Towards an Information Ontology for Knowledge Asset Trading

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Abstract

The overall objective of the INKASS ("Intelligent Knowledge Asset Sharing and Trading") project is to develop an intelligent Internet-based marketplace of knowledge assets. More specifically, the project aims:

- To develop and validate intelligent agent-based and ontology-enabled knowledge trading tools for facilitating automatic transactions in the marketplace and supporting semantic mappings between sellers' provisions and buyers' needs.
- To develop and validate innovative business models for a virtual knowledge marketplace.
- To apply, validate and exploid the INKASS system as an electronic marketplace for knowledge assets that assists European SMEs in meeting their knowledge needs in specific business management and engineering areas.

At the core of our technological approach stands a comprehensive metadata description of information objects which represent tradeable knowledge assets. The structure of these metadata frames is determined by the INKASS Information Ontology which is discussed in its first version in this paper.

Keywords

eWork and eBusiness, Business-to-Business Networks, Knowledge Management

1 Introduction

INKASS is a European RTD project that addresses the area at the intersection of Knowledge Management and Electronic Commerce (Apostolou et al., 2002; Inkass, 2002b). This area refers to the trade of explicit and implicit knowledge at an inter-organisational level. It addresses the opportunities and risks found in the purchase and selling of knowledge at the business-to-business (B2B) environment, the need for supporting long-lasting relationships of knowledge exchange and the requirement for facilitating digital community contexts where knowledge seekers can find suitable knowledge providers and knowledge providers can advertise and sell their knowledge. To this end, we develop a total solution consisting of:

- A managed repository of **knowledge products** providing **matchmaking facilities** between the knowledge requirements of buyers and the knowledge products provided by sellers.
- A **business and community infrastructure** to support the members participating in knowledge exchange.
- An e-commerce platform supporting **business models and pricing schemes** for knowledge product exchange.

At the core of the above mentioned "managed repository" stands a catalogue of knowledge product descriptions which instantiate a metadata schema which we call Information Ontology (Abecker et al., 1998). The dev elopment of this Information Ontology is the major topic of this paper. The results should be considered preliminary in the sense of work in progress.

2 Existing Theories and Work

Since a couple of years there exists an active research community working on intelligent methods for e-Commerce solutions. Most of them focus on aspects of intelligent agents taking part in trading and negotiation processes (Dignum & Sierra, 2001; Moukas et al., 2000; Dignum & Cortés, 2001; Liu & Ye, 2001). Most of these works are more or less independent from the question which kinds of goods are traded, and virtually nobody explicitly takes into account the particularities of knowledge as a tradeable good. Hence, the resulting solutions neglect systematically many efforts made in the Knowledge Management, the Digital Library, or the e-Learning area dealing with the question how Knowledge Objects like, e.g., Lessons Learned, Expert's Skills, Intellectual Propery Rights (IPR), or Consulting Services are described best. Normally, the few existing knowledge marketplaces treat knowledge more or less like all other tangible goods, i.e. a knowledge object is represented by a simple, static metadata schema, content is described by referring to a taxonomy of subject matters, few other attributes are provided, e.g., for quality assessments by simple Amazon-like five-star ratings.

(Kafentzis et al., 2002; Inkass, 2002) provides a detailed overview of existing knowledge marketplaces, including their information ontologies. In the work presented here, we aim at a comprehensive upper-level information ontology which covers the different most common knowledge products to be traded, which spans all relevant dimensions for Knowledge Object desription in a trading platform, which provides the representation means to plug-in and represent in a declarative manner evaluation, versioning, and trading aspects, and which is – on all dimensions - easily extensible with specific new attributes and specific ontologies describing the ranges of allowed attribute values.

Such a flexible knowledge representation scheme should allow, e.g., to plug-in easily relevant external developments, like the work presented in (Delgado et al., 2002) about ontologies for describing IPR issues, or Gordijn's work about service modelling (Gordijn, 2002). It should also make use of links between knowledge object descriptions, e.g., for bundling several isolated knowledge products into more complex aggregates which provide much more functionality and can be designed much better to serve specific customer needs.

3 Research Approach

As mentioned above, we develop methods and tools for a total Knowledge Trading solution, the technical core of which is an e-Commerce platform implemented using the commcercial e-commerce middleware offered by Empolis[1]. This platform – based upon the Case-Based Retrieval approach to realize matchmaking between offers and demand – provides expressive means for describing structures of Knowledge Products and background knowledge for retrieval.

[1] http://www.empolis.com

The idea of an Information Ontology was introduced by (Abecker et al., 1998) in the Knowledge Management area and normally referred to as a metadata schema in the Digital Library, or, e.g., the e-Learning areas. Its purpose is to provide a declarative specification of the knowledge representation schema used describing knowledge products and the related background knowledge. This shall be the basis for more content-type specific characterizations of knowledge products that allow better search and retrieval; it shall also be the basis for powerful new services (e.g. in the areas of collaborative filtering, or elaborated versioning and evaluation mechanisms); and it shall allow to transport easier an encapsulated Knowledge Object description from one trading platform to the other because it is self-contained to a great extent.

Hence, a full-fledged Information Ontology in the "ideal knowledge trading system" comprises:

- A specification of all *attributes* an Information Object for trading knowledge may possess.
- The *value ranges*, and – if necessary – supplementing related ontologies – for defining the ranges of attributes used.
- A specification of all *links and relationships* that may exist between information objects (indicating, e.g., that some knowledge object could provide prior knowledge useful for understanding and applying some other knowledge object).
- The specification of – if required – *aggregated knowledge objects*, represented by aggregated information objects, which deliver some complex piece of knowledge or service by an appropriate combination of several simpler objects (e.g., a series of training measures used for a complex qualification and certification process).
- All other *supporting data structures* required, e.g., for representing contracts or transactions which are required for managing a whole transaction through all its phases before, during, and after selling a knowledge products.
- Ontologies may contain additional supporting information which is exploited by the marketplace for some purpose, like the *similarity between concepts* which is required for assessing similarity of demand and offer representations in a case-based retrieval approach like ours.

In INKASS we followed a combined bottom-up / top-down approach to define a comprehensive information ontology for knowledge trading. Bottom-up means concretely that we analyzed the specific requirements of three real-world case studies to be implemented in the project, as well as the metadata schemas found in the existing marketplaces (Inkass, 2002). Top-down means that we analysed both what is provided in an "ideal" knowledge trading scenario and can be derived from our overall trading framework, and what metadata are foreseen in the Dublin Core Digital Library standard, the IEEE Learning Object Metadata standard, and two earlier industrial projects done by the INKASS partners. In detail, for designing the INKASS Information (and related) Ontology(ies) we "compiled" the following input:

- The current state of practice and the acquired requirements of the three INKASS pilot environments[2] at :
    - TWI – selling very specific technology documents, training measures, specifically configured knowledge packs, or consulting services in the area of welding and joining technology to subscribed members
    - Planet Ernst & Young – selling consulting projects to long-term customers
    - ACCI – finding and configuring specific information packs (containing fact books, experience reports, links to relevant events and trade missions etc.) about trading conditions and similar economic information for companies interested in an engagement in aforeign country
- Prior research and customer projects done at DFKI and Empolis.

[2] For an overview of INKASS project partners, see the acknowledgment at the end of this article.

- The state of the art in the scientific literature, in particular the Dublin Core initiative and the IEEE Learning Object Metadata standard (LOM), as well as some specific approaches for special problems, like IPR representation or contract representation.
- As a further input we used WordNet (Miller, 1990) which helped us to group and structure certain aspects of content and context descriptions.

4 The INKASS Information Ontology

The Figure below gives an overview of the INKASS information ontology metadata facets.

The vision behind this faceted description is: If all the facets are sufficiently described, it should be possible to assess the content and potential usage and value of a knowledge object comprehensively, to support all processes, transactions and modifications during the lifetime of an Information Object, and to ship such an IO as a self-contained object, thus transferring it with its complete creation and modification history from one marketplace to another one, without loosing information, without getting into legal or business problems because of changed contextual factors on another platform, etc.

Of course, we do not expect to reach this vision already in the INKASS project, but we try to prepare it as far as possible with our generic Information Ontology and marketplace data structures. We will try to develop these models as far as possible during the project, in order to foster scientific progress, to prepare later extensions of the project results, and in order to challenge the pilot users for using the possibilities provided by the tools. We should also mention, that the facets described, in particular the details of content and context representation are a *superset* of what will presumably be used in each specific application case

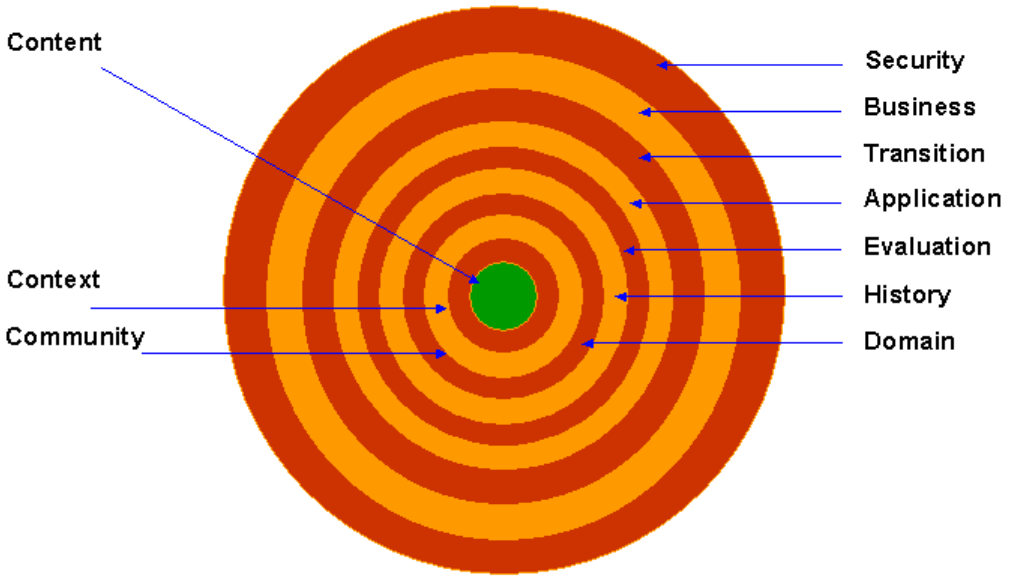

Figure 1: Overall structure of INKASS Information Ontology facets

Here is a short overview over all facets:

- The ***content facet*** shall describe the core content of an information object, i.e. both what it is about (e.g., "this is a textbook about operating systems") and how it is physically manifested (e.g., "the book has 342 pages").
- The ***context facet*** shall describe under which circumstances a knowledge product may be used and applied in a customer organization. For instance, we could know that some lesson learned should be useful in all marketing processes of car manufacturing companies.

  It may be the case that only one of these two central IO description dimensions will be used in a concrete example (e.g., Digital Libraries typically talk only about content, not about context, whereas lessons learned (LL) systems may talk only about the context where some LL could add value), but we discuss both dimensions and feel that it opens promising chances to consider both.
- The ***community facet*** shall address the whole community of agents interacting with an IO representing a knowledge product, i.e. the knowledge providers, disseminators, and users with their roles, rights, and responsibilities with respect to a certain IO. Hence this facet is the interface to all business processes related with knowledge trading. The community facet could define, e.g., that a buyer of some teaching software has the right to use and personalize it, and the right to send bug reports to the programmer (author), whereas the author may have the obligation to inform all buyers about new releases or bug fixes.
- The ***domain facet*** shall ensure that all content-specific statements about an IO are understandable and interpretable even if one transfers the IO from one trading platform to another. Hence it contains the background ontologies or domain vocabularies that define the logical space where an IO and its description facets is situated in.
- The ***history facet*** shall document creation, modification, and change history of an IO, which might be interesting for manifold purposes, e.g. to assess its quality (e.g., think about changes as answers to bug reports or evolving environment or topics) or actuality.
- The ***evaluation facet*** shall contain information suitable to assess the quality of the knowledge represented by an IO. Basically, such information may comprise direct measures describing intrinsic features of an IO (e.g., one may measure the redundancy freeness of a text, the absence of inconsistencies in a formal knowledge base, or the compliance with modeling standards and guidelines for a data model) or its creation process (e.g., it might have been created in an ISO 9000 compliant procedure), or it may contain customer feedback of qualitative (comments of happy users) or quantitative (e.g., a five-star-rating like in Amazon) nature.
- The ***method facet*** shall inform about technical provisions required to apply some knowledge described by an IO. For example, in order to use a given PowerPoint presentation, you may need a Laptop with appropriate version of the program and operating system, as well as sufficient memory.
- The ***transition facet*** shall describe how the application of some knowledge may affect and change the application environment. A typical example comes from the e-Learning area: in order to apply a learning object (LO) (e.g., consume some lesson) you are supposed to have some prior knowledge level, and appropriately applying the LO will change your level of expertise, e.g. such that you may subscribe to an examination.
- The ***business facet*** shall be used to store all data and information used to establish the trading functionalities of the marketplace, in particular pricing information.
- The ***legal aspects*** shall comprise everything related to legal aspects of knowledge trading transactions, i.e. in particular all IPR issues affected.
- The ***security facet***, finally, shall represent all information required to ensure that the whole transaction on the web is secure, e.g., with respect to payment and knowledge transfer.

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It goes far beyond the scope of this paper to discuss the INKASS Information Ontology in all details. This will be done to some extent in the conference talk; further we plan to provide more information at the INKASS project website. To give an impression, we show the first cut of the top-level structruing of the context facet:

The Figure below depicts the general structure of the description of potential usage context. It is composed from two parts:

- the *static context*, i.e. the organizational context in which a knowledge product may be applied, and
- the *dynamic part*, i.e. the concrete dynamic situation in which a knowledge product may add value

The *organizational context* shall describe as comprehensively as possible an intended consumer of a given knowledge product. Currently we foresee the following attributes to realize such a comprehensive description:

- the intended *User_Organization*, if some knowledge product is produced exclusively for specific customers, or if its applicability depends on certain customer-company characteristics, like the size, the location, or the legal form of a company
- the intended *User_Department* within this organization, because, e.g., a given knowledge product may only make sense to be used by the marketing department or the production planning
- the *Organizational_Role(s)* which may apply a knowledge object successfully (because they have the competencies, rights, or responsibilities to do so, or because a knowledge product – like a lesson learned or a best practice – affects in particular their specific job)
- the *Age and Professional Experience* of the people in these Organization_Roles, because there might be preconditions which must hold to employ a knowledge product effectively (for instance, such conditions frequently exist in the TWI case)

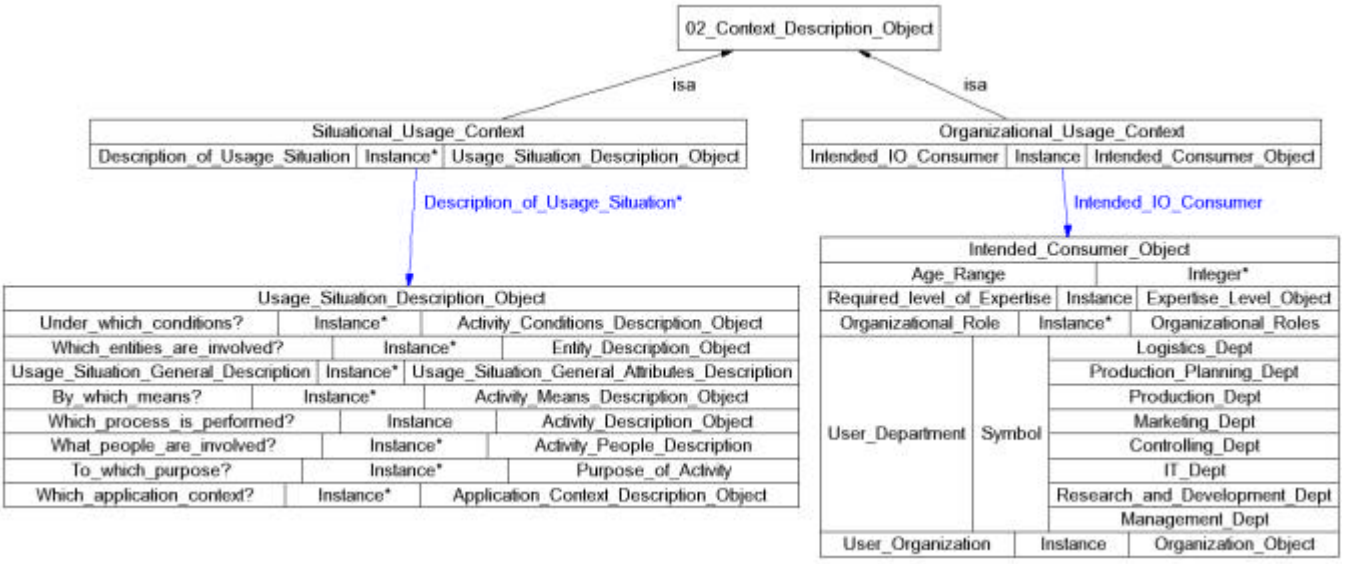

Figure 2: Top-level structure of Context facet

On the other hand, the dynamic, situational context is constituted by following attributes trying to describe as detailed as possible what activity shall be executed in which manner. For this

description, we oriented ourselves on the classical "W-Questions", Who, What, When, … . We shortly summarize the respective attributes:

> We describe which process (e.g. a certain production process) is performed, manipulating what entities (as input, output, or auxiliary products), under which conditions (e.g., obeying to specific regulations with respect to health or environment), and to which purpose, by which people, through which means, and in which general application context (e.g., the industry sector).

Some more details on this can be found in the INKASS project deliverable D8 and in (Maass et al., 2003).

5 Conclusion

In this paper we presented the INKASS Information Ontology as the data structure specification of the INKASS Knowledge Trading platform. We described 11 facets of Information Object (IO) description that we consider necessary for a comprehensive IO characterization in a trading scenario. The overall approach aims at a generic reusability of most parts in a wide range of applications, and has clear interfaces to extend and adapt by case-specific adaptations. While some facets are already well understood and modelled in much detail, others are quite new and must be further investigated in the future. Two design decisions – besides the design for reuse and adaptibility – for the overall approach should be mentioned which are quite unique to our project and prepare the stage for further powerful extensions:

1. The distinction between a ***content*** facet and a facet for describing potential usage ***context*** opens the possibility for an extremely powerful retrieval approach and reflects the fact that in many situations a customer may not know the details of a solution, but he knows the details of his problem.
2. The declarative representation of each and everything in the trading scenario – technically, as cases in the Empolis tool suite (products, customers, transactoins, contracts, search queries, feedback,versioning) allows for a maximum portability of IOs and partial solutions, and it allows for far-reaching analysis and learning capabilites as to be investigated in the second year of the project.

The presented Information Ontology is derived from a broad range of scientific and practical inputs thus guaranteeing a quite good coverage of applications. Nevertheless, this is defintely work in progress which still needs much thought and experimentation. However, it seems that at least the overall structure is much more comprehensive than other comparable approaches, and that all those facets are required in order to achieve a Knowledge Economy in a networked world. The clear relationship between Knowledge Trading as a general approach and an Information Ontology-based knowledge marketplace on the one hand, and the overall vision of Concurrent Enterprising on the other hand, still needs to be clarified more. We assume that the next coming challenges here are not so much of a technological character, but more questions of economic models and organizational questions for Concurrent Enterprises.

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