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Knowledge Mobilisation for Knowledge Whenever and Wherever Needed

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Abstract
Knowledge mobilisation is a transition from the prevailing knowledge management technology to some innovative methods for knowledge representation, formation and development and for knowledge retrieval and distribution. Knowledge mobilisation also carries the connotation on "knowledge on mobile phones" and this is actually one of the platforms that will be used. Fuzzy ontology replaces classical ontology for knowledge representation. We will show that fuzzy ontology is useful to represent real world knowledge and to give us answers which are sufficiently good for real world situations for which we need sufficiently good knowledge. We demonstrate the knowledge mobilisation approach by showing how amateurs can become wine connoisseurs with support from the technology.

Keywords: Knowledge mobilisation, knowledge support, mobile phones

1 Introduction

Knowledge mobilisation represents a change of paradigm in the creation, building, handling and distribution of knowledge. The traditional approach has been *knowledge management* [KM] which is to collect knowledge from experts, knowledge workers and professionals and to redistribute it (unsuccessfully, as it has turned out) throughout the organisation. The new approach is to produce timely and relevant knowledge for the context in which the user intends to operate, in a form which is consistent with the background knowledge the user has, with a context-adaptive content and with modern information and communication technology. One of the intentions is to find forms for producing "knowledge on mobile phones" which carries some challenges of its own as the processing power and capacity of the mobile phone cannot match the capacity of even a modest laptop.

Knowledge mobilisation is an enhancement of the knowledge management methods and technology and develops new forms for using information and communication technologies (ICT) in management processes. The use of ICT is commonly believed and accepted to help improve the quality of planning, problem solving and decision making as these processes are supported with relevant and updated knowledge.

The introduction of knowledge mobilisation will shift the focus from a *supply driven* to a *demand driven* approach, which will help reduce some of the obstacles for (re-)using knowledge in many organisations (Keen and Macintosh 2001): (i) knowledge workers who develop relevant, useful and advanced knowledge are unwilling to give it away to others who are less knowledgeable and/or unwilling to spend as much time to build a knowledge base unless there is a good and effective reward system in place; (ii) knowledge becomes obsolete and there should be incentives for updating, enhancing and improving core elements of the knowledge; (iii) knowledge is partly tacit and difficult to represent and share with other knowledge users, and (iv) knowledge is difficult to distribute and use independently of the knowledge producer.

To *mobilise* means "to make or become ready for action" – i.e. *knowledge mobilisation* can be interpreted as "to make knowledge available for real-time use in a form which is adapted to the context of use and to the needs and cognitive profile of the user". This is one of the classical visions of an efficient use of knowledge which we intend to turn into actual use. Modern smart phones carry context information in several forms of applications and in some cases user interfaces will represent the cognitive profiles of the users. Then it is short intuitive step to make knowledge available for real-time use on smart phones; the step may be intuitive but the realization requires some effort.

This paper is a result from a project with industrial partners in which we work to develop the practical use of fuzzy ontology techniques for enhanced situation diaries to monitor and report on industrial problem-solving processes, i.e. we have collections of documents (hundreds, thousands, etc.) that describe how complex industrial processes were solved and which we want to retrieve very quickly when we have to deal with a problem we have solved some time. In the next section we will introduce a technology framework for knowledge mobilisation, in section 3 we will work out a wine ontology, in section 4 we introduce fuzzy ontology, section 5 is a demonstration of how to select a proper wine with the ontology and section 6 summarizes and concludes.

2 Technology Framework

The semantic web is based on the Resource Description Framework (RDF), which integrates a variety of applications using XML for syntax and URIs (Uniform Resource Identifiers), for naming. The RDF makes it possible to represent the semantics of a web page as metadata by expressing meaning in sets of triples: <subject, predicate, object>; each element of a triple is identified by URIs, which identify resources in the web; URIs include URLs or locators.

The RDF is built with a set of primitives for simple ontology (which is not enough for knowledge mobilisation purposes); ontology is an executable, formal conceptualisation with shared agreement between members of a community of interest – more precisely:

collections of statements which define the relations between concepts and specify logical rules for reasoning about them; typically this is done with a taxonomy and a set of inference rules.

The RDF and the Ontology Web Language (OWL) form the semantic web. The basic standards were recently enhanced with the SPARQL standard, which can be used to express queries across diverse data sources, whether the data is stored natively as RDF or viewed as RDF via middleware.

The Semantic Web being designed deals with hard semantics for handling crisp data; RDF cannot be used to represent soft semantics; it is possible that Semantic Web will be irrelevant for handling most of the information used in practice, which is built on soft semantics.

It is possible to extend the RDF by encoding fuzzy sets/fuzzy logic in the RDF format; the fuzzy component will simply have a URI to a system of fuzzy sets or fuzzy logic or fuzzy conceptual graphs (which is a promising way to deal with natural language applications). A fuzzy ontology is preferable to a classic ontology as it can be used to represent the same semantic content in much less space (a reduction by 90 % has been reached in some experiments) than a classic ontology.

The W3C announced on November 13, 2007 that the RDF Data Access Working Group has published three SPARQL Proposed Recommendations: SPARQL Query Language for RDF, SPARQL Query Results XML Format, and SPARQL Protocol for RDF. The first specification defines the syntax and semantics of the SPARQL query language for RDF. SPARQL can be used to express queries across diverse data sources, whether the data is stored natively as RDF or viewed as RDF via middleware. The results of SPARQL queries can be results sets or RDF graphs; the second specification defines an XML format for the variable binding and Boolean results formats. The third specification uses WSDL 2.0 to describe an HTTP protocol for conveying SPARQL queries to an SPARQL query processing service and returning the query results to the party that made the request. These standards can be applied in the development of the knowledge mobilization technology.

Ontology is metadata, which uses a defined vocabulary of terms, each with an explicitly defined and machine process able semantics; when the vocabulary relates to real world observations and events it will be ill-structured, uncertain and imprecise, which will require the use of fuzzy sets and fuzzy logic.

3 Wine Ontology

A good way to find out what possibilities we have to realize knowledge mobilisation with the help of a fuzzy ontology and to really make it work is to build a working prototype. This is what we are doing with enhanced situation diaries in cooperation with industrial partners; the details of these prototypes are confidential and we needed a test case that can be shown and discussed with people knowledgeable about ontology. Thus the idea to build *knowledge mobilisation tools that can turn amateurs into wine connoisseurs*. For good reasons wine ontology has been an enjoyable test ground for theoretical ontology constructs (Calegari and Ciucci 2006, 2010).

Wines are described with a number of attributes and there are different rules for how to choose the “right” wine for different contexts. Wine knowledge is expressed in common sense terms and most of the finer points on how to select a good wine build on tacit knowledge.

Repeated testing and sometimes heated arguments (at conferences with people doing fuzzy logic and fuzzy sets research) show that a minimum dimensionality for advice on wine need to cover at least the following features, attributes, contexts and wine drinker categories:

<u>Country of origin:</u> wines from France, Italy, Spain (and Australia, Chile, Hungary, New Zealand, Portugal and US) have different character and have their own supporters; within a country each wine gets different characteristics depending on the region, vintage, wine yard, grapes and the brand/label (which may communicate a specific characteristic)

<u>Quality:</u> there is some consensus that wine quality is expressed in terms of acidity, sugar and alcohol level which all will have an impact on the actual taste; then there are more difficult characteristics in terms of body, flavour and overtones which are given classifying linguistic attributes

<u>Context:</u> the type of wine which suits a context is often determined in terms of macro attributes such as country (“typical French or Italian wines”) or quality (“light or heavy flavour” or “little or medium acidity”); the contexts which differentiate between wines are *formal dinner* (the emphasis on “good quality wines”), *business dinner* (“good quality wines” or “wines known to be favoured by the guests”), *family dinner* (“sufficient quality wines”, “old favourites”, “new experiments”, etc, according to family preferences), *pick nick* (“light flavour and non-expensive wines” as an outdoors meal may interfere with the flavours), *dinner with friends* (“good quality wines”, “experimental combinations of wines with good reviews” depending on the friends and what type of wine drinkers they are), *candle light dinner* (“wines that fit a romantic event” (which may support many different interpretations)); the indications given here are, of course, loose and general – the users of the ontology need to work out their own preferences

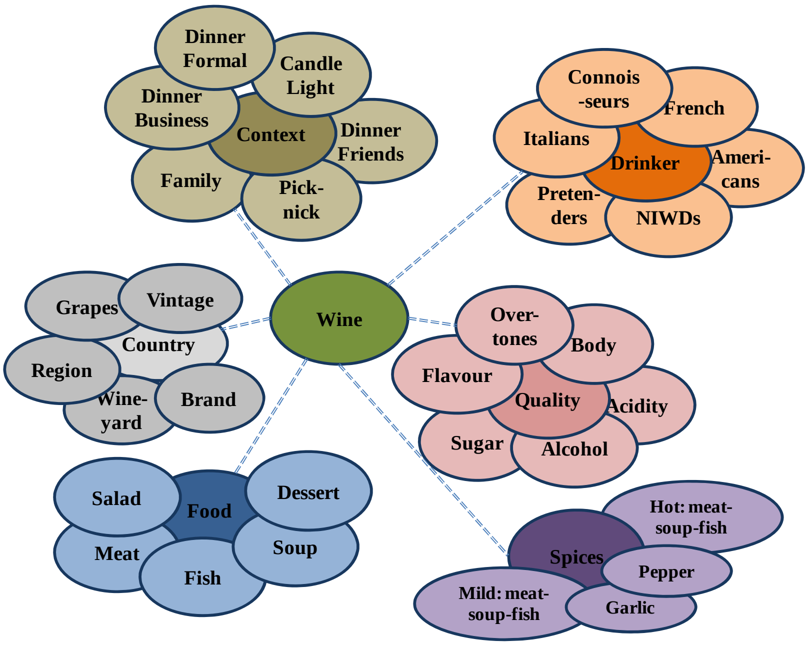

Figure 1: A wine description

Drinker: the tastes in wine are very individualistic and will eventually be fully personalised by the user of the ontology; some rough categories can be identified as a basis for the ontology; *connoisseurs* know the wines and have their well-articulated opinions about most wines (as ontology users they will work out their own preferences; as guests they are challenging to please), *Italians* normally prefer Italian wines (they may develop and calibrate the ontology for the Italian wines; as guests they may accept other wines), *French* mostly prefer French wines (they will develop and calibrate the ontology for the French wines in considerable detail; as guests they will not accept other wines), *Americans* (as ontology users they do not have any opinions, as guest they do not care too much about the origin or quality of the wine), *NIWDs* for "not interested wine drinkers" could not care less what they drink (cannot contribute much to the ontology, as guests they are satisfied if the wine is liquid), *pretenders* have acquired opinions and may know details about some wines (can contribute as ontology users to wines they know about, as guests may be hard to please as they are not sure about what they like or not); the characterisations give here are, of course, loose and general and sometimes a parody, the ontology user needs to work out a personal classification which fits his/her user context.

Food: most recommendations for wine are based on the type of food with which the wines are going to be combined; the recommendations are often given by experts of various kinds who motivate their recommendations with how the acidity, body, flavour, alcohol, etc. mix with the food; typical categories are *salad* ("a light rosé brings our the flavour of the salad"), *meat* ("the typical choice with meat is a red wine; game requires a heavy read wine to bring out the taste; fowl requires a light red wine"), *fish* ("white wine is the only choice with fish as it brings out the lighter flavours of the fish"), *soup* ("soup is a typical starter and should be combined with white wine (if fish is the next course) or a light red wine (if meat is the next course); the idea is to not desensitise the palate for the next wine"), *dessert* ("a sweet dessert requires a contrasting wine; a fruitbased dessert requires a supporting wine") – here individual preferences will decide the eventual choice

Spices: the presence or choice of spices may disqualify all recommendations given so far as they may completely destroy the character of any wine; there are several categories that need to be worked out; *hot spices used with meat, soup or fish* will desensitise the palate and will take away the taste of any lightly flavoured wine offered with the next course; *mild spices used with meat, soup or fish* can be supported with a wine "that appears behind the spices" (whatever that may be, the experts seem to know); *pepper* of different types and in different quantities may take away any sense of taste (a good opportunity to serve the cheapest wine possible); *garlic* may take away any sense of taste at all (a good opportunity to serve water) – again there are (sometimes strange) individual preferences and the ontology needs to be calibrated for individual users

4 Fuzzy ontology, implementation and utilization

As defined by Gruber (1993), "an ontology is an explicit specification of a conceptualization". Since the beginning of the nineties, ontology has become increasingly popular and studied in the field of artificial intelligence (Lee et al 2005; Parry 2006). Let us consider two not necessarily distinct sets, i.e. it may be $X = Y$, where $X = \{x_1, \ldots, x_n\}$ and $Y = \{y_1, \ldots, y_n\}$; X is a set of concepts which need to be described and *Y* is the set of concepts which can be used in order to describe the objects in *X*. Having said this, an ontology can be represented by a relation $R \subseteq X \times Y$ with a characteristic function

$$\chi_R : X \times Y \to \{0,1\}$$

The following semantic can be associated with the characteristic function χ_R

$$\chi_R = \begin{cases} 1, \text{if } x_i \text{ can be well described by } y_j \\ 0, \text{if } x_i \text{ can not be well described by } y_j \end{cases}$$

In other terms, if y_j can be coherently used to describe x_i, then $\chi_R(x_i, y_j) = 1$ and $\chi_R(x_i, y_j) = 0$ otherwise. Let us give a very easy example.

$$\chi_R(shark, fish) = 1 \qquad \chi_R(shark, reptile) = 0$$

Ontology can be represented in several different forms and here we will represent it as a table.

Let us consider the ontology for wines and their characteristics shown in Table 1. In this case we have:

$$X = \{\text{Tommasi Crearo}, \ldots, \text{El Tiempo Rosado}\}$$
$$Y = \{\text{Alcohol\_low}, \ldots, \text{Alcohol\_high}, \text{Price\_low}, \ldots, \text{Food\_beef}\}$$

And the following ontology

	Alcohol			Price				Food		
	low	Med.	high	low	Med.	high	…	Chicken	…	Beef
Tommasi Crearo	0	1	0	0	1	1	…	0	…	1
Trimb Pinot Gris Reserve	0	1	0	0	1	0	…	1	…	0
Morada Aged Tempranillo	0	1	1	0	1	0	…	1	…	1
…	…	…	…	…	…	…	….	…	…	…
El Tiempo Rosado	0	1	0	1	0	0	…	1	…	0

Table 1: Excerpt from a crisp ontology

From Table 1, we can see, that El Tiempo Rosado is a wine with medium alcohol; it is cheap and combines well with chicken. This is rather a poor representation of the knowledge demonstrated in fig.1 which we built with tacit knowledge and imprecision.

In order to come to terms with imprecision, scholars working with fuzzy sets theory (Zadeh 1965), have worked out a definition for a *fuzzy ontology* (Parry 2004; 2006). The wine ontology in Table 1 is totally binary and based on a true-false logic where degrees of truth are not accepted. Indeed, two wines that cost 100€ or 1000€ may both be classified as expensive, but the second is far more expensive than the first which is not taken into account if we use a crisp ontology. A fuzzy ontology can be represented by a relation $R \subseteq X \times Y$ with an associated *membership* function,

$$\mu_R : X \times Y \to [0,1]$$

Here the value $\mu_R(x_i, y_j)$ is an estimate of the *degree to which* x_i and y_j are related. In our case the semantic underlying the relation is *to which extent* y_j is capable of describing x_i (cf. Table 2).

	Alcohol			Price				Food		
	low	Med.	high	low	Med.	high	…	Chicken	…	Beef
Tommasi Crearo	0	0.80	0.25	0	0.48	0.38	…	0.54	…	0.42
Trimb Pinot Gris Reserve	0	0.80	0.25	0	0.60	0.29	…	0.90	…	0.08
Morada Aged Tempranillo	0	0.60	0.50	0	0.60	0.29	…	0.67	…	0.50
…	…	…	…	…	…	…	….	…	…	…
El Tiempo Rosado	0.40	0.60	0	1	0	0	…	0.67	…	0.10

Table 2: Excerpt from a fuzzy ontology

Table 2 shows that a fuzzy ontology is more informative than a crisp one. We can see that both Morada Aged Tempranillo and Trinb Pinot Gris Reserve combine well with chicken and that Trinb Pinot Gris Reserve is the wine that goes best with chicken.

Formally, a fuzzy ontologycan be seen as an enhanced crisp ontology. In fact, the range of values in the real interval allows us to express the degree of relationship between elements of the two sets, whereas a crisp ontology is a binary representation of a relation and does not allow degrees of relationship.

Values of the relation can be estimated in several different ways.

An expert or a pool of experts can *subjectively* evaluate the entries of the ontology. Hence, values of the relation between pairs are the values given by some *sommeliers* based on their expert opinions. The case with one single decision maker is clearly easy but also the case with a greater number of experts can be handled relatively easy (Carlsson et al 1992).

We can map numerical values into the unit interval and use this approach whenever a concept can be expressed with a numerical scale. For the wine example, concepts such as price, alcohol and acidity can be evaluated with a numerical scale; for the price, a solution could be to map the maximum and the minimum possible prices to 1 and 0 respectively and the values in between to the interval]0,1[by using a properly chosen, monotonically increasing function.

By means of *rules* we can infer some missing values from some known values. This approach allows us to estimate unknown entries by means of known entries; it would be reasonable to assume that how strongly a wine is recommended to a person who does not really care about what he/she drinks, could depend on the price. It is reasonable to argue that we would not be willing to pay much for something we cannot really appreciate. In the same manner, as we know some rules we can infer the value of a relation between a wine and our choice of food starting from the properties of the wine and the usual rules for combining the choice of food and wine. More formally we can build a rule based system in the form:

if x is A and if y is B, then z is C.

5 Selecting a Proper Wine

Once our ontology is complete, it is possible to query it in order to find the most suitable wine for a given context. Logic allows us to form a query using the three operators of *conjunction*, *disjunction* and *complement* denoted as $\wedge$, $\vee$ and $\neg$, respectively.

Conjunction, disjunction and complement can be interpreted as “and”, “or” and “not” in semantic expressions. Furthermore, the first two are binary operators in the sense that they operate on pairs of arguments.

Let *a* and *b* be real numbers in the unit interval, then conjunction is defined as

$$a \wedge b = \min\{a, b\},$$

Similarly, disjunction is

$$a \vee b = \max\{a, b\}$$

Conversely, a complement is a unary operator

$$\neg a = 1 - a$$

Let us now work out an example of a query for a fuzzy ontology. Suppose that we are looking for a wine of medium alcohol level *and* such that it is good with chicken *or* pork. Our quest can be translated into the following query

$$q = alcohol\_medium \wedge (food\_chicken \vee food\_pork)$$

If we use the fuzzy ontology in Table 2, we get the following results

$$q(\text{Tommasi Crearo}) = \min\{0.8, \max\{0.54, 0.42\}\} = 0.54$$
$$q(\text{Trimb Pinot Gris Reserve}) = \min\{0.8, \max\{0.9, 0.08\}\} = 0.8$$
$$q(\text{Morada Aged Tempranillo}) = \min\{0.6, \max\{0.67, 0.50\}\} = 0.6$$
$$q(\text{El Tiempo Rosado}) = \min\{0.6, \max\{0.67, 0.10\}\} = 0.6$$

We can then see that, the wine which best fits our query is Trimb Pinot Gris Reserve.

Nevertheless, we can develop the method and replace the three logical operators used so far with some more general ones. In other words, instead of focusing on their forms, we will try to see what properties must be satisfied in order for them to be considered consistent (Klir and Yuan 1995). Nowadays, it is possible to find some standard definitions for fuzzy intersection, fuzzy union and fuzzy complement. Let us briefly recall them without discussing the details.

A *fuzzy intersection (t-norm) i* is a binary operation on the unit interval that satisfies at least the following axioms for all $a, b, d \in [0,1]$: (i) $i(a,1) = a$ (boundary condition); (ii) $b \leq d$ implies $i(a,b) \leq i(a,d)$ (monotonicity); (iii) $i(a,b) = i(b,a)$ (commutativity); (iv) $i(a, i(b,d)) = i(i(a,b),d)$ (associativity); a possibilistic product is a t-norm: *ab*

A *fuzzy union (t-conorm) u* is a binary operation on the unit interval that satisfies at least the following axioms for all $a, b, d \in [0,1]$: (i) $u(a,0) = a$ (boundary condition); (ii) $b \leq d$ implies $u(a,b) \leq u(a,d)$ (monotonicity); (iii) $u(a,b) = u(b,a)$ (commutativity); (iv) $u(a, u(b,d)) = u(u(a,b),d)$ (associativity); a possibilistic sum is a t-conorm: $a + b - ab$.

Given a membership value, its *fuzzy complement* is a function $c:[0,1] \rightarrow [0,1]$ which has to satisfy at the axioms of bounded condition and monotonicity.

It can be seen that the logical operators of conjunction, disjunction and complement are special cases of the three fuzzy operators, cf. Table 3.

Family	***Special case***
t-norms, *i*	conjunction, $\wedge$
t-conorms, *u*	disjunction, $\vee$
fuzzy complements, *c*	complement, $\neg$

Table 1

Having said this, using the fuzzy operators in the place of the classical operators, we can reformulate our query as it follows

$$\tilde{q} = i(alcohol\_medium, u(food\_chicken, food\_pork))$$

Using the possibilistic sum and the product we get to the following results

$$\tilde{q}(\text{Tommasi Crearo}) = 0.8 \cdot (0.54 + 0.42 - 0.54 \cdot 0.42) = 0.58656$$
$$\tilde{q}(\text{Trimb Pinot Gris Reserve}) = 0.8 \cdot (0.9 + 0.08 - 0.9 \cdot 0.08) = 0.7264$$
$$\tilde{q}(\text{Morada Aged Tempranillo}) = 0.6 \cdot (0.67 + 0.50 - 0.67 \cdot 0.50) = 0.501$$
$$\tilde{q}(\text{El Tiempo Rosado}) = 0.6 \cdot (0.67 + 0.10 - 0.67 + 0.10) = 0.4218$$

This shows that the wine that best satisfies the query is still Trimb Pinot Gris Reserve. However, we should note that the ranking of the wines is different compared to the ranking we obtained by querying the fuzzy ontology with ordinary logical operators.

Let us note that a logic formulation is not the only way we can make use of an ontology. Formulating a query requires that we are able to use logical connectors such as *and*, *or* and *not*. This is not always possible. Nevertheless, in all these cases we can use some other tools as aggregating functions (Beliakov et al. 2007). We have tried out the OWA operators (Yager 1988, Yager and Filev 1999) and approximate reasoning (or AR-) schemes (Zadeh 1979; Carlsson and Fuller 2002; Takagi and Sugeno 1985). There are doubtless a few more methods that can be used “to put the ontology in action” to which we will return in the next paper.

Let us conclude this section with a sample of a fuzzy ontology of almost forty wines. In the following Table 4 we have summarized the relevant values for our query: “a wine that goes well with game *or* pork *and* suits a dinner with friends who are wine connoisseurs”. The final score obtained by each wine is reported in the last column, Q.

	Game	Pork	Friends	Connoisseurs	Q
Domaine Depeyre	0.75	1.00	0.59	0.11	0.07
Morada Real Barrel Aged Tempranillo	0.38	0.50	0.20	1.00	0.14
Lambrusco Grasparossa di Castelvetro	0.50	0.33	0.32	0.15	0.03
Pasqua Bardolino Classico	0.32	0.33	0.41	0.11	0.02
La Buxynoise Bourgogne Réserve Pinot Noir	0.46	0.42	0.31	0.18	0.04
Marsannay Clos de Jeu	0.53	0.42	0.10	1.00	0.07
Castillo Murviedro	0.31	0.42	0.50	0.08	0.02
Il Papavero Rosso	0.39	0.33	0.39	0.11	0.03
Montecillo Crianza	0.25	0.33	0.40	0.19	0.04
Tommasi Crearo	0.56	0.75	0.10	0.38	0.03
Rosé Chantal	0.00	0.00	0.00	1.00	0.00
Terres de Berne	0.13	0.17	0.40	0.18	0.02
Gabbiano Rosé	0.00	0.00	0.25	0.01	0.00
Château d'Aquéria Tavel	0.22	0.25	0.43	0.02	0.00
El Tiempo Rosado	0.07	0.00	0.40	0.07	0.00
René Barbier Rosado	0.11	0.00	0.35	0.10	0.00
Rémy Pannier Rosé d'Anjou	0.25	0.00	0.13	0.06	0.00

Torres Viña Esmeralda	0.04	0.00	0.36	0.16	0.00
Le Cardinal Cristal	0.25	0.00	0.33	0.12	0.01
Corallo Grillo	0.00	0.00	0.00	0.80	0.00
Passito di Pantelleria	0.50	0.33	0.52	0.00	0.00
Sancerre La Chatellenie	0.07	0.00	0.10	0.27	0.00
Trimbach Pinot Gris Réserve	0.06	0.08	0.10	0.29	0.00
La Capannuccia Vin Santo	0.39	0.33	0.40	0.35	0.08
Nicolas Potel Auxey-Duresses	0.31	0.08	0.10	0.79	0.03
Príncipe de Viana Chardonnay	0.04	0.00	0.32	0.00	0.00
Petit Bourgeois Sauvignon	0.25	0.00	0.31	0.01	0.00
La Luciana Gavi	0.00	0.00	0.32	0.02	0.00
Torres Gran Viña Sol	0.13	0.17	0.51	0.02	0.00
Pascal Jolivet Sancerre Blanc	0.11	0.00	0.00	0.56	0.00
teroldego rotaliano riserva	0.56	0.75	0.31	0.00	0.00
Pieropan Soave Classico La Rocca	0.56	0.75	0.10	1.00	0.09
Coste Rubin Barbaresco	0.79	0.92	0.30	1.00	0.29
Valdifalco Morellino di Scansano	1.00	1.00	0.40	0.09	0.04
Talenti Rosso di Montalcino	0.83	0.92	0.30	0.51	0.15
Terre di Ginestra Nero d'Avola	0.94	0.92	0.48	0.07	0.03
Villa Canlungo Pinot Grigio	0.11	0.00	0.19	0.00	0.00
Lahn Sauvignon	0.31	0.08	0.20	0.14	0.01
Pieropan La Rocca Soave Classico	0.31	0.08	0.10	1.00	0.04
i sistri	0.19	0.25	0.30	0.47	0.06

Table 4

The score Q is the beginning of being a wine connoisseur. It is worth noting that a simple but effective fuzzy ontology can easily be implemented with the help of a spreadsheet; this implementation works on a mobile phone with a standard user interface.

6 Summary and Conclusions

A need to find alternatives to the knowledge management theory and technology has gradually emerged during the last few years. There are both technical reasons - the technology is not flexible enough to cope with the quick changes of a dynamical knowledge environment and knowledge will become incomplete and obsolete - and more fundamental reasons - knowledge workers resent sharing their advanced and useful knowledge with co-workers who are not as skilful as they are or are not willing to work as hard to get to the same skill level.

In the digital economy we will be more and more dependent on the availability of good up-to-date knowledge which should be available anywhere and anytime at a reasonable cost as the economic processes move fast when they build on digital products and services. In this paper we showed that we can build a fuzzy ontology framework as a basis for knowledge mobilisation, and we showed that we can get systematic answers to queries with standard methods building on fuzzy sets and fuzzy logic.

Knowledge mobilisation carries a goal "to make knowledge available for real-time use in a form which is adapted to the context of use and to the needs and cognitive profile of the user". This is one of the classical visions of an efficient use of knowledge which we intend to turn into actual use. Modern smart phones carry context information in several forms of applications and in some cases user interfaces will represent the cognitive profiles of the users. Thus it is not a long mental jump to give knowledge mobilisation some hype as "knowledge on the mobile phone".

The actual knowledge mobilisation technology is being developed for some industrial applications but as these are still confidential we cannot show the constructs. Instead we use the approach to show how amateur wine drinkers can become wine connoisseurs with the support of the knowledge mobilisation methods.

The next steps will show that the fuzzy ontology – and the fuzzy description logic at its core - can be enhanced with the introduction of approximate reasoning schemes to work with real world data and observations. This will offer a good way to build a connection to the semantic web standards and actually getting the knowledge mobilisation methods to work as part of the semantic web as one of the fuzzy description logics is already part of the standard. Along this line there will be a further possibility to make knowledge available through so-called smart phones which is the actual goal we have with knowledge mobilisation.

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