A KNOWLEDGE SERVER FOR SUSTAINABLE AGRICULTURE
Main Computing Features

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Abstract: Agriculture must evolve into a more environmentally-friendly approach, while remaining economically viable and socially interesting, which is necessary so that the process can be pursued in the long term, i.e that the process is sustainable (Brundtland, 1987). Sustainable agriculture has a systemic logic and therefore requires a strong knowledge base. In this study, we propose a knowledge management computing tool. In the first part of our article, we discuss the potential actors of the tool and their possible implications. The second part deals with its contents. In the third part, the main computing features of the tool are shown.

1 INTRODUCTION

Agriculture is involved in a vast societal movement, imposed on it by the framework and the values associated with sustainable development. To make a success of this transformation, agriculture will have to become both integrated into its environment and organic. This transformation depends largely on the mobilization of human knowledge (all that is held for known or known by an individual or a given society) and know-how (Ikerd, 1993; Cerf, Gibbon et al., 2000). But in 2011, while numerous professional software packages are accessible to farmers, no structured, interactive IT tool for knowledge management is available to them. We thus suggest developing a knowledge management tool dedicated to organic farmers, called KOFIS: Knowledge for Organic Farming and its Innovation System. In the first part of our article, we study who the actors of this tool are, and their possible roles. The second part deals with the contents of the tool. In the third part, the main computing features of KOFIS are shown.

2 ROLE OF THE ACTORS IN KOFIS

Not all the actors have the same importance. However farmers, researchers, agricultural advisers have not the same expectations, the same needs. The actors have also to share the same objectives. We distinguish various accesses to KOFIS according to the type of actors.

Agricultural advisers or agricultural teachers can monitor and transfer academic knowledge stemming from research. Rooted in the institutional environment, external actors such as cooperatives influence farmers by their specific requirements, and this implies a knowledge adaptations process. Their intervention will also be important via their contributions on innovative subjects in more open exchange spaces. The experience and creativity of agronomic engineers from cooperatives and traders can be very useful here. The exchange and innovation will be opened to all the actors to encourage the new ideas.

3 CONTENTS OF KOFIS

We have decided to concentrate our study on arable farming. In 2008, 19% of organic farms were specialized in this type of agriculture.

3.1 Main Content Elements

We have noticed that most of the knowledge about

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sustainable agriculture system are not generalizable on a large scale and is, rather, contextualized.

We wish to obtain cognitive representations of critical knowledge, particularly in order to design Innovative Agriculture Systems (IAS) which are effective and sustainable in their context. To do this, we distinguish two types of mobilizable cognitive resource: thematic knowledge and contextual knowledge.

3.1.1 Thematic Knowledge

Thematic knowledge is agronomic, economic or environmental knowledge. It is generalizable for all types of farm. It applies only in part to any particular farm.

3.1.2 Contextual Knowledge

On the farm level, IAS illustrates contextual knowledge. The notion of reference introduces a cognitive concept which is specific to agriculture. A reference is therefore both agricultural advice and localized facts enabling the data to be interpreted. References which illustrate the theoretical operation of a farm could be present in the library, as either a typical or a concrete case.

A typical case is a “fictitious farm, constructed by modeling, and described using concrete and coherent data from farms using the same system” (Cerf and Lenoir 1987). The typical case is cognitively efficient for transmitting knowledge which is tried and tested in a given environment to the operational actors.

Similarly, a concrete case is "a typical case studied because of the innovative character of some of its features, but whose representativity is generally minor in the local or regional territory. The main interest of this concrete case is that it can provide possible orientations, strategies and adaptations of the main farming systems in the local region.” (Chambre régionale d'agriculture de Bourgogne 2009).

3.1.3 Which Model to Use?

The tool to be constructed is first of all a computerized book of knowledge. We selected the Mask method (Ermine 1996, 2nd edition 2000) used in knowledge engineering to represent both thematic knowledge and the operations of a farm. These models are gateways to deeper forms of knowledge, such as texts, and also perhaps images and videos (Moity-Maïzi and Bouche 2008). Thus, the models structure the knowledge.

3.2 Content–actor Relationship

Agricultural advisors or farmers have a role to play in renewing knowledge, since they are continually introducing new practices. Researchers, for their part, make available academic knowledge. Agricultural advisors or teachers comprise the pedagogical interface of this empirical and academic knowledge.

Finally, in the exchange and innovation space, all the actors can exchange their ideas concerning innovative subjects, or can react to knowledge which has already been presented.

4 THE TECHNOLOGICAL COMPONENT

We will present the general specifications of KOFIS and then, based on a list of KOFIS properties, we will propose the general tool architecture.

4.1 KOFIS – General Specifications

In the four following sections, we will describe successively what is globally required of the tool.

4.1.1 What are the General Expectations for KOFIS?

KOFIS needs to be accessible to actors of different origins in various computing environments. In the first two sections, we identified two expression spaces with different logical approaches: a knowledge capitalization space and an innovation space. In the following, by convention, we will call [K] the knowledge space and [I] the innovation space. Thus, KOFIS stores operational knowledge objects in [K] and builds interactions in [I] to produce new knowledge.

One of the key success factors for knowledge management (Soulignac, Chanet et al. 2009) is the users’ appropriation of the tool. **The first property of the tool is its ergonomy.**

Knowledge objects should be quick to access. In addition, when faced with an unsolved problem, the system rapidly provides pertinent and explicit knowledge in the form of datasheets, images or videos, which facilitate the solution.

Two important functional requirements emerge: the knowledge capitalization and the organization and structuring of explicit and tacit knowledge. We shall see how an adaptation of the C-K theory of (Hatchuel and Weil 1999) and the use of a semantic web respond respectively to these two requirements.

4.1.2 Proposed Responses: Capitalization and Innovation

The C-K design theory (Hatchuel and Weil 1999) distinguishes two spaces, one associated with tried and tested knowledge, the other devoted to innovation, and it reflects human reasoning when faced with a problem.

Like the C-K theory, KOFIS therefore has two different spaces: an exchange space [I] where all the actors can discuss the resolution of a problem, and a knowledge capitalization space [K] where the knowledge is stored in a structured way. From the space [I] it is possible to query the closed space [K]. The discussions of the exchange space allow enriching the knowledge of the capitalization space. **A second property of the tool is its capacity to maintain a trace of human design reasoning.** The activity diagram in figure 1 shows the sequence of actions and decisions within an activity of a member of <agricultural knowledge system>.

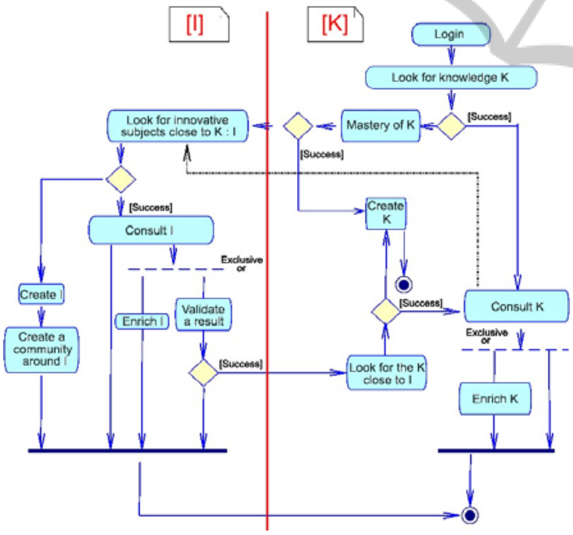

Figure 1: Main KOFIS activities for an actor of the agricultural knowledge system.

The actors of the <agricultural knowledge system> are responsible for maintaining a coherent tree structure for the innovative solutions. They also validate knowledge coming from this innovation space in order to publish it in the [K] space.

4.1.3 Proposed Responses: Structuring the Knowledge

Most web tools have no separation between Knowledge and data presentation language; only human intervention can retrieve and process knowledge. One solution is to annotate the documents.

Social web-type annotation is based on tagging documents. A tag is a lexical marker which is associated with a resource. The search tool will thus retrieve all the resources associated with the selected tag.

A second type of annotation, associated with the semantic web, facilitates the use of knowledge by machines. The semantic web initiative is supported by W3C, the international consortium which standardizes web technologies.

The different semantic web technologies: URI (Universal Resource Identifier) addresses locate the resources. The XML language proposes a syntax to structure all types of contents. RDF and RDFS represent knowledge in triplets of resources of the form <subject, predicate, object>. They describe classes and properties. These triplets are the basis of the formal description language OWL used to describe ontology. This language has mathematical bases, which is why OWL can be manipulated by computers. In addition, OWL is capable of instantiating classes, which increases its power to describe reality. Finally, an ontology can be a reference, which facilitates exchanges between computers. SPARQL is a tool for querying recorded knowledge elements. The semantic web as described by (Berners-Lee, Hendler et al. 2001) proposes a proof system. Encrypted blocks ensure the reliability of the sources.

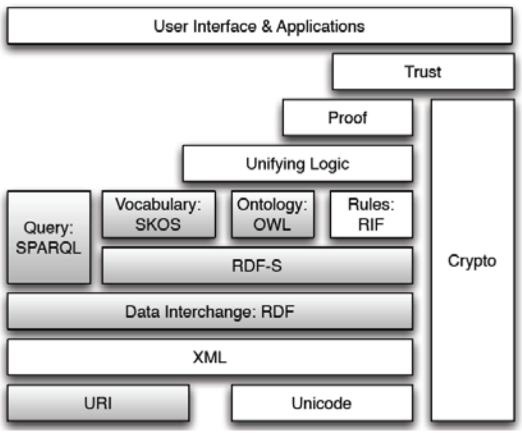

Figure 2: The multiple layers of the semantic web. (Bernhard Haslhofer, Linked Data Tutorial, 2009).

In hypertext modeling, links are static and their semantics are not specified. On the other hand, a semantic annotation, thanks to semantic query, enables the computer to retrieve the correct knowledge element directly.

A document annotation system will therefore facilitate their retrieval, which constitutes the third property of KOFIS.

We propose that the system should use the semantic content associated with the identification of each farmer, with a view to creating the most appropriate communities with respect to their centers of interest. **This capacity to construct a pertinent community is our fourth property.**

4.1.4 What are the Functional Requirements of Each User Group?

KOFIS' users have various different profiles (farmer, advisor, teacher, researcher…). Thus, the difficulty is to find a balance between allowing the largest possible number of actors to publish in the tool and maintaining control of what is published. According to their status, the actors access the contents with varying rights. Thus we find the five types of actor whose rights are present below in a hierarchical sequence.

The KOFIS <visitor> has free access; other users are authenticated by a classic login/password system. Apart from <visitors>, all users communicate identity information to the system, in order to inform the community's creation process later on. The ontology, once defined, is relatively stable; only the <moderator> may change it.

Table 1: Distribution of users types in [I] and [K].

<table>
<tr><th>Space type / User type</th><th>[I] Innovation</th><th>[K] Knowledge</th></tr>
<tr><td>Visitor</td><td>Read-only</td><td rowspan="2">Read-only</td></tr>
<tr><td>Institutional environment</td><td rowspan="2">Proposes and modifies innovative subject
Posts comments and annotations on innovative subject</td></tr>
<tr><td>Agricultural knowledge system</td><td>Opens, annotates and modifies new knowledge pages</td></tr>
<tr><td rowspan="2">Moderator</td><td>Moderates exchanges</td><td>Validates knowledge</td></tr>
<tr><td colspan="2">Administers ontology
Manages actors</td></tr>
<tr><td>Administrator</td><td colspan="2">Manages architecture
Manages actor types</td></tr>
</table>

The analysis of functional requirements gives rise to a fifth and a sixth property:

- **The fifth resides in KOFIS' capacity to generate different user types.**
- **The sixth is its approach to collaborative publishing and exchange.**

We will add a seventh property: **the capacity to conserve a trace of modifications,** which enables a clean version to be reconstructed in the case of error or damage.

4.2 Architecture of the KOFIS Tool

In the previous paragraph concerning the KOFIS tool's specifications, we identified seven main properties of the tool summarized in table 2 below:

Table 2: KOFIS properties.

Property	Description
1	Ergonomy
2	Trace the human reasoning associated with the design
3	Semantic annotation
4	Construction of a pertinent community
5	Differentiated management of user types
6	Collaborative publishing and exchange
7	Traceability

4.2.1 Exploration of Different Types of Tool

First, we explored the software market (Balmisse 2006) corresponding to our need for a collaborative and semantic knowledge management tool:

Table 3: Comparison of technical solutions.

<table>
<tr><th>Tool / Properties</th><th>CMS</th><th>WIKI</th><th>Semantic Web solution</th></tr>
<tr><td>Ergonomy</td><td>Yes</td><td>No, in particular for discussion of knowledge pages</td><td>Yes</td></tr>
<tr><td>Traceability of the human reasoning associated with the design</td><td>Sometimes</td><td>No</td><td>Yes</td></tr>
<tr><td rowspan="2">Semantic annotation</td><td>Sometimes</td><td>Sometimes</td><td>Yes</td></tr>
<tr><td colspan="2">More advanced for Wiki than for CMS</td><td></td></tr>
<tr><td>Construction of a pertinent community</td><td>No</td><td>Yes</td><td>Yes</td></tr>
<tr><td>Differentiated management of user types</td><td>Yes</td><td>Yes</td><td>Yes</td></tr>
<tr><td>Collaborative publishing and exchange</td><td>Wiki extension</td><td>Yes (all the site)</td><td>Yes</td></tr>
<tr><td>Traceability</td><td>No</td><td>Yes</td><td>Yes</td></tr>
</table>

CMS - Content Management System – is an IT application which designs the contents of a web site and manages its updates dynamically.

A wiki has a strong collaborative aspect for elaborating documents. This co-construction leads to a rich knowledge base, the result of combining the knowledge and the experience of users/contributors in a particular domain.

The choice of several pertinent frameworks also enables the complete development of the application, but at the cost of a considerable development effort. We compare the three possible options in table 3.

To produce KOFIS, we therefore chose the following tools:

The innovation space [I] is devoted to collaborative reflection about a new subject. We chose the CMS tool, because of its capacity to organize content and its popular publication system: blogs. However, content management systems are less developed on the semantic level.

Due to its collaborative production capacity and its semantic dimension, we therefore chose the semantic wiki tool for the [K] space. However, it appears complicated to differentiate between the user profile of these two communities in a wiki tool, typically very liberal in terms of rights management.

4.2.2 Tool Choice

For [I], we chose Drupal. This is a high-performance, robust, open-source tool. Drupal includes blogs, forums, FAQs, etc. and features a WYSIWYG interface.

Drupal proposes a tree structure “book” system to organize its contents. For an innovative subject, this very visual tool can represent research work as illustrated in figure 3. The tree structure illustrates the C-K theory. Drupal offers a classification system based on taxonomy. This provides the vocabulary necessary to tag each blog entry serving to support a solution. The [I] part has a web 2 type annotation, and thus does not yet have a semantic web dimension.

For [K], we require a semantic wiki which combines the collaborative features of a wiki with the resources of the semantic web (Ludwig, O'Sullivan et al. 2004; Khun 2008; Schaffert, Eder et al. 2009). We chose the SMW (Semantic MediaWiki) module (Völkel, Krötzsch et al. 2006).

SMW accepts OWL and a semantic query language, ASK. Each page (knowledge page or user page) of SMW can be annotated by a semantic annotation. At this stage, we can notice that the [I] and [K] parts thus have no same type of annotation. However these two annotation systems are hierarchically organized in the form of taxonomies; we have thus worked on taxonomy alignment (Chhuo Vanna, 2011). In addition, the social network thus created would be constructed from ontology. Thus the system will create different communities depending on the annotation mode. A community created from a category will be different if we associate a property with this category. The IT architecture is presented in the figure below.

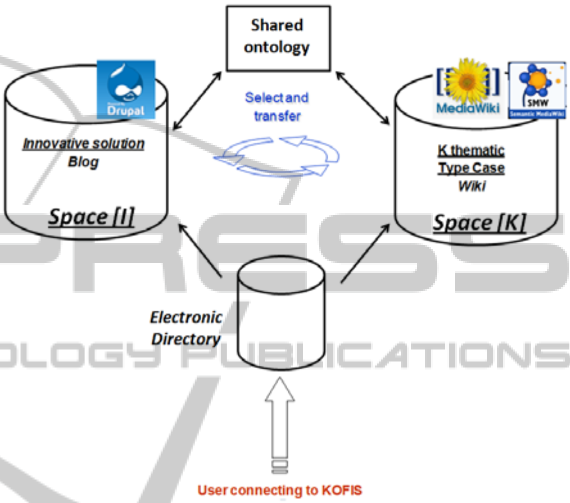

Figure 3: KOFIS architecture.

5 CONCLUSIONS

In the previous paragraphs we described the specifications and the properties of KOFIS. For every specification of the tool, for every property we present a technological solution. So, we noticed that Web 2, also called the social web and Web 3, also called semantic web are a good solution for a knowledge server. KOFIS architecture exploits the capacities of web 2, as well as the latest developments from the semantic web. Thus the tool enables the collaborative construction and storage of knowledge in the [K] space and exchanges in the [I] space.

Although Web 2 combined in Web 3, answers our need. Both technologies do not collaborate still in a satisfactory way. That is why, we work about the taxonomy alignment, and knowledge querying of [I] towards [K].

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