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SEMANTICALLY ENRICHING THE KNOWLEDGE PAYLOAD OF KNOWLEDGE OBJECTS THROUGH THE UTILIZATION OF KNOWLEDGE OBJECT WRAPPERS

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ABSTRACT

Aim/Purpose	In this research the authors present the designs of three different knowledge object meta-data wrapper models as a supportive technology to assist the knowledge intensive operations of a network of knowledge, such as a living lab.
Background	Within any knowledge driven network environment there is a need to increase the corporate knowledge capacity of the network. The role of experts and knowledge brokers are emphasized, and the exchange of knowledge based on prior experiences informing corporate memories of the members, is the departure point of this research.
Methodology	The primary research method applied is that of the design science research methodology supported by experience and application research and the literature.
Contribution	Three different metadata models are presented that will when implemented support the informing process within the network of knowledge.
	The models are grounded on the utilization of metadata elements composing of various key descriptors as found in activity theory and normal means of heuristic enquiry which entail common questions. The elements are annotated and further enriched using standard JSON-LD IRI pairs. The presented models expand on the extant knowledge of the use of metadata annotations and present a novel way in encapsulating the corporate memories of knowledge workers in the form of knowledge object wrappers.
Findings	The results of the evaluation process of the design science research methodology applied, showed that there is a consensus that the use of knowledge object

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wrappers as additional metadata, containers could enhance the knowledge capacity and efficiency of a LL and in particular the knowledge brokers.

Keywords JSON, JSON-LD, knowledge objects, network of knowledge, knowledge object wrappers

INTRODUCTION

The value and efforts of corporate memory retention through the application of innovative knowledge management practices within knowledge driven networked organizations, such as living labs (LLs) are recognized in the literature (Burch et al., 2018; Cooper & Gorman, 2018; Mercier-Laurent, 2016).

In essence, a living lab (LL) is a collaborative innovation eco-space that enables and supports information infrastructure development, refinement, and adoption (Lucassen et al., 2014). Information infrastructure development could entail the development and management of digital artefacts to support the entrepreneurial operations of the LL for different digital platforms and support services (Le Dinh et al., 2018).

The most basic definition of the concept 'corporate memory' describes corporate memory as "the body of information that an organization needs to keep for re-use" (Megill, 2005). It relates to the entire body of knowledge that the organization requires to deliver its strategic aims and objectives (Khilwani & Harding, 2016). According to Kühn and Abecker (1998), "A Corporate or Organizational Memory can be characterized as a comprehensive computer system which captures a company's accumulated know-how and other knowledge assets and makes them available to enhance the efficiency and effectiveness of knowledge-intensive work processes."

Knowledge objects (KOs) are used to describe knowledge assets (Kutsikos & Mentzas, 2012). KOs are most frequently used within an organizational environment (Grover & Davenport, 2001), that also comprises of users such as a LL. Becker et al., (2016) explain that the learning community and the users "have to externalize their tacit needs, requirements, assets, knowledge, information, and experiences into explicit digital content and knowledge objects."

In this paper the conceptual designs of different types of metadata wrappers (or knowledge object wrappers KOWs) are presented to be used in conjunction with KOs to assist with the knowledge intensive requirements of a network of knowledge (NoK) such as a LL.

Also discussed is how KOs and KOWs could be used as the raw or semi-raw 'material' in a NoK, for the 'capturing', informing, management, and transfer of the tacit knowledge and the corporate memories of the various LL members, through annotations and semantic integration.

RESEARCH AIMS

Knowledge is the 'fuel' on which LLs function and operate (Bergvall-Kareborn & Stahlbrost, 2009). Knowledge and knowledge generation in LL environments are the driving engine for innovation and value chain optimization (Dekkers, 2011). Within LL environments it is imperative to consider and harness all the corporate memories of the stakeholder. The process of generating knowledge in a LL environment may take on many forms, such as knowledge generation as part of a NoK. To attain a sufficient level of knowledge support, a common understanding of the knowledge seekers' information needs is required, leading to establishing relevant, effective, and appropriate tools with usable content. This requires the interrogation of various sources of information to facilitate learning and empowerment though the interaction of various stakeholders (Mngomezulu-Dube et al., 2018).

Learning objects and knowledge objects have been described as ideal mechanisms to support information dissemination and learning in a NoK (Sychov & Chirtsov, 2018).

Bearing the above in mind, this research aims to:

- present the conceptual designs for three knowledge object wrapper (KOW) meta-data models, which could be used to describe and annotate the various knowledge objects used within a NoK such as a LL; and
- describe how KOs and KOWs are used as the raw or semi-raw 'material' in a LL enabled NoK, for the 'capturing', management and transfer of the tacit knowledge and the corporate memories of the various LL members, through annotations and semantic integration.

LITERATURE REVIEW

In this section the contents of the core literature pertaining to the conceptual aspects that underpins this study is illuminated by means of a literature review. The literature review covers the concepts of a network of knowledge, knowledge objects and semantic annotation using JSON-LD.

NETWORK OF KNOWLEDGE AND COMMUNITY OF PRACTICE

Communities of practice are groups of people who share a concern or a passion for something they do and learn how to do better, as they interact regularly with one another (Wenger, 2011). A community of practice (CoP) often contains an intrinsic network of knowledge (NoK) (Nousala & Hall, 2008) and a NoK requires an integrated and active CoP for support (Nesshöver et al., 2016). Expanding on the relationship and difference between a CoP and a NoK, Hustad and Bechina (2012) explain that a NoK is a more focused type of CoP, with a stronger focus on a proactive knowledge management strategy. A NoK could also be a smaller constituent of a CoP, where the NoK has the responsibility to foster knowledge sharing within the CoP by providing mechanisms and functions to better leverage information and knowledge support by optimizing existing knowledge management practices (Sedighi & Zand, 2012).

The concept of 'knowledge in action' CoPs was presented by Lesser and Prusak (1999) when they explained that the word 'practice' as part of a CoP entails knowledge in action, due to the knowledge and know-how that each individual uses in performing their respective duties. In addition, knowledge in action CoPs also support the consideration that the dynamic interaction amongst the members also impacts the overall larger value chain of which the community is part (Lowitt et al., 2015).

Knowledge systems could also comprise of networks of linked actors, organizations, and objects that perform several knowledge-related functions (McCullough & Matson, 2016). These authors further explain that the various functions enable the network to link knowledge and know-how with action (including research, innovation, development, demonstration, deployment and adoption).

Figure 1 presents the common layered composition of a LL NoK comprising of various users, such as knowledge workers and other experts provisioned with various LL cloud-based services and tools. Of importance to this study is the LL knowledge base that consists of various repositories such as a knowledge object repository (KOR) and the knowledge object wrapper repository (KOWR).

The KOR contains meta-data descriptions of KOs applicable to the current LL domain, whilst the domain ontology repository (DOR) provides links and references semantic knowledge from external domains. The authors propagate the notion that DKOs may take on different forms and that Web 2.0 sources, such as YouTube and Facebook postings, are ideally suited for the purpose of inherent knowledge sharing as well. This could be described in conjunction with the application of tools and services such as the Zotero API and the Facebook platform.

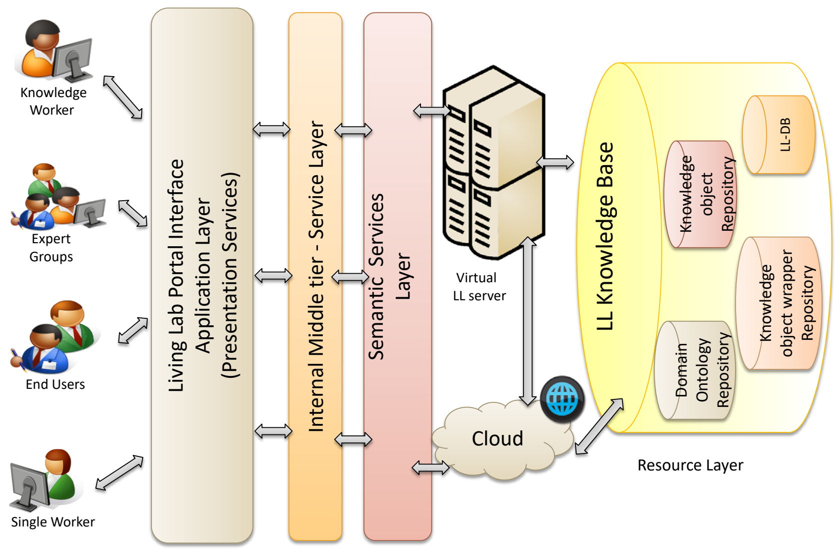


Figure 1. LL as a network of knowledge

From the above definitions and descriptions as depicted in Figure 1, it is evident that every participant of the NoK, portrays a role and that the individual actions of each participant could lead to knowledge sharing and learning within the community. Various tools and services (such as a question and answer service and a knowledge brokerage service) enable the knowledge driven operations of the LL including that of knowledge support.

Knowledge Objects

The knowledge object (KO) concept is not new. KO is defined as being "a highly structured interrelated set of data, information, knowledge, and wisdom concerning some organizational, management or leadership situation, which provides a viable approach for dealing with the situation" (Bellinger, 2004). Some scholars regard a learning object (LO) which is defined by Wiley (2000), as "as any digital resource that can be reused to support learning which has been intentionally designed to support learning" and a knowledge object (KO) to be equivalent (Merrill, 1999; Paquette & Rosca, 2002). In contrasting various concepts relating to LO and KO, McGreal (2004) highlighted the fact that a KO is sometimes regarded as a component of a LO.

A knowledge object (KO) is described by a simple knowledge ontology, such as inner metadata tags or elements of the sharable content reference model (SCORM) which is written to the knowledge repository or knowledge base of the LL. The repository inter alia stores meta-data (using KOWs) of stored artefacts in an external knowledge base. In applicable instances meta-data are generated using the METS schema, which is a standard for encoding descriptive, administrative and structural metadata (*METS: An Overview & Tutorial*, 2013). Additional web sources are also gathered with semantic processes from the Web itself. This may include links to other Web 2.0 sites and the extraction of other possible and potential KO meta-data. The semantic extrapolation process generates tags which are compared with existing meta-data, using semantic pattern clustering in the semantic knowledge repository, which matches existing classes, relations, axioms, functions and instances of prior searches and results.

As far as knowledge objectives are concerned in this research, the focus is on digital knowledge objects semantically described by knowledge object wrappers. A digital knowledge object (DKO) is described as an instrument for the contextualization and re-contextualization of knowledge in order to facilitate the provision of advice and to aid in the learning processes of a computer or an individual (Flynn et al., 2016).

Figure 2 shows the authors' diagrammatic conceptualization of a most basic form of a DKO based on the work of Flynn et al. (2016). Throughout the rest of this paper, a DKO and a KO are considered as synonyms and the concepts are used interchangeably.

Figure 2 depicts the concept that a DKO contains at least one asset, referred to by Flynn et al. (2016) as the knowledge core or payload, which could take on different forms (such as digital content, notes, and other LO related artefacts) and an optional basic meta-data layer describing the object or knowledge asset. Some digital assets could include meta-data by default, such as YouTube videos (Rangaswamy et al., 2016) and pdf documents (Xu et al., 2016). It may also take on the form of a SCORM manifest file if the KO is in the form of a SCO where the manifest file is described by XML meta-data (*SCORM solved and explained*, 2018). In certain cases, the digital resource or asset could also have an existing Dublin Core (DC) meta-data record, either embedded within the digital asset itself or contained as a separate record entry stored elsewhere (DublinCore.org, 2012).

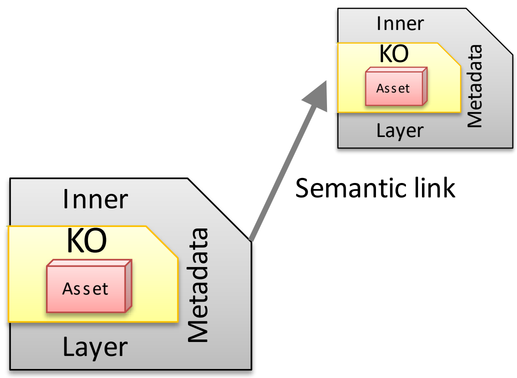


Figure 2. DKO in its most elementary form

In the context of this research, important considerations in the light of the above definition of a digital knowledge object (DKO) by Flynn et al. (2016) relate to the idea that the knowledge payload of the DKO could refer to any digital knowledge object, which is described in part by a meta-data wrapper. The main purpose of a KO is regarded as being to allow the holder of the KO to gain more knowledge or to be provided with new insights and to know better (Hsu et al., 2007). According to Bedford (2012), one of the most important KOs in any organization consists of the persons or people involved in the organization's business. This author stresses that people's 'personal knowledge' is the predominant asset for all organizations in the new millennium.

The notions of Woźniakowski et al. (2014) and of Flynn et al. (2016), that LOs or KOs could either be linked by a common relationship or by some kind of meta-data ontology scheme are also important for this study. Interlinking various KOs with one another and that to a user or case, would create the opportunity for discovering new patterns and trends.

JSON-LD

JSON (JavaScript Object Notation) is a lightweight data-interchange format which humans can read and write, and machines can easily parse and generate (*Introducing JSON*, n.d.). JSON is often used as a technology to describe digital content and knowledge such as metadata wrappers in knowledge intensive environments and systems (Lanthaler & Gütl, 2012; Sporny et al., 2014).

Linked Data (JSON-LD) is an initiative which utilizes JSON to provide linked data capabilities. JSON-LD is easy to interpret by both humans and machines and it provides a way to help JSON data interoperate at Web-scale (Sporny et al., 2014).

JSON-LD differs from JSON as JSON-LD also provides:

- a universal identifier mechanism for JSON objects via the use of IRIs;

- a way to disambiguate keys shared among different JSON documents by mapping them to IRIs via a context;
- a mechanism in which a value in a JSON object may refer to a JSON object on a different site on the Web;
- the ability to annotate strings with their language;
- a way to associate data types with values such as dates and times; and
- a facility to express one or more directed graphs, such as a social network, in a single document. (Sporny et al., 2014)

Currently, the JSON-LD 1.1 enhancements and specifications are being standardized and drafted, (see https://www.w3.org/TR/json-ld11/). In addition, JSON-LD is based on an entity-centric approach where traditional Semantic Technologies are based on a triple centric approach (Lanthaler & Gütl, 2012). According to Steiner and Mirea (2012) "JSON-LD is a format for expressing directed graphs, mixing both Linked Data and non-Linked Data in a single document. JSON-LD allows for adding meaning by simply including or referencing a so-called (data) context." It is added that JSON-LD objects can easily be encoded and transformed into RDF graphs, which in turn could be encoded as plain JavaScript objects with an additional nested object that contains the mapping from keys as well as values to RDF properties, URIs and literals (Garrote & García, 2011; Steiner & Mirea, 2012).

The utilization of the JSON-LD notation with standard nested references to vocabularies is suggested by the researchers in order to provide semantic concepts for standard items used as part of the knowledge object wrapper model as presented later.

As part of the example JSON-LD document, the keywords @context and @id provide the basic functionality of JSON-LD, where the @context is used to map terms to an internationalized resource identifier (IRI) and the @id is used to uniquely identify the node objects labeled in the document with IRIs (Sporny et al., 2014).

Various IRIs could be used, including the following:

- Dublin core meta-data initiative that represents a set of vocabulary terms which could be used to describe digital resources. (See http://purl.org/dc/terms/).
- Friend of a friend vocabulary for linking people and information. (See-http://xmlns.com/foaf/0.1/).
- GeoJSON, vocabulary set relating to geographical and spatial information. (See https://purl.org/geojson/vocab#).
- Provenance vocabulary set, that represents "information about entities, activities, and people involved in producing a piece of data or thing, which can be used to form assessments about its quality, reliability or trustworthiness" (https://www.w3.org/TR/2013/NOTE-prov-overview-20130430/). (See http://www.w3.org/ns/prov#).
- Very popular and widely used schema vocabulary (in the form of different schemas) for structured meta-data representation and encoding for various web-based sources. (See http://schema.org/).
- Simple Knowledge Organization System vocabulary and data model for sharing and linking knowledge organization systems (See http://www.w3.org/2004/02/skos/core#).
- XML schema vocabulary describing various XML schemas and their composition (See http://www.w3.org/2001/XMLSchema#).

Figure 3 provides an example of a listing of a JSON-LD document (rendered at http://json-ld.org/playground/) which could be used to represent a partial representation of the user entity as presented as part of the Knowledge Object class model.

```
{
  "@context": {
    "name": "http://xmlns.com/foaf/0.1/name",
    "homepage": {
      "@id": "http://xmlns.com/foaf/0.1/homepage",
      "@type": "@id"
    }
  },
  "@id": "http://www.facebook.com/EdwardBaloy",
  "@type": "http://xmlns.com/foaf/0.1/Person",
  "name": "Edward Baloy",
  "http://xmlns.com/foaf/0.1/title": [{
    "@language": "en",
    "@value": "Dipl.Agric-Sci."
  }, {
    "@language": "en",
    "@value": "BSc"
  }],
  "http://xmlns.com/foaf/0.1/workplaceHomepage": {
    "@id": "http://www.agrisa.co.za/"
  }
}
```


Figure 3. Example JSON-LD document describing a user

METHODOLOGY

The main research strategy followed in this study is that of design and creation research. A design and creation research strategy focuses on developing new IT related artefacts which could include models that "represent a situation and are used to aid problem understanding and solution development" (Oates, 2005, p. 108).

Figure 4 shows the design science research methodology (DSRM) process model as developed by Peffers et al. (2007) and used in this study. The process model comprises of a set of six distinct activities, which are represented as the rectangles in Figure 4. In the figure the entry point of this particular study is indicated, as well as the use of the experience and application research method (see ISTAG EAR report, 2004) deployed to assist in defining the objectives of the solution and as part of the design thereof. The applicable solution or artefact designed as part of this study is that of the different sets of KOWs used to semantically describe and enrich the direct and indirect knowledge payload of a KO. As shown in Figure 4, each of the activities presents a clear and concise set of guidelines and activities on which a DSR study could be based. Sandkuhl and Fellmann (2017) point out that as presented by Peffers et al. (2007), the model "provide[s] a procedural reference model to guide DSR research processes and a vocabulary to communicate the research entry point and phases."

With the first activity of the DSRM process model having been dealt with above, the focus now falls on applying activities two to five of the DSRM process model in this study, as illustrated in Figure 4. This discussion entails respectively defining the solution objectives; the design and development of the KOW metadata models; KOWs as a metadata illustration using JSON-LD; and an evaluation of the various KOW artefacts. This is followed by wrapping up and making a case for KOWs before dealing with its communication, the sixth activity of the DSRM process model.

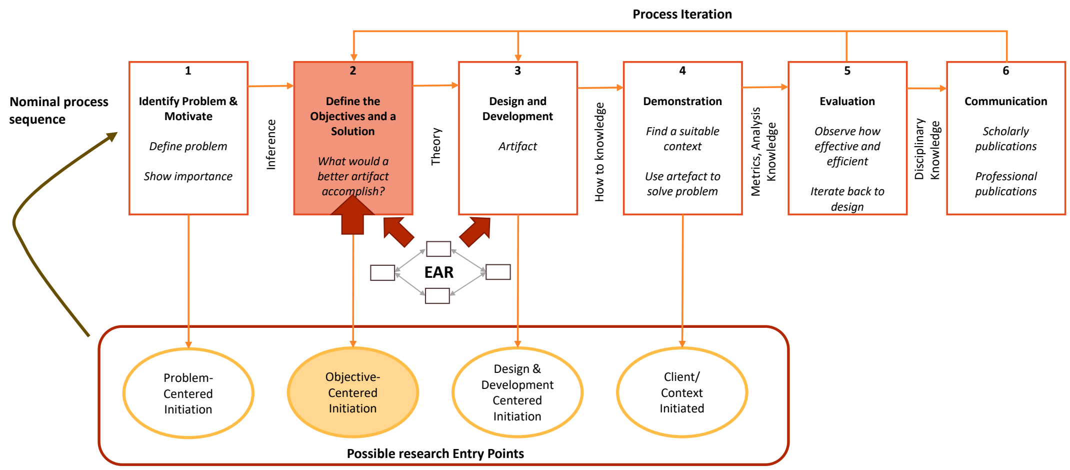


Figure 4. DSRM process model (Peffers et al., 2007)

Defining the Solution Objectives

As highlighted in Figure 4, the entry point of this research is dealing with an objective-centered solution (activity 2). As noted in the introduction the main objectives of this research are as follows:

- To present a conceptual design for a knowledge object wrapper (KOW) meta-data model which could be used to describe and annotate the various knowledge objects used within the LL environment.
- To describe how KOs and KOWs are used as the raw or semi-raw 'material' within a LL (as a NoK supported by various tools and services), for the 'capturing', management and transfer of the tacit knowledge and the corporate memories of the various LL members, through JSON-LD annotations and semantic integration.

The attainment of the objectives allows answering the following research question:

> *How can a KOW be modeled to incorporate the use of metadata tags annotated with JSON-LD to assist the knowledge workers with their knowledge support and knowledge related operations?*

The main proposition in this research is that question-and-answer pairs could be used as metadata elements constituting the design and composition of a KOW.

None of the scholars whose research was studied propagate or suggest the implicit use of questions as part of the meta-data schema from which the KOW could be constructed (Alshawi et al., 2006; Bannan-Ritland et al., 2002; Flynn et al., 2016; Seo et al., 2001). The use of questions and the linking of answers to extension source documents are suggested by Sanga, et al. (2016), but no details are given of how these questions are linked to the knowledge sources.

For the researchers, the idea to use questions as meta-data tags held a promise to address the question of how the tacit knowledge of a knowledge worker could be to some degree encapsulated. The use of questions has a two-folded impact: firstly for the reader of the questions and the subsequent answers linked to it, as well as for the knowledge worker who has to present some form of interpretation through internalization (or as part of the process for capturing of the relevant descriptions based on questions). KOs as accelerated epistemic objects (Zwick & Dholakia, 2006) have the potential to raise particular questions by embedding or describing knowledge therein, for which answers could be found and knowledge be generated (Ewenstein & Whyte, 2009). In other words, the knowledge worker needs to apply his or her cognitive ability in the creation (completion of the annotation) of the KOW entry, and as part of interpreting a KOW of an existing digital asset or KO. The application of the cognitive ability in thinking about how a particular KO is used and how it materialized in the experiences of its user and creator, relates to the concept of 'agential realism', where knowledge is regarded as someone's view and experiences (Barad, 1996). Agential realism has the potential to address and limit the tacit knowledge gap in traditional knowledge systems. Holford and Hadaya (2017) explain that agential realism could be accomplished, "by creating an opportunity for individuals (or groups) who possess and act out embodied tacit knowledge to continue to do so in the presence of communication and information technology, which in turn, act as enhancers of tacit knowledge creation and sharing within the groups or individuals in question."

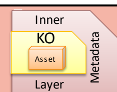
Design and Development of the KOW Metadata Models

The design and development of the KOW metadata models (as the artefacts) of this research (activity 3 in Figure 4) entailed two different sub activities. In the first sub activity the design requirements of the KOW are given attention which is followed by the second sub activity, the actual designs of the proposed models.

Presenting the design requirements of a KOW

The design requirements for a KOW to be used within a LL environment as part of the knowledge service provisions and tools are set out in the Table 1. One of the main objectives of a KOW is to allow for the encapsulation of knowledge related meta-data that will assist the knowledge workers and services, with processes to identify appropriate knowledge sources and to establish possible knowledge and other resource linkages.

Table 1. Design requirements of a KOW

KOW design requirement Code and description 	Explanation / Clarification
KOWDR1 KO should reference an asset	A KO should reference at least one KO, LO or sharable content object (SCO).
KOWDR2 A KOW should allow one KO to link or reference 0 to M other KOs	Multiple KOWs should be able to link to other KOWs.
KOWDR3 Single KO would have multiple KOW from single or multiple users	A KO could have more than one associated KOW annotated by one or more users.
KOWDR4 The included meta-data should reference existing schemas and vocabularies	For semantic interoperability and discovery, a KOW should comprise of meta-data data elements that also reference existing semantic vocabularies and schemas such as resource description frameworks (RDF)s.
KOWDR5 KOW should reference case, use and experience related meta-data	The case and associated question and other experience related metadata, such as the value and the applicability of the KO towards the solving of the problem or towards the provisioning of an answer, should be stored. Experience meta-data in the form of ratings/endorsements and the applicability of the KO should also be stored.
KOWDR6 KOW should encapsulate existing knowledge taxonomies tied to questions	Meta-data to tie and connect data elements to existing ontologies and schemas should also be included. This for example, includes meta-data in relation to the persons, products, events, things and other schema objects.
KOWDR7 Data interchange should be presented in JSON and/or JSON-LD format	In order to submit structured KOW meta-data between various services, JSON or JSON-LD should be supported.
KOWDR8 KOW should be managed separately from the KO and referenced data sources	KOW wrapper meta-data should be managed separately to avoid duplication of SCO and other KO resources and ease retrieval and the management thereof.
KOWDR9 KOWs should be stored in their own LL Knowledge base (repository)	The descriptions and relational meta-data of the various KOWs should be stored and managed in a separate knowledge base.

The designs of the KOW meta-data models or layers

Attaining the first research objective is the focus of this subsection, namely, "To present a conceptual design for a knowledge object wrapper (KOW) meta-data model which could be used to describe and annotate the various knowledge objects used within the LL environment". This is discussed under the headings relating to three concepts and design propositions, namely the -

- knowledge case meta-data layer;
- question and answer view meta-data layers; and
- KCML-KOW Domain class diagram and code illustration.

With reference to Figure 2, a DKO is depicted in its most elementary form. The next two subsections suggest the inclusion and design of two additional layers of meta-data elements annotated and presented in the form of KOWs. The first suggested layer is discussed next, followed by another set of meta-data layers (referred to as the question and answer view meta-data layers) where the knowledge worker has the option to use either one, both, or none of the second layer alternatives. Each of the layers described below could be regarded as optional additional meta-data wrappers tightly coupled to a KO reference or instance. These discussions are followed by discussions regarding the KCML domain class and an illustration of how KOWs could be semantically described and enriched using JSON-LD.

The knowledge case meta-data layer

One way in which the use of an existing KO or group of related KOs could be significantly enhanced is through the inclusion of meta-data relating to the case (that is the 'use' case) to which and for which the KO is tied and or associated. The following basic class diagram (Figure 5) depicts the researchers' conceptual suggestion for a meta-data layer (in the form of a wrapper) that, from a knowledge worker activity perspective, contains some descriptive meta-data.

As illustrated in Figure 5, the meta-data are related to some of the main applicable classes and the basic association between one another. The *Subject* (for example the knowledge worker) is assigned to a particular *Case* for the provisioning of one or another knowledge support *Service*. Service provision is based on a *Request* and a request is grounded in a *Question*. The *Subject* (that is the knowledge worker interacts with the *Object* (namely the knowledge seeker).

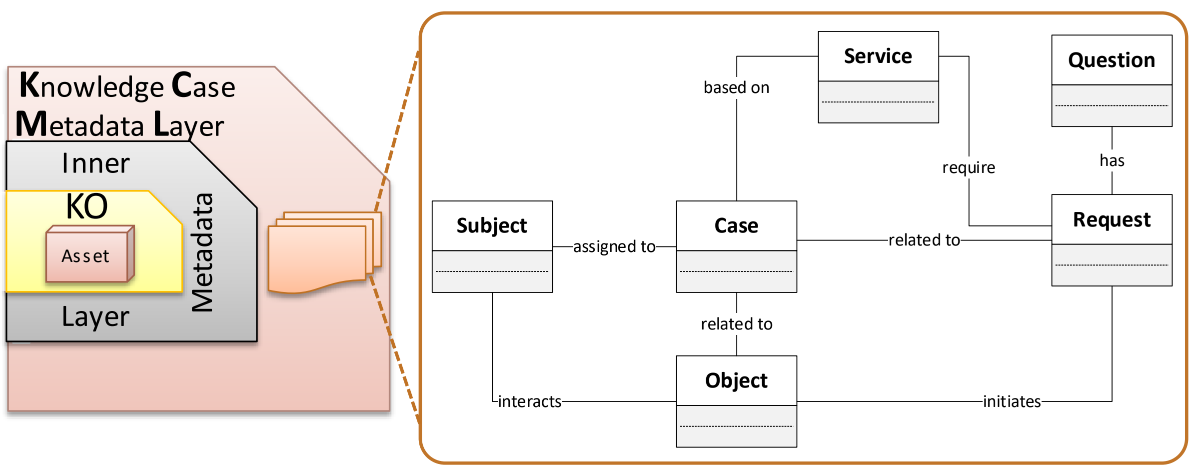


Figure 5. Elements of the KCML-KOW

The concept of a KO which could provide a linked answer to a single question, or a multiple of questions and combination of KOs to a single question, is also possible (as depicted in Figures 6 and 7). The KCML-KOW is linked to a KO and one KO could be described by various KCML-KOWs. As depicted the KCML-KOW also contains a pointer to a question embedded as part of the KOW and the answer to the question contained within the original KO. The answer to the question is contained within the KO and the KCML-KOW describes both the question and the answer in the form of meta-data descriptions.

The *Object* is related to a particular *Case* and is primarily responsible for the initiation of the *Request*, which is related to some, or other question or knowledge request. The following two additional viewpoints also need to be clarified:

- A singular KO (which might also be a SCO or SKO) aggregated and described with an inner meta-data layer (IML) could be annotated with more than one KCML-KOW. Each KCML-KOW could have the same or different authors (namely the *Subject*) based on the contextual use of the KO as represented in Figure 5.
- A KOW could also include a set of questions relating to each KO with the aim of encapsulating the externalization and internalization processes of the individual knowledge worker.

Figure 6 illustrates the researchers' notion, in line with the conceptual presentation of Woźniakowski, et al., (2014), about the different connection paths possible between various DKOs (also compare Figure 2) where one single KO (which could also be a SCO or a SKO) could be described by one or a multiple set of KCML-KOWs, where each KOW relates to a question for which there is an answer. As shown in Figure 6, it is suggested that a KO with a base inner meta-data layer (IML) could have one or more related KCML-KOW, each of which could be related to its own case, with one or more creators. The typical creators of the KCML would be the applicable knowledge workers within the LL. Therefore, if different knowledge workers are assigned to a particular case, different KOs could be utilized and annotated for the purpose, as each knowledge worker could have his or her own perspectives and insights about the case. It could also be that different KOs could have the correct possible and alternate sources of information for the solution that is the answer to the intrinsic main question of the case. One other possible scenario could be that there are related cases from a previous request or case, which could be utilized and analyzed for use with the new or arising case.

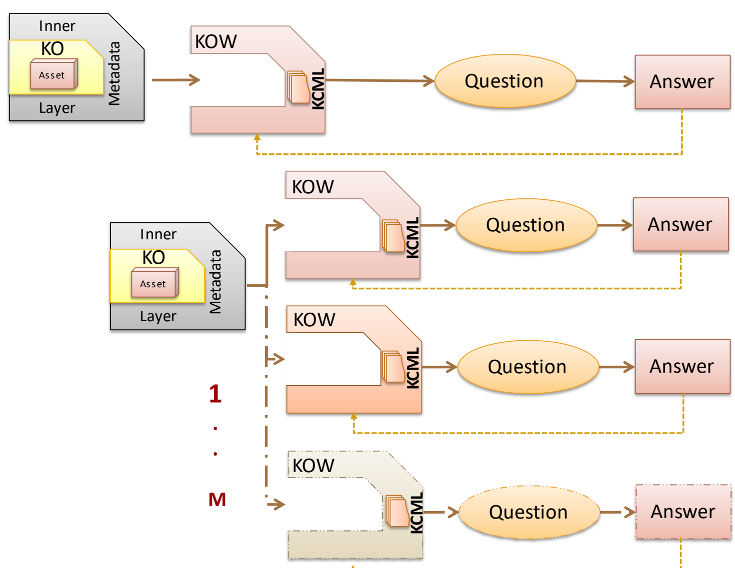


Figure 6. KOW as a meta-data envelope linked to a question

The question and answer view meta-data layers

In order to provide an even richer related meta-data set to each KO primarily described by an IML-KOW, two additional optional interchangeable meta-data layers are suggested as motivated and explained next.

Answering a set of questions relating to a KO, could further describe the current KO in terms of its purpose, meaning and use. Presenting this type of additional meta-data (in the form of answers to a set of questions) to the user of the KO and storing it for the user, could further enhance the learning, understanding and knowledge transfer processes as part of the knowledge support activity. This should not be mistaken for the main question related to the case, as they are questions from which the answers are further descriptors to the case and the usefulness applicability and application of the KO. This ultimately leads to improving the KM practices of the LL. In some essence it aims to capture some of the tacit knowledge of the knowledge worker in relation to the KO and the knowledge requirements at hand.

Figure 7 presents the suggestion that two additional alternate meta-data layers could be included for each KO. In essence a KO could have one or either of the two layers as meta-data descriptions and each KO could also have zero or more of each meta-data description.

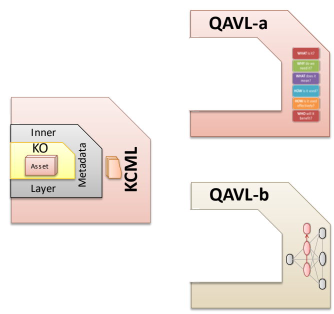


Figure 7. Additional meta-data layers based on questions

In Figure 7, a wrapper indicated as 'Question and Answer View Layer' (a QAVL–a), lists questions in relation to the instance of the KO. The second layer, QAVL–b lists questions in relation to the use of the KO as a tool for the knowledge extension activity, based on the common questions and elements in relation to those of activity theory (compare Engeström, 1999).

Figure 8 proffers an example of a set of questions with their corresponding suggested answers, that when included as part of a KO, would present an additional layer of meaning to the KO.

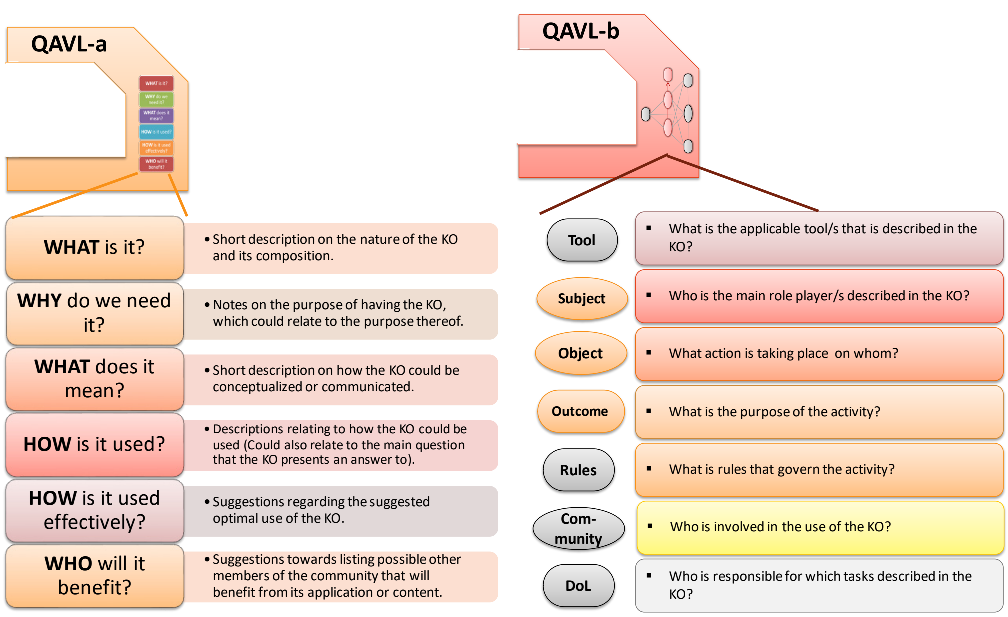


Figure 8. Question and answer view - meta-data layer A and B

It should be noted that the questions and the set of answers are not the only meta-data stored as part of the KO. Other types of meta-data are also stored, such as the question itself and the case to which the KO is linked. This is described in the next sections as part of the suggestion and development phases.

To illustrate the practical use of the questions as meta-data elements and stimulate the internalization process of the individual knowledge worker, the concept of a KOW based on the questions is presented. Table 2 gives a description of a KOW using the set of questions offered in Figure 8, as an example to illustrate the concept 'typical meta-data answers' as answered by the researcher (who take on the role of knowledge workers) and where applicable substantiated by the literature.

Table 2. Typical meta-data annotations relating to the different QAVL layers

QAVL-a (Based on common questions)		**QAVL-b (Based on the elements of Activity Theory)**	
Meta-data question element	Descriptive illustrative answer	Meta-data question element	Descriptive illustrative answer
WHAT is it?	A KOW is a meta-data structure which stores data relating to a KO in a relational DB as part of the applicable company (such as a LL) knowledge base. The meta-data could easily be transformed to JSON-LD documents for interoperability and exchange between various knowledge-based services. Data relating to the KO and other entities involved (such as the users, the case for which the KO are required and the link to where the KO could be found, which is the URL) are stored and captured for future use and inferences.	**Tool**	Any applicable service that utilises KOs. For example, QAS, Knowledge interchange service or the EKB service.
WHY do we need it?	There is a need to be able to capture the essence of know-how and innovation embedded within a single or various knowledge sources (Frappaolo & Capshaw, 1999; Joshi et al., 2007; Meihami & Meihami, 2014), such as a KO or the know-how of a knowledge worker. Storing various meta-data descriptions as well as related questions, presents the LL with a source of data which could be linked to other ontologies for semantic interoperability (da Silva et al., 2014), improved levels of integration and better exploitation of inherent knowledge and synergies (Wruck et al., 2014).	**Subject**	The knowledge worker that utilises a service to better understand and interpret available knowledge for dissemination purposes.
WHAT does it mean?	It means that better mechanisms for provisioning knowledge support in a knowledge driven environment could be created as part of the operations of various services and tools. The thought processes of the individual knowledge worker are also captured when various patterns between the data and KO sources overlap (Smith, 2001). The data stored will be available for later referral and inferences and for analysis with a view to the discovery of possible trends and patterns (Nayak, 2002). It also provides the opportunity to discover and create connections or patterns between various KOs (Hodgins, 2002) and KOWs in relation to the different questions and meta-data relating to the questions that it encapsulates. It furthermore means that having such data available in conjunction with the utilisation of KOs in the organisation, should provide a competitive advantage to the members (Jing Cao et al., 2016; Mentzas, 2004; Pires & Cota, 2016) and the respective knowledge workers as part of the network of knowledge. It would also improve the knowledge workers' capacity to gain access to knowledge, solve problems and provide answers to questions (Al-Omari et al., 2016). This implies that the application of KOWs would also require the active participation of the knowledge workers to be more involved and apply various thinking processes both in the capturing of the meta-data and its interpretation.	**Object**	The knowledge seeker that has a knowledge request. Existing KOWs are analysed and evaluated to assist the knowledge worker to best help with the knowledge seekers' request for information.

HOW is it used?	The use of KOWs (which includes capturing the required meta-data) is related to the use and knowledge management processes (KM) of KOs (see Ale, Toledo, Chiotti & Galli (2014)) as part of the network of knowledge (NoK). As each KO is described and annotated by knowledge workers and stored as part of a repository, more data could be available for future inferences and knowledge retrieval (Ale et al., 2014). KOWs could carry a rating load in relation to the KO and the question that the KO aims to address.	Outcome	How did the KOW address the problem or information request of the knowledge seeker? Were the KOWs analysed adequate and did the knowledge support rendered, have the desired effect in terms of learning and knowledge dissemination?
HOW is it used effectively?	The effective use of the KO is dependent on the constant creation, and maintenance thereof as well as the KOW that annotates it. The effective use of the KOW will also be dependent on the tools and services that are provided for the management and use of KOs in the NoK (such as the LL) for the various knowledge workers, and in the case of this research for the individual or groups of extension officers.	Rules	Relates to the procedures and policies regarding the creation, maintenance and annotation of the KOWs.
WHO will it benefit?	The application of KOWs to annotate KOs as part of the knowledge support service provisions of the LL, would benefit the various knowledge workers, the community that the knowledge workers serve and the larger value chain.	Community	Relates to the community and entities that are intrinsically referenced within the applicable KOW references as well as the community for which the KOs and KOWs are used as knowledge support.
		DoL	Relates to the work that the knowledge workers are required to do with regard to the annotation of KOWs based on knowledge requests as well as the use of existing KF and KS services as part of the knowledge factory portal interface.

Table 2 illuminates the suggestion of how various questions and QAVL elements could be used as practical meta-data descriptions. The following additional elements for suggesting how various questions and QAVL elements could be used as practical meta-data descriptions, could be added, and annotated as part to the KOW included meta-data:

- Presenting the main question to be addressed as part of the knowledge support request, by the knowledge seeker.
- Suggestions relating to the case, problem, community, or the project that the extension officer (as the knowledge broker) is assigned to (Hlatshwayo & Worth, 2016).
- Suggestions about the skills set, technical knowledge and expertise of the extension officer (David & Samuel, 2014; Suvedi & Kaplowitz, 2016).
- Descriptions relating to the composition of the applicable KO (as a specialized LO) that the KOW describes. Such descriptions could include the title, details, segment and topics, perceived difficulty and level and the content link (Davies & Newell, 2015; Sabitha et al., 2016) of the KO or LO (which could be aggregated as a set of digital assets (Yaghmaie & Bahreininejad, 2011; Zouaq et al., 2007).
- Suggestions about the linked answer and other knowledge resources supplied to the knowledge seeker (in relation to the knowledge request) and the position and composition thereof as part of the KO. (It is promulgated by this research that the applicable KO contains the answer to the question at hand).

In essence, the proposition of the use of KOWs relays to the enhancement of the knowledge support activities of the LL through the creation of provisions in the form of services, which are enriched through the application of meta-data. The meta-data are captured as part of a KOW, where the meta-data include some of the knowledge workers' thought processes and other semantic descriptors such as to why the KO is useful, how it was used to address a problem, and to whom the KO could be recommended for future use. In other words, stating for whom and in which cases the KO could be used in the future to partially or completely (where a rework of the KO would be required) provide an answer to a knowledge support request.

KCML-KOW domain class diagram

The previous two subsections presented descriptions relating to the awareness and suggestions about the design of a KOW. In this subsection the development stage of the design and creation methodology is addressed in the design of a domain class diagram for the storage of the applicable meta-data that a KCML-KOW would comprise of.

JSON-LD is a semantically enriched and fully compatible extension of JSON which allows developers to present meta-data and other entries linked to common vocabularies (Lanthaler, 2013). Many popular web-based software services and tools such as LinkedIn, Twitter, Meetup and Zotero (for research purposes) utilize JSON as an interchange format that could easily be transformed to meaningful JSON-LD documents (Young, 2016). This is particularly appealing to this research, since JSON-LD could be used as a data format for the description of a knowledge object wrapper (KOW). For the purposes of this research, a KOW is regarded as being able to provide an 'additional layer' to current meta-data models, with the specific objective to include questions, as well as unique cases as part of the meta-data. For the researchers, the main idea behind the implementation of the KOW is not to substitute or replace existing meta-data models, but to extend the models with new functionality, by adding a new dimension with additional semantic content, besides that of tags in the form of questions.

Referring to the conceptual class model as part of Figure 5, the extended domain class model that follows (Figure 9) is presented. This extended version includes an indication of various subclasses and an indication of the specialization relationships for each of the classes. Figure 9 represents the domain class diagram with various domain classes that also relate to various vocabularies as part of the schema.org domain. The main notion is the idea that a case refers to a KO and that a KO contains a creative work reference. The other classes relate to the knowledge case instance.

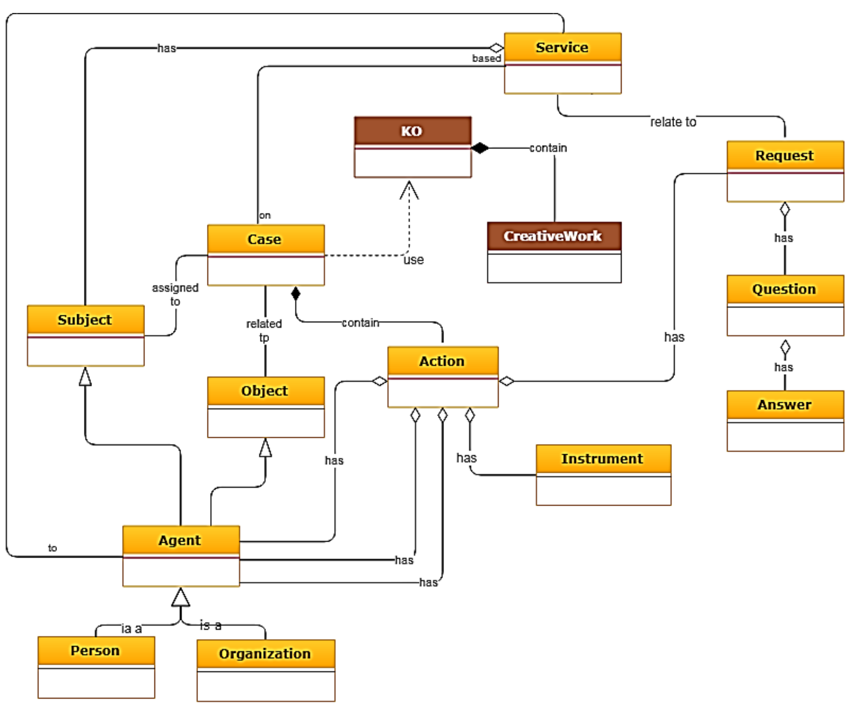


Figure 9. KCML-KOW domain class diagram

Table 3 describes all the domain classes presented in Figure 9 with a short description of their relationships and association with one another and possible IRIs.

Table 3. KCML-KOW domain class description and related IRIs

Domain class (Class)	Description and relation	Possible IRIs
Case	The *case* class represents the applicable case that is opened and instantiated by the subject in relation to a knowledge request. The case object relates to the particular agent that is assigned to the case'. A case is dependent on a knowledge object. A case also comprises of an action.	http://dbpedia.org/ontology/Case
Subject	The *subject* class represents the base class for an agent object which could be either a person or an organisation. The subject triggers the instantiation of a case.	http://schema.org/Person https://schema.org/Organization
Object	The *object* class represents the base class for an agent that is responsible for managing the applicable case. The object responsible for a case could either be a person or an organisation. The agent in this regard could perform the role of a broker.	http://schema.org/Person https://schema.org/Organization
Agent	The *agent* represents the base (superclass) of the person or organisation that is involved in an act. Both the subject and object are super classes for the agent object.	http://dbpedia.org/ontology/Agent http://xmlns.com/foaf/spec/#term_Agent
Person	The *person* class represents a human being. In this research the person could either be a knowledge seeker, knowledge agent, or any person that is involved in the LL processes.	http://schema.org/Person
Organization	The *organisation* class represents an entity such as a business, school, higher educational institution, bank, or government department.	https://schema.org/Organization
Action	The *action* class relates to an action performed by an agent on an object. The object here is not an object class instance, but rather a thing or artefact.	https://schema.org/Action
Instrument	An *instrument* is the tool used as part of an action. It relates to the object that the agent used to perform the action.	https://schema.org/instrument
Service	A *service* is provided by an organisation (which is an agent). A case is based on a services request. A service relates to a request.	http://schema.org/Service
Request	An action relates to a *request*, and a request is part of a service.	https://schema.org/InteractAction
Question	A request has an intrinsic *question* and a question has a potential answer. A question also has an aggregated list property to an item list. This item list could be a list of applicable KOs.	https://schema.org/Question
Answer	This refers to the *answer* or set of possible answers to a question. The answer in itself could refer to a list of possible answers, which could be contained within a question object.	https://schema.org/Answer
KO	A *KO* relates to a case. The KCML-KOW refers to a particular KO and is dependent on it.	https://schema.org/Thing
CreativeWork	A KO contains a *creative work*. This relates to any type of artefact created by a person, such as a book, article, tool or video.	https://schema.org/CreativeWork

KOWs - A META-DATA ILLUSTRATION USING JSON-LD

This section about KOWs as a meta-data illustration using JSON-LD, entails a simple demonstration of the practical application of KOWs (action 3 shown in Figure 4). In order to explain how a typical set of KOWs could be rendered in JSON-LD, the researchers constructed three illustrative examples respectively in the form of an:

- inner meta-data KO layer example (compare Figure 6);
- example of how a KCML-KOW dataset could look like, based on a knowledge case (KCML-KOW); and
- example of an QAVL-a meta-data layer.

The examples that follow are based on the following realistic scenario of an emergent farmer (knowledge seeker) seeking advice from an extension officer (knowledge broker):

Andries Nkadimeng is an emergent beef farmer in Vissershoek. He wants to know "*Which cattle breed is best for beef in South Africa*?". In order to obtain assistance with his query, he sought advice from the National Emergent Red Meat Producers' Organisation (NERPO). A chief breed advisor named Jackson Baloyi which deals with extension requests was assigned to help Andries. Jackson opened a case to assist him with the action of dealing with Andries' question. When the case was opened, unique identifying keys were created for the case and the associated action. Being part of a larger LL and having access to the various KF services and tools, Jackson used the question and answer service tool to search for possible corresponding cases and similar questions stored in the LL KB. Some answers and matches were returned, but Jackson also decided to do a normal Google search. This search resulted in him finding an article online as part of the Farmers Weekly website (Coleman, 2017). Jackson decided that the article is very suitable to assist Andries and extracted the article's meta-data with the knowledge object wrapper management service (a tool that is part of the service layer of the LL, compare Figure 1). The newly created knowledge object wrapper was also allocated a unique key which was assigned to the case.

Figure 10 consists of a basic 'use case' diagram of an extension officer initiating an extension request. The use case diagram presents the two main cases and their applicable related cases. As depicted in Figure 10, the applicable knowledge worker creates a case entry. This action includes assigning an object in relation to the case that refers to the subject which is the knowledge seeker. An applicable agent is also assigned. It may be the knowledge worker him or herself, or it may be a search based on previous cases and expertise (this is not included in the use case diagram).

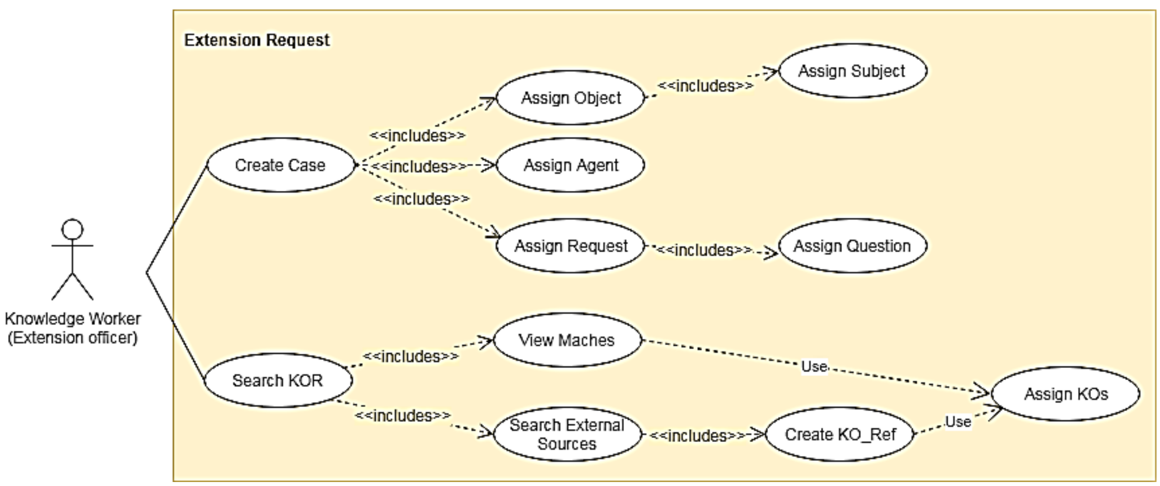


Figure 10. Extension request use case

A knowledge request in the form of a question is also assigned. The knowledge worker may in addition search the KOR and view record matches regarding previous cases and KOs utilized, or if no satisfactory KO is found, an external search is performed. Existing KOs would have KO-References (outer meta-data layers). For new knowledge objects a KO-Reference needs to be created.

The initiation of an extension request could entail the creation of an inner meta-data wrapper (in case a KO is sourced from an external source) and must entail the creation of a KCML wrapper. Each of these wrappers is elaborated on as follows in the discussion on the inner meta-data layer; knowledge case meta-data layer (KCML); QAVL-a and QAVL-b; optional meta-data wrappers; and Motivating questions as meta-data tags.

The inner meta-data layer

The inner meta-data layer as portrayed in Figure 5, is basically a digital knowledge source (DKO) tied to an asset. The asset in relation to the scenario refers to the online Farmer's Weekly article referred to in the example above (Coleman, 2017), available at:

> *https://www.farmersweekly.co.za/animals/cattle/select-top-performing-beef-cow/*

Using existing API tools and parsers such as (https://www.npmjs.com/package/schema-org-parser-json-ld), encapsulated JSON-LD meta-data embedded in the applicable Farmer's Weekly article HTML page (Coleman, 2017) could be extracted.

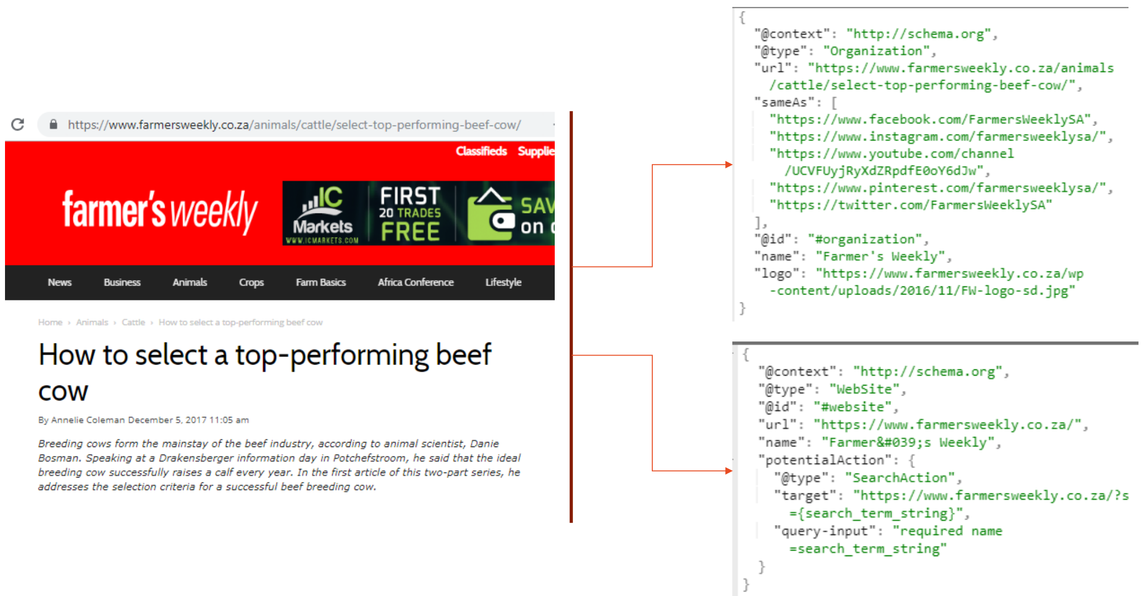


Figure 11. JSON-LD meta-data extracted from the Farmer's Weekly (Coleman, 2017)

Figure 11 shows two JSON-LD meta-data fragments extracted from the Farmer's Weekly page using the schema.org vocabulary (Coleman, 2017). The upper JSON-LD fragment would typically constitute the inner meta-data layer. As part of the LL service layer (compare Figure 1), a KOW management service (KOW-MS) would provide functionality to extract entity (object) data (in this case that of the organization) into the applicable tables as part of the KOWR in the LL KB (compare Figure 1).

The snippet of JSON mark-up could also be stored as a complete large blob field within the table, or as a separate text file reference. For this instance (the record instance), a unique KO key is also created and stored. For illustrative purposes it is assumed that the KO key for the article associated with the IRI (URL) (Coleman, 2017) is *C000000034*. Table 5 represents the most basic record entry created as a KO reference named KO 34 with a key value of *C000000034*.

Table 5. Conversion of a JSON-LD document to a relational table defined in SQL

JSON-LD meta-data of a KO_Ref entry	Corresponding SQL table create and insert
{ "@context": "http://schema.org", "@type": "Thing", "name": "KO 34", "id": "C000000034", "mainEntityOfPage ": { "@type": " WebPage", "url": "https://www.farmersweekly.co.za/animals/cattle/select-top-performing-beef-cow/", "name": "Farmer's Weekly" } }	CREATE TABLE IF NOT EXISTS KO_RefTable (context VARCHAR(17) NULL, type VARCHAR(5) NULL, id VARCHAR(10) NULL, entity_of_page_type VARCHAR(7) NULL, entity_of_page_name VARCHAR(15) NULL, entity_of_page_url VARCHAR(78) NULL, name VARCHAR(5) NULL); INSERT INTO KO_RefTable VALUES ("http://schema.org","Thing", "C000000034"," WebPage", "Farmer's Weekly", "https://www.farmersweekly.co.za/animals/cattle/select-top-performing-beef-cow/", "KO 34");

The knowledge case meta-data layer

As shown in Figure 5, the knowledge case meta-data layer (KCML) contains meta-data regarding the case that is opened. The opened case refers to the query (namely the extension request), lodged by the knowledge seeker (also compare Figure 10). In this process, a unique key is created for the particular request in the form of a case number, which is stored as part of the case entity (compare Figures 5 and 9 and Table 5).

Figure 12 portrays the JSON-LD mark-up representing a KCML-KOW based on the scenario. The data which include, both the mark-up and the values, could be extracted from applicable tables as part of the KOWR. The JSON-LD document as presented in Figure 12 was created by the researchers to demonstrate the concept. The mark-up presented in Figure 12, was validated by using the structured data testing tool of Google, which supports schema.org vocabularies (see https://search.google.com/structured-data/testing-tool/u/0/).

JSON-LD

```
{
  "@context": [
    "http://schema.org/",
    {
      "case": http://dbpedia.org/ontology/Case     }
  ],
  "@type": "Thing",
  "identifier": "C000000741",
  "name": "Case 741",
  "potentialAction": {
    "identifier": "CR00022541",
    "@type": "AskAction",
    "object": {
      "@type": "Person",
      "address": {
        "@type": "PostalAddress",
        "addressLocality": "Gauteng",
        "postalCode": "0251",
        "streetAddress": "R513 Plot 88A Vissershoek"
      },
      "email": "mailto:AndriesNkadimen@gmail.com",
      "image": "Andries.jpg",
      "jobTitle": "Farmer",
      "name": "Andries Nkadimeng",
      "telephone": "(083) 123-4567",
      "url": "https://www.facebook.com/AndriesNkadimeng"
    },
    "agent": {
      "@type": "Organisation",
      "name": "NERPO",
      "url": "http://nerpo.org.za/",
      "telephone": "(012) 492 1383",
      "employee": {
        "@type": "Person",
```

```
        "address": {
          "@type": "PostalAddress",
          "addressLocality": "Gauteng",
          "postalCode": "0081",
          "streetAddress": "160 Garstfontein Rd"
        },
        "email": "mailto:Jackson@Nerpo.org",
        "image": ".jpg",
        "jobTitle": "Chief Breed Advisor",
        "name": "Jackson Baloyi",
        "telephone": "(081) 671 5501",
        "url": https://nerpo.org.za/BaloyiJ }
    },
    "question": {
      "@type": "Question",
      "name": "Red meat cattle breed",
      "upvoteCount": "10",
      "text": "Which cattle breed is best for beef in South Africa?",
      "dateCreated": "2017-11-10",
      "author": {
        "@type": "Person",
        "name": "Andries Nkadimeng",
        "sameAs": "https://www.facebook.com/AndriesNkadimeng"
      },
      "answerCount": "1",
      "suggestedAnswer": {
        "@type": "Answer",
        "upvoteCount": "1337",
        "dateCreated": "2017-12-07",
        "isBasedOn": {
          "@type": "Answer",
          "identifier": "C000000034",
          "url": "https://www.farmersweekly.co.za/animals/cattle/select-top-performing-beef-
                cow/"
        },
        "author": {
          "@id": "https://www.farmersweekly.co.za/AnnelieColeman",
          "@type": "Person",
          "name": "Annelie Coleman"}
      }
    }
  }
}
```


Figure 12. Possible JSON-LD mark-up representing a KCML-KOW

In broad terms the document could be used to semantically describe the following scenario applicable to a case:

> Case 741 relates to an action that involves an emergent farmer asking a question to an advisory employee from Nerpo. The question asked entailed the object, namely the farmer posing a question to an agent. The question reads “Which cattle breed is best for beef in South Africa?” A suggested answer was found in knowledge object C000000034 in an article written in Farmer’s Weekly by Annelie Coleman (2017).

The real value of utilizing KCML-KOWs as one of the products of the KF becomes evident. Within the KF one of the main tasks of the knowledge workers as presented and suggested by this research, relates to the creation, management and maintenance of KOs and the applicable meta data wrappers. These could be -

- inner layer meta-data wrappers;
- KCML-KOW (as described in this section); and
- QAVL-a and QAVL-b meta-data layers (discussed next).

QAVL-a and QAVL-b: optional meta-data wrappers – An illustration

In a previous section two additional optional meta-data wrappers are suggested. These meta-data wrappers are created by a knowledge worker that deems an applicable KO as being of high value. It may also relate to a knowledge worker that wants to add additional semantic connotations to applicable aspects of the KO. Each of these types of wrappers contains a particular question that is assigned to an answer (compare Figures 6 and 8 and Table 2).

The meta-data elements contained in the two suggested wrappers, could easily be converted into standard record entries by incorporating a bridging entity. The records relating to each wrapper entity could easily be represented by using JSON-LD, as well tying and associating the questions to standard schema.org elements.

Figure 13 depicts a domain class diagram representing the associated classes and attributes that constitute a QAVL instance. Not indicated in the diagram, is the concept that both the QAVL_a and QAVL_b classes are base classes of a QAVL superclass. In essence the mapping and associations between a QAVL_a and QAVL_b instance is the same. A QAVL_a instance references a KO_Ref object, which in turn contains and refers to applicable knowledge objects. Both the KO_Ref and the KO classes represent an inner meta-data wrapper. A QAVL_a contains a reference to a KO_Ref instance and a set (or list) of questions. Each of the questions contains at least one accepted answer and a list of other possible suggested answers. An answer contains the answer to the question and an applicable IRI.

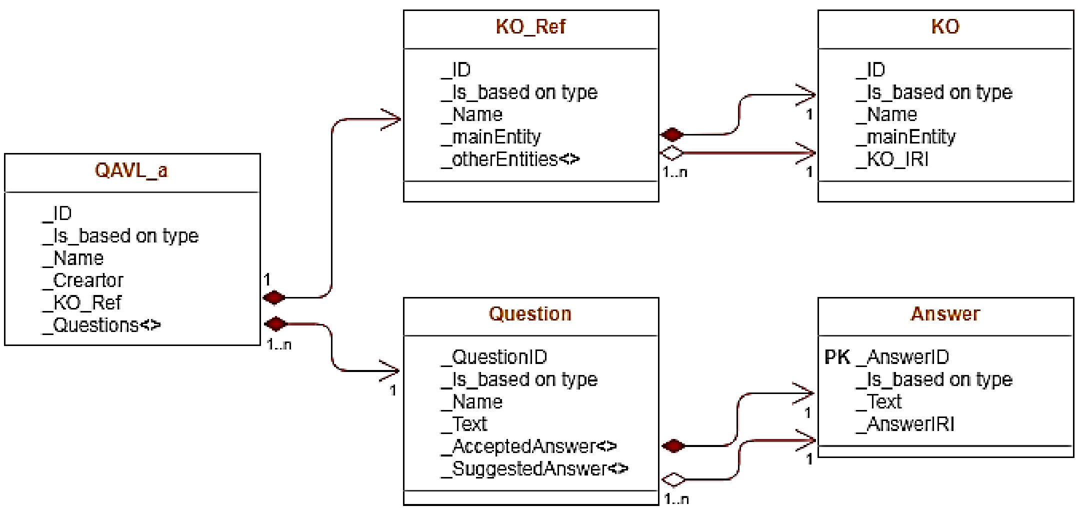


Figure 13. QAVL_a domain class diagram

Figure 14 illustrates the JSON-LD mark-up, representing a QAVL_a-KOW based on the farming scenario as described. The data in the form of both the mark-up and the values, could be extracted from applicable tables as part of the KOWR. The JSON-LD document as presented in Figure 14, was created by the researcher to demonstrate the concept of how a QAVL_a-KOW could be populated, grounded on the data from the tables which the knowledge worker created based on the article. The typical questions as indicated in Figure 8 and described in Table 2 were answered by the researcher for illustration.

JSON-LD

```
{
  "@context": "http://schema.org/",
  "@type": "CreativeWork",
  "identifier": "QAVLa_0001981",
  "creator": {
    "@type": "Person",
    "name": "Jackson Baloyi",
    "url": "https://nerpo.org.za/BaloyiJ"
  },
  "isBasedOn": {
    "@type": "CreativeWork",
    "mainEntity": [
      {
        "identifier": "C000000034",
```

```
        "url": ""
      },
      {
        "identifier": "",
        "url": "https://www.farmersweekly.co.za/animals/cattle/select-top-performing-beef-
cow/"
      }
    ]
  },
  "dateCreated": "2017-12-10",
  "hasPart": {
    "@graph": [
      {
        "@type": "Question",
        "name": "Q1",
        "text": "What is the KO?",
        "acceptedAnswer": {
          "@type": "Answer",
          "text": "Article relating to the factors to consider when selecting a top
                performing beef cow"
        }
      },
      {
        "@type": "Question",
        "name": "Q2",
        "text": "Why do we need it?",
        "acceptedAnswer": {
          "@type": "Answer",
          "text": "Provides valuable advice on aspects and advice such as: Calving percent
                        ages, and maternal ability"
        }
      },
      {
        "@type": "Question",
        "name": "Q3",
        "text": "What does it mean?",
        "acceptedAnswer": {
          "@type": "Answer",
          "text": "Resource in relation to cattle breeds and profitability aspects"
        }
      },
      {
        "@type": "Question",
        "name": "Q4",
        "text": "How is it used?",
        "acceptedAnswer": {
          "@type": "Answer",
          "text": "Reading article with references"
        }
      },
      {
        "@type": "Question",
        "name": "Q5",
        "text": "How is it used effectively",
        "acceptedAnswer": {
          "@type": "Answer",
          "text": "Read in conjunction with an advisor for clarity of terms which could be
                        unknown"
        }
      },
      {
        "@type": "Question",
        "name": "Q6",
        "text": "Who will it benefit?",
        "acceptedAnswer": {
          "@type": "Answer",
          "text": "Any farmer and advisor requiring information on the aspects to consider
                        when selecting a cow type for beef production"
        }
      }
    ]
  }
}
```


Figure 14. Possible JSON-LD mark-up representing a QAVL_a KOW

From the above discussion it transpires that the QAVL_a-KOW attempts to encapsulate some of the tacit knowledge of the knowledge worker. This wrapper is related to a specific KO_Ref object. It would be possible to add an additional IRI element to each of the answers as well, as shown in the domain class diagram (see Figure 13). The composition of a QAVL_b-KOW would closely resemble that of the example given, but with questions and answers relating to the AT elements of the applicable KO when used as a tool for informing.

Motivating questions as meta-data tags

The role and predominant use of questions as meta-data tags are strongly supported by the researchers and forms one of the pillars on which this research is based. This is evident in the examples as portrayed in Figures 6, 8, 9 and 12 to 14, as well as in the discussions regarding the use and importance of questions for knowledge transfer and informing, such as:

- where the concept of a NoK and the role that asking questions plays in the knowledge dissemination process;
- where partaking in living labbing operations entails knowledge operations and seeking answers to questions;
- about the activity of knowledge creation and the knowledge worker operations;
- about the intrinsic processes of externalization and internalization through dialogue supported by questions; and
- where the initial concept of a question tied to a KO and the use of questions as meta-data tags are presented.

In the researchers' experience, including questions as meta-data-tags adds a new dimension to the process of knowledge comprehension and understanding. Such questions to be asked by the user could relate to:

- better understanding of the nature of the knowledge source presented as an answer to a problem;
- evaluating the result-set of a question posed in a browser or search engine, with prior stored questions (the subsequent evaluation of the question to the result set, could have the knowledge seeker either modifying the existing question stored as a meta-data tag, or adding an additional question as reference to the resultant knowledge source);
- presenting additional context to the KO relating to the scope and content of the KO;
- better analyzing and contextualizing the existing tags; and
- tying-in additional semantic constructs in the form of linguistics.

Evaluation of the Various KOW Artefacts

The fifth stage of the DSRM of Peffers et al. (2007) evaluation of the various KOW artefacts (activity 5 in Figure 4), is the focus of attention in this section. The evaluation process involved the use of a simple questionnaire which was supplied to five experts (coded as ER-E1 to ER-E5) respectively in the fields of knowledge management, web-based support services and tools, ontologies, living labs and networks of knowledge. As part of the evaluation process of the research, the designs and motivations presented in the first sections of this report which entailed the designs, composition, and illustration of the use of the various KOWs, were supplied to them for review. An overview of these experts' evaluation of the various KOW meta artefacts is presented in Table 4.

Table 4. Evaluation of the various KOW meta artefacts

Criterion	Strongly disagree	Disagree	Slightly disagree	Slightly agree	Agree	Strongly Agree	Motivation
1 - The utilisation of KOs would increase the knowledge capacity of the LL.				20%	60%	20%	Yes, this is value adding to the service (ER-E5).
2 - The discussions pertaining to the design of the KCML are clear.				20%	60%	20%	
3 - The inclusion of the metadata classes and subsequent elements as portrayed in Figure 5, as an additional wrapper would allow for the partial capturing of tacit knowledge				20%	40%	40%	Each of the classes as presented in Figure 5, relates to that of an activity system. Capturing and managing data about the use of a KO as a tool in the knowledge transfer process, encapsulates some of the thought processes and reasons, as well as the application thereof, which to an extent presents some of the tacit knowledge of the subject and the object with regard to a knowledge system (ER-E1). Yes, this could definitely enhance tacit knowledge and contribute to the long-term memory of the LL (ER-E5).
4 - The idea that a single KO could be linked to several different KOWs as depicted in Figure 6, would allow the encapsulation of the externalisation and internalisation knowledge processes of the individual knowledge worker.				20%	60%	20%	Motivations: The idea that the research aims to present here, is based on having a knowledge worker complete a group of datasets regarding the knowledge requests that are presented as a case. In doing so, the knowledge worker must internalise the request and the use of the knowledge object. This process in itself attempts to capture the tacit and implicit knowledge of the worker to a certain extent (ER-E1). Yes, the "linking" of such KO's could be of great value to all roll players and as such contribute to all levels of knowledge (ER-E5).
5 -The notion that different knowledge workers could be assigned to the same case, each creating their own KOW based on the KCML metadata wrapper would create a rich knowledge set and for current and future references.					60%	40%	Motivations: I fully understand this and from practical experience, having a rich dataset on any item would surely assist not only in future decision making but also for future analysis purposes. It would also be possible to discover trends and patterns (ER-E1). Yes, this kind of approach will be enriching and if knowledge workers get the opportunity to share their experiences with one another in terms of the kinds of services they provided, it could be of great value to the LL (ER-E1).
6 - The exposition, design and presentation of the KCML_KOW domain class diagram in Figure 9 and Table 3, are clear and understandable.					60%	40%	

Statement	Strongly disagree	Disagree	Slightly disagree	Slightly agree	Agree	Strongly Agree	Motivation
7 - The proposition and design of the two question and answer view metadata layers as discussed, are clear and purposeful					80%	20%	
8 - The argumentation pertaining to the various elements of the different wrapper compositions (QAVL-a and QAVL-b) (see Table 2) in relation to their use and implementation, would add value to the fundamental knowledge load of a KO when applied.					80%	20%	As elaborated upon in 2.5.3, having a rich set of data would surely increase the knowledge source and trustworthiness of the related knowledge object. It indeed makes sense In a practical manner, the more experts review for example a tool, the more reliable the data become (ER-E1).
9 - The argumentation pertaining to the various elements of the KCML knowledge object wrapper elements (see Table 3) in relation to its use and implementation, would add value to the fundamental knowledge load of a KO when applied.					100%		
10 - The illustration regarding the use of the KOWs composed as JSON-LD documents is clear and concise				20%	40%	40%	Yes, it is a standard depiction and implementation of JSON-LD scripts and mark-up (ER-E1).
11 - The use of JSON-LD as a technology is suitable to describe, annotate and encapsulate the various elements in the form of JSON-LD documents.				20%	60%	20%	
12 - The use of JSON-LD documents would contribute to the interoperability of various knowledge services of the LL and facilitate the exchange of data.					60%	40%	
13 - The motivations for the use of questions as metadata tags add an additional dimension to the way in which tacit and explicit knowledge could be stored and shared.					20%	80%	Yes, I think that makes the process more advanced and as such helps to provide an improved service to the users (ER-E5).
14 - The discussions and motivations in relation to the case for KOWs are valid.					100%		

	Strongly disagree	Disagree	Slightly disagree	Slightly agree	Agree	Strongly Agree
15 - The discussions and motivations in relation to the use of the various KOW metadata models are novel and unique. (In other words, the way in which the use of KOWs is suggested in this section presents a knowledge contribution.)				20%	60%	20%
	Motivation I have not come across the use of knowledge objects and in particular the notion of different sets of knowledge object wrappers. In the best of my judgement the approach is unique (ER-E1).					

As is evident from the results presented in Table 4, there is a consensus among the experts that the use and implementation of KOWs in the design of knowledge intensive services and tools could lead to the better functioning of a NoK. The additional benefits and case for the application of KOW are presented in the next section.

WRAPPING UP –THE CASE FOR KOWS

The voluminous information obtained from the numerous sources consulted and encapsulated within the sample KCML-KOW and sample QAVL_a-KOW, was immense. Applying the process of utilizing KOW in conjunction with KOs as part of a knowledge support service, will present the knowledge worker with a rich set of knowledge that would otherwise not have been available if for example, the knowledge worker only referred to the applicable Farmer's Weekly article (Coleman, 2017).

From the dataset (compare Figure12) various sets of information could be inferred, such as the following:

- Who the farmer (that is the object/ knowledge seeker) is in relation to the case.
- Who the agent is that assisted the farmer with his or her query.
- To which organization the agent belongs.
- What the question is that the farmer posted.
- The suitable answer provided in relation to the question.
- Who the person (author) is that created the knowledge object and for which organization he or she works.

In relation to the knowledge taxonomy presented by Lundvall and Johnson (1994) it is possible to present an answer from the KCML-KOW about the nature of each of the four knowledge classifications, namely:

- **Know-what** –the facts encapsulated in the Farmer's Weekly (Coleman, 2017) article part of KO identified as C000000034;
- **Know-why** –encapsulated in the knowledge of the applicable agent from NERPO, as well as the expert opinion of the author of the article (Coleman, 2017);
- **Know-how** –the knowledge of knowing which cattle breed to select; and
- **Know-who** –realized in the notion that 'who knows what', as the agent knows about the case and question; and 'who knows how to do what' that relates to the agent knowing how to refer the applicable question to the correct knowledge source. The agent now also has knowledge about the 'who', in the form of who is the farmer (the knowledge seeker) and who is the carrier of the knowledge (the author). This could also be interpreted from the viewpoint of the knowledge seeker, as the knowledge seeker now knows who to contact with additional problems and questions regarding cattle breeds.

In the 'case', a similar type of question could be posted in future (by another knowledge seeker). The existing KCML-KOW could be returned as a dataset, and by using just this dataset the new knowledge seeker could then be linked to the applicable agent, the applicable farmer as well as the author of the KO. This only from one KCML-KOW. In practice it is envisaged that the knowledge workers of the LL would create a KCML-KOW entry for each of the extension requests that they are assigned to.

Having an ever rich and expanding repository or knowledge base containing different tables from which the data encapsulated as part of the KCML-KOW, could be rendered (based on simple queries), would present the LL knowledge workers with an in invaluable knowledge resource. Three of the most obvious advantages of this are -

- being able to obtain a list of similar KOs and references (know-what, know-why);
- harnessing knowledge based on previous experiences; and
- knowing which extension workers and knowledge agents were assigned or managed similar cases previously (know-how, know who).

Within the LL environment typical services and tools will be predominantly tasked with the management of KOWs, but each KO as well as derived KOWs as part of the KB, play an important role in the overall functioning of the LL to ultimately provide holistic linkages between the correct knowledge seekers and knowledge holders, and between different entities. This concept has to do with research objective seven, with the aim to describe how KOs and KOWs are used as the raw or semi-raw 'material' in the LL NoK for the 'capturing', management and transfer of the tacit knowledge and the corporate memories of the various LL members, through annotations and semantic integration in relation to research objective four, are also partially attained.

A corporate memory could be regarded as knowledge captured in one or another format, that could be fully interpreted by the document holder. Having a rich set of KOWs in different formats as suggested above, will also assist in building a KB that encapsulates a rich set of experiences based on usable knowledge. The knowledge encapsulated within the KOWs is both readable in a human form and could also be interpretable applications, tools and software that could query the data. The querying of the data is achieved through the implementation of a relational DB structure. The design and discussion of the relational schema for the standard operational KOWs that could be created from standard queries and tables stored in the LL-DB and KOR as part of the KB (see Figure 1), are illuminated. The KO table in this schema represents any entity with an IRI, which could include any person, organization or artefact.

One of the requirements stipulated by one of the expert reviewers in the review of the design requirements of the KOW, is that the KOs which are semantically enriched should be sharable amongst different systems. Utilizing JSON_LD (as does JSON) allows interoperability and the sharing of data between different systems.

Communication

The final stage of the DSRM (depicted in Figure 4, as activity six in the DSRM process model) involves the communication of the results and the findings. This article attempts to fulfil that requirement.

Conclusion

In this article the researchers attempted to demonstrate the notion that the application of KOWs in a networked knowledge intensive environment such as a LL, could better and expand on the corporate knowledge attainment of its members.

These artefacts present the technology that will enable the knowledge operations of the LL. The description and application of reusable KOs annotated and defined with a suggested design and description of various metadata models in the form of KOWs in the JSON-LD format as part of a living lab, are presented to facilitate and provide expanded possibilities for knowledge management which include the practice of knowledge support and other LL operations, like information transfer, for solution development.

Two different metadata models are presented, namely question and answer view layer a (QAVL-a) and question and answer view layer b (QAVL-b). Each of these models is annotated by using different metadata elements that could be stored and rendered in various formats such as JSON-LD. These metadata wrappers are added to existing knowledge objects and attempt to facilitate the capturing of corporate knowledge and memories within the LL and the NoK. Various KOs could be annotated with different and a combination of different types of QAVL wrappers, resulting in a rich descriptive set of elements to describe a KO. The QAVL-a metadata model utilizes standard questions as metadata tags, whereas the QAVL-b model is based on the typical elements of activity theory.

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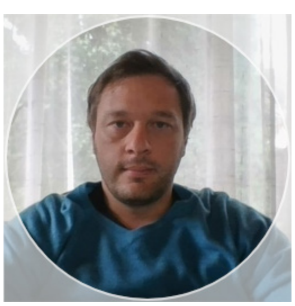

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