retrieval and reuse. The concept *External Interaction* of the ontology links *Domain knowledge* (Information), related to the project, with knowledge of *Specific and Global Contexts*. There, the chapter "Earth Pressure and Hydraulic Pressure" of the book "Monobe-Okabe Method" is a scientific report required suddenly by the engineers for accomplishing projects activities.

Some conclusions and future works are presented in next Section.

5 Results and Future works

The proposed Enterprise Ontology provides the concepts for Modelling an Organizational Memory, which aims at covering technical and managerial aspects of a civil engineering enterprise in studies and design domain. In fact, this Memory constitutes an Organizational Memory meta-model supporting specific Organizational Memory models covering particular organizational aspects. These Memory models, based on parts of the ontology, fill only some particular segments of the total enterprise Organizational Memory represented in an XML model. The enterprise ontology incorporates a project ontology based on the life cycle of a civil engineering design product and on the processes executed in each phase.

Our work considers generic relationships between the *domain knowledge* and *reasoning knowledge* extending this last concept from reasoning domain existent objects to reasoning domain created objects and contextual objects, considering existent and created object relationships. In accordance with the characterization of the *information* concept in terms of: predefined, communication-oriented, arising from structured processes or from systematic intervention of agents, three knowledge types are found in the domain: *predefined knowledge* corresponding to consolidated information treated by traditional information systems, *referenced knowledge* representing transitional information managed by evolving information systems, which uses knowledge techniques to manage the information, and finally, *discovered knowledge* denoting emerging information considered by prospecting information systems. Thus, *domain knowledge* is *information*. While *Knowledge* is consider in our work as all that may be known, understood and imagined about a subject, taking account of existent or created objects, agents, means and methods.

In this total concept, three Knowledge Categories are identified: *Domain Knowledge (Domain Information)*, *Context Information* and *Expanding Knowledge*. Reflecting these three concepts on the ontology let us manage together *knowledge* and *information*. In fact, the concept *External Interaction* of the ontology relates the domains concepts to knowledge of the *Specific Context* and to *Global Context Knowledge*. Thus, the Organizational Memory based on the ontology manages *knowledge* and *Information* together. This aspect is verified with a case study in the studies and design area of civil engineering. Integration of

Knowledge and Information constitutes a contribution to interoperability of enterprise applications and enterprise knowledge in the sense claimed in the European Project INTEROP. The perceived trends "to Computerize knowledge", that is, to convert *knowledge* into *information* contributes to capitalize enterprise knowledge and to develop an enterprise culture for knowledge reuse and exploiting the Organizational Memory.

Ongoing works aim at developing software support for knowledge and information storage, reuse, and retrieval, exploiting the enterprise and project ontologies and the Organizational Memory concept.

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