

## **Improving Knowledge Sharing through Knowledge Objects Representation**

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**Abstract:** People need information to create new knowledge. For each piece of information obtained, a range of previous knowledge, competences, beliefs and own concept definitions significantly influence personal perception and one's knowledge creation. This in turn, affects the ability to remember, reason, solve problems and interpret information. These issues have to be considered when planning knowledge management systems, in which information retrieval and handling, reuse, people interaction, knowledge interchange and dissemination comprise its characteristics. This paper is based on the Knowledge Object definition from Merrill and proposes an approach which more precisely enables Knowledge Object representation, taking into account the domain in which a KO is used, a range of previous knowledge, competences, beliefs, concept definitions, user profile and recommendation from community users.

**Keywords:** knowledge management systems, knowledge representation, knowledge objects, learning objects, ontology

**Category:** H.4 (Information Systems Applications)

### **1 Introduction**

Nowadays, people create and exchange information faster and in much greater volumes than in the past. This exchange can be through a document form, such as e-mails, articles, letters, magazines and books, or through informal or tacit knowledge exchanged between people. In this current scenery, information technology has an important participation, enabling a faster communication, improving the document research and management, and connecting people no matter distance, space or time. One practical way of summarizing knowledge management is to say that it is to get the right knowledge at the right place, at the right time. If knowledge management is quickly made, services can be improved by solving problems better and avoiding mistakes made in the past, new products can be brought to market faster, processes are continually improved, new customers are acquired, and innovative new ideas brought to commercialization. As the flow of knowledge is so important then, information technology plays an important role in knowledge management.

However, it is necessary more than to store data for an efficient handling of information. It is necessary to manage different kinds of information, such as the resource description, their authors, keywords, those who usually manipulate them,

description quality, relations to other resources, and others. This kind of information about the information itself is called metadata, and its scope is to be machine-understandable, so that it can be used by software agents to easily retrieve resources from a huge pool of resources, like the Internet, business data warehouses and other kinds of data storage. Some standards were created to normalize retrieval, access and use of metadata between different information systems.

There are serious questions concerning whether these standards provide mechanisms to supply knowledge creation and knowledge reuse rather than merely to describe information. Some issues are not available as i)reusing content at all levels, ii)permitting to combine (manually or automatically) pieces of knowledge to create new knowledge, iii)placing user knowledge in the context where it was created and recording all the other factors which motivate its creation, iv)leading to the interoperability among systems, so knowledge content used for one tool (like collaboration tools, such as discussion forums, chats, screen-sharing and videoconferencing) can run on other systems as well, v)making that a piece of knowledge serve multiple purposes, vi)enabling and simplifying the delivery of knowledge and vii)adapting existing knowledge to new purposes and different systems without increasing its cost. The issues cited above and the concern to meet education and collaboration needs in group activities are reflected in some proposals, and in the literature they are referred as the "instructional object", "educational object", "learning object", "knowledge object", "intelligent object" and other terms.

This paper is based on the Knowledge Object (KO) definition from Merrill [Merrill 99] and proposes an approach which more precisely enables Knowledge Object representation, taking into account the domain in which a KO is used, a range of previous knowledge, competences, beliefs, concept definitions, user profile and recommendation from community users.

The remainder of this paper is organized as follows: Section 2 discusses a number of theoretical Knowledge Object aspects, as Learning Object definition, Merrill's Knowledge Object concept and the difference between them. As the objective of this research is proposing a KO representation to facilitate collaboration, knowledge reuse and creation, section 3 presents our proposal. Future works and the conclusion are shown in section 4.

## 2 Knowledge Object Proposals

Approaches to define a precise way for describing the subject matter content or knowledge to be taught were created in different times with different names as "content object" [Scorm 01], "knowledge objects" [Merrill et al. 91; Merrill 97], "instructional components" [Wiley 00], "pedagogical documents" [Ariadne 99], "educational software components" [ESCOT 01], "online learning materials" [Merlot 00], "resources" [ALI 00], "virtual apparatus" [Ip et al. 96; Ip et al. 97; Ip et al. 97b; Fritze et al. 98] and "learning object"[LSTC 00]. Although the gap between these proposals related to learning object systems has focused primarily on technological attributes, metadata standards and system specifications issues such as levels of granularity and ensuring interoperability are common among them [Wiley 98; Singh 00].

The concept of learning object defended by IEEE LSTC (Learning Technology Standards Committee) [LSTC 00] has been broadly used, and its definition will be described as follows.

## 2.1. Learning Object

As per [LSTC 00], learning objects are defined as any entity, digital or non-digital, which can be used, reused or referenced during technology supported learning. Examples of Learning Objects (LO) include multimedia content, instructional content, learning objectives, instructional software and software tools. LOM (Learning Object Metadata) is a standard proposal by [LSTC 00] which specifies a structure for interoperable descriptions of learning objects.

LOM Schema defines a structure divided into 9 categories, as follows:

- General – general info about learning resource as a whole;
- Life cycle – history, current state and contributors;
- Meta-metadata – information about the metadata instance itself;
- Technical – the technical requirements and characteristics;
- Educational – the educational and pedagogic characteristics;
- Rights – intellectual property rights and conditions of use;
- Relation – the relationship between learning resources;
- Classification – The resource in relation to a classification system;
- Annotation – comments on the resources and their creators.

Each of these categories attempts to characterize the resource by a separate aspect and these categories represent a group of data elements, which may contain sub-elements or not.

Some negative aspects about LO and LOM are faced. First, the definition is so broad, and several things that are not related to educational proposes can be considered as an LO, as a banner. It is important to have a more restrictive definition and representation when we desire to infer and automatically create new knowledge.

Second, LOM defines concepts to describe learning objects, but does not define how to implement them. With the use of XML in a pure approach to represent LOM concepts, we have lost in semantic. Another aspect is compatibility. In the XML binding, there is no standard way to reuse other meta-data standards. A good attempt is presented by [Nilsson 03], but this is not yet a standard.

Another issue is the definition about LO (and, consequently, LOM adopts it) rejects non-digital and non-reusable resources, not including people, historical events, books, competences, learning level, models, decision criteria, computational architectures and processes.

A more precise approach about knowledge representation, organization and use for learning and collaborative purposes is the Knowledge Objects concept defined by [Merrill 97], which is structured into entity, part, property, action, process and kind.

### 2.1.1 Merrill's KO Definition

Although Merrill's approach to knowledge design tends to be abstract, it provides a highly flexible method of explaining how the structure of knowledge can be coupled to the structure of efficient and effective reused objects.

A knowledge object is a precise way to describe the subject matter content or knowledge to be taught. A knowledge object is a framework for identifying necessary knowledge components. Knowledge objects should consist of components which are not specific to a particular subject matter domain [Merrill 98].

A knowledge object can have five major components. These include the following:

- the entity - entities are essentially things which qualify as nouns, such as some device, person, creature, place, symbol, object, or anything;
- parts of the entity – describe or illustrate a part of an entity;
- property - properties are qualities or quantities associated with entities, activities, or processes.;
- activity – activities are sets of related actions performed by a user on, with, or to, the entity;
- process - processes are sets of related actions which take place without the user's participation. They are events triggered by an activity or another.

A knowledge object consists of a set of fields (containers) for the components of knowledge required to implement a variety of instructional strategies. These components include: the name, description, and the portrayal for some entity; the name, description, and the portrayal for parts of the entity; the name, description, values, and corresponding portrayals for properties of the entity; the name, description and the process triggers activities associated with the entity; and the name, description, condition, consequence and process trigger processes associated with the entity [Merrill 00]. This structure is called a PEAnet for Process, Entity, Activity Network.

Merrill proposes three basic ways in which those objects can be related: They can be related via a component relationship, i.e., a relationship denoting that something is part of a larger structure. They can be linked by an abstraction relationship. This means that an entity, activity or process could be viewed as a subclass or superclass of other entities, activities or processes. They can also be linked by meaningful connections called associations.

Our proposal is based on this KO definition and structure to provide reuse, creation and dissemination of knowledge between people and knowledge management systems. We extend Merrill's definition to be able to represent knowledge objects and their context using already-known standards (LOM) and creating new description templates, as describe in next section.

### **3 Our Approach: KOD**

Our approach entitle KOD (Knowledge Object Descriptor) intends to provide a way for describing all kinds of knowledge, marking the search, reuse, manipulation of pieces of knowledge and their interchange among people and environments easier. We have envisioned describing, storing and disposing knowledge objects from different domains. Merrill's model was chosen because it is more complete and inclusive than others.

Regarding this proposal, we extended Merrill's Knowledge Object concept, allowing for the addition of some components important for handling the multiple viewpoints, meanings, perspectives and contexts of a KO. These changes are shown in 1, and the new components are described below.

**Domain** – This is the domain in which knowledge objects are created, used and deployed. Knowing the domain is vital to provide right concepts definitions and relationships intrinsic to a domain. An entity is a concept or a set of related concepts from a domain. It has as fields, as the name, description and link to a domain ontology concept.

**Handler** – This component represents everyone (users) or everything (systems) which manipulates, creates, accesses or uses a KO. In Merrill's approach, a handler could be represented by an entity. We decide to separate the entity from those who handle it for tracking information as the kind of knowledge has been used by a user/system. We have 3 kinds of handlers, to wit: i) user – those who use a KO, a system or a human, ii) owner – those who have rights over the KO, it can be a system or a human, iii) creator – those who create the KO, it can be a system if the KO is being created automatically. It has as fields, as the name, description, type (human or system) and kind (user, owner, creator).

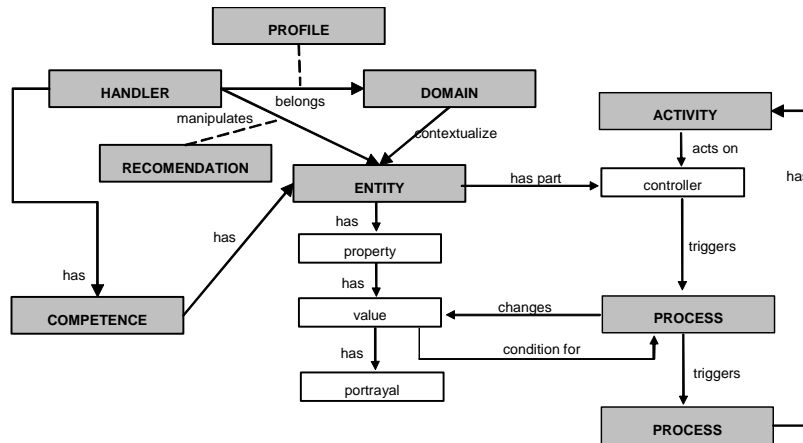


Figure 1: Knowledge Components and their Relationships – An Extended Version

**Profile** – More important than providing information is knowing how much you know about the situation and circumstances of the user. Personalization of the knowledge objects requires knowing about the user: his/her interest degree in a subject, and the domain in which he/she acts. Also important, the collaborative environment must know what the user knows. To assemble relevant learning experiences, it must know about the users' past experiences, learning preferences, learning style, and more. An environment which automatically identifies people's areas of expertise based on the issues they are interested in, the ideas in their documents, the e-mail messages they create, and the topics they follow in their knowledge bases, facilitates creation of virtual workgroups, encourages communication, provides certain information to users and reduces duplication of

efforts. A profile is related directly from the user existence and his/her experience in a domain. It has as fields the name, description, user interest degree, age, learning style and geographic location.

**Recommendation** – Describes a user's contribution, an evaluation over a KO. It has fields as the name, description, user contribution, and user evaluation (degree).

**Competence** – This component is responsible for describing the competences of a handler. It is important to emphasize that a competence can consist of one or more entities. Similar to profile importance, knowing people who are experts on an issue can bring an important contribution to a community. It has as fields as the name, description and the knowledge degree on this issue.

Another modification is the relationship between process and activity (a process has one or more activities). This is useful because one process can be represented as a set of sub-processes, and each of these sub-processes can have embodied another sub-processes or a set of activities. Then, to describe this aggregation we introduce this relationship.

In the previous Merrill's model we faced difficulty to represent historical events, because time was not represented. Thus, a field to represent time was included in the components Activity and Process, permitting the tracking of past processes and the historical evolution.

With this approach, we can represent several things which we are not able to describe in the LO approach [LSTC 00] as people/systems, historical events, documentation (in this approach, as an entity), competences, learning level, models (in this approach, as an entity), computational architectures (in this approach, as an entity), processes, knowledge creators, users, recommendations, context, profile, learning experience, activities and processes.

We have defined a structure to provide computational representation using XML-Schema (which will not be shown because space limitations). Entity is the main component in this approach, and, to represent it, we use the LOM standard to describe this level. Thus, integration with resources already described in LOM can be made in the future.

## 4 Ontology

Having a framework to define KOs and their relationships (a KO can be construct by other KO, like an aggregation relationship) is only the first step. What if different applications use different description from different KOs definitions to indicate the same thing? In order for them to interoperate and exchange information, they must reconcile the two terms. This meaning consensus is provided by ontologies. The term ontology has been used by different communities like Artificial Intelligence, Database, Software Engineering and Knowledge Management. Ontologies, in computational representation, contain a taxonomy of terms and a set of inference rules to make sense of the terms, usually in machine-readable form.

Using the XML-Schema provided to represent KOs, we can easily: i) represent semantic relationships between KOs in a domain, ii) represent an ontology as a KO and consequently iii) exchange and reuse ontologies or parts of them.

While XML is fully accepted as the main standard for data representation, especially for purposes of interchange and software interoperability, the use of

Semantic Web technologies - including RDF (Resource Definition Framework), RDFS (RDF Schema), DAML+OIL (DARPA Agent Markup Language + Ontology Inference Layer) and OWL (Ontology Web Language) - for some applications which are intensive knowledge reuse and dissemination, remains relatively limited. However, the combination of XML, RDF/RDFS and OWL provides an overall architecture for resources.

In our work we use OWL to specify and manipulate KOs and their relationships (the ontologies).

## 5 Conclusion and Future Works

By allowing people or systems to organize, restructure and represent their knowledge by adapting or creating new knowledge objects, there will be a significant need to support them in effectively constructing resources for future use and reusability. This work aims providing a way to describe knowledge objects and, consequently, i)to afford discovery, reuse and manipulation of existing objects, ii)to allow for user-designed and user-created artifacts that could become knowledge objects if posted to the system and iii)to consist of multiple levels of granularity to afford reusability, flexibility, accessibility and adaptability of knowledge objects. To such purpose, we use and extend the Merrill's concept of Knowledge Object and use the LOM Standard (Learning Object Metadata) to describe the main component of knowledge. These complementary approaches permit knowledge interchange and reuse through knowledge object representation.

As future works we intend to expand this approach to grid computing environments, that are a kind of computational environment which exchanges several different kinds of knowledge. We intend to evaluate our proposal by doing several tests (performance, usability and improvements gained in collaborative environments). Systems providing design and development support would need to include guidance in the development of granularized objects, an authoring-like system to guide the creation and adaptation of learning objects. This resource shall comprise a future work, too.

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