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Supply chain knowledge management supported by a simple knowledge organization system

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ABSTRACT

Supply chain management and business-to-business procurement present several drawbacks in terms of knowledge management. Every stage of a supply chain lacks an effective approach to integrate data workflows for knowledge acquisition. Thus, semantic technologies such as the *simple knowledge organization system* (SKOS) are being adapted to the requirements of the knowledge management systems of companies. The literature is focused on assets, data, and information elements of exchange among supply chain partners, even though improved integration and collaboration require more complex features of know-how and knowledge. This article proposes a new software architecture named SKOSCM to offer a brokerage service for e-procurement in supply chains. The approach uses ontologies and a Web-based platform that improves collaboration among supply chain partners. A case study is proposed in order to validate the software architecture's development.

1. Introduction

Since the efficient use of knowledge is critical to the survival and success of companies in competitive globalized markets, *knowledge management systems* (KMS) have become an essential tool for *supply chain management* (SCM). The importance of knowledge sharing relies on its strong potential for problem solving and enhancing organizational performance, decision-making, and innovation. In this context, *knowledge management* (KM) has emerged as a process for capturing (Matheus et al., 2005), developing, sharing, and effectively using organizational knowledge (Davenport, 1994).

In addition to knowledge management, collaboration among *supply chain* (SC) partners is another promising research area for academics and practitioners. Companies can obtain several benefits for their supply chains from this collaboration. They include intelligent inventory management, new product development, and collaborative product design management, to mention but a few.

There is a growing recognition that SCM gives companies significant opportunities to develop a strategic advantage toward their competitors (Wen and Gu, 2014). This interest has steadily increased since the decade of 1980, when firms perceived the benefits of collaborative relationships within and beyond their own organizations. Firms recognized that they could no longer effectively compete by isolating themselves from their suppliers or other entities in the supply chain (Lummus and Vokurka, 1999).

Following the premises that knowledge is an asset for companies and that knowledge management and collaboration are essential in every echelon in the supply chain, several KMSs have been developed. They are available in the market and are suitable for e-procurement, supply chain management, knowledge management and collaboration among supply chain partners. However, they fail to detect issues at the procurement stage. Further, data transformation into knowledge depends on each supply chain administrator's expertise, since the type of data generated is different in every supply chain echelon.

The term *supply chain* is subject to different interpretations. Some are related to management processes, while others stress the structural organization of businesses. However, supply chain management integrates the management of supply and demand.

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Moreover, according to the Council of Supply Chain Management Professionals, it encompasses "the planning and management of all activities involved in sourcing and procurement, conversion and logistics". Thus, supply chain management also covers coordination and collaboration with channel partners, such as customers, suppliers, distributors, and service providers.[1]

This research focuses on the procurement stage, since a common source of problems in a supply chain is raw materials procurement. Raw materials and assets determine the success or failure of some subsequent production process. Also, the first concern of knowledge management is supplier selection. Note that knowledge management allows for the improvement of production processes, operational and organizational performance, and decision-making processes, among others. Considering the key elements for a successful supply chain, which are collaboration among all partners and the live sharing of data among them, the success of semantic Web technologies in B2B and e-commerce has turned them into promising technologies to design and build effective business collaboration systems and KMS in companies.

According to Schandl and Blumauer (2010), a *simple knowledge organization system* (SKOS) has recently become one of the sweet spots in the *Linked data ecosystem*. It is the key to improving semantic information management thanks to the capabilities of taxonomy and thesaurus management, text mining and entity extraction, and knowledge engineering and ontology management.

SKOS is an area of study developing specifications and standards to support *knowledge organization systems* (KOS) such as thesauri, classification schemes, subject heading systems, and taxonomies within the framework of semantic Web. However, even though several studies have reported theoretical and practical foundations for knowledge management (Lee and Goodwin, 2006), little research has addressed the use of semantic Web technologies, such as SKOS for supply chain management.

SKOS allows for the automatic information exchange across the supply chain among the production, procurement, and distribution stages. Also, it is produced in an automated way, due to domain-specific knowledge inferred from the ontology and passed over to SKOS to provide benefits for organizations. With recent advances in communication and information technologies (ICT), especially semantic Web technologies, organizations can reduce operating costs by coordinating these stages.

Our aim is to introduce *SKOS-based supply chain management* (SKOSCM), a new semantic Web-based approach that uses SKOS to improve and facilitate knowledge management among all supply chain partners between the procurement and production stages. The importance of using a new approach for knowledge management relies on the benefits of the *linked data paradigm* and SKOS. In this regard, this research identifies opportunities such as open data sources of knowledge (linked open data, social networks, and others) and some benefits, including automation of data organization and procurement for non-expert organizations. Our main contribution of this study is the application of knowledge management through SKOS for supplier selection, which matches with some preconditions to maintain a desired production in a multi-provider scenario for a milk supply chain as a proof of concept.

Section 2 presents the state-of-the-art about Web technologies for knowledge management in supply chains and e-procurement. Section 3 discusses the general research methodology, presents the data acquisition method, and details how SKOS is used in supply chain management. It describes how SKOSCM resolves the problems and how it is employed in the case study. Section 4 discusses SKOSCM evaluation, addresses the features of KMS, and presents the evaluation finding. Finally, Section 5 summarizes results obtained from applying SKOSCM and provides concluding remarks and directions for future work.

2. The state-of-the-art for supply chain systems

Several works have been recently proposed to develop e-procurement and supply chain management systems. Therefore, the relevant topics for this research include e-procurement, supply chain management, semantic technologies, and knowledge management.

2.1. Hierarchical business domain: knowledge acquisition by using ontologies

Originally, the term *ontology* was rooted in philosophy where it denotes "the science of what is, the kinds and structures of objects, properties events, processes, and relations in every area of reality" (Floridi, 2008). According to Gruber (1993), in the context of knowledge sharing an ontology is a specification of a conceptualization. Ontologies can be a component of knowledge-based systems, but they also provide a common language for communication among domain analysts, developers, and users.

In this research, we have improved SKOS with the use of ontologies. A brief comparative analysis of ontologies for supply chain management is performed over the results of the initial search query of "supply chain" and "ontology" throughout the online databases used for a keyword-based search. Additionally, alternative terms are employed to reflect the actual use of various terms for the key concepts. These terms are: "supply network," "supply chain management," "knowledge model," "semantic model," and "ontology model." They are based on the parameters proposed by Scheuermann and Leukel (2014) in their literature review. The literature provides and discusses various SCM ontologies suitable for a range of industries and tasks (Gonnet et al., 2007; Grubic et al., 2011). Table 1 lists these suitable ontologies.

According to the literature, IDEON and SCOntology are suitable for the purpose of this research. They are used to design the SKOS-based software architecture for knowledge management. IDEON is an extensible ontology to design, integrate, and manage collaborative distributed enterprises. On the other hand, SCOntology is a formal approach toward a unified and integrated view of the supply chain. IDEON and SCOntology are appropriate for our research because they support production processes, activities, resources, product delivery, and return schemas. IDEON represents the business domain depicted in Fig. 1 and provides a hierarchical schema to organize and classify data among the supply chain data flows. This is appropriate for supply chains due to the highly-coupled relationships among supply chain partners.

2.2. Electronic procurement

The e-procurement supply chain includes indent management, e-tendering, e-auctioning, vendor management, catalog management, purchase order integration, order status, ship notice, e-invoicing, e-payment, and contract management. Therefore, communication among all supply chain partners is crucial to the success of these activities. One of the most suitable forms of improving communication is the use of an electronic procurement system, such as a brokerage service using semantic Web

[1] According to Thomas and Griffin (1996), the three recognized, fundamental stages of the supply chain – *procurement*, *production*, and *distribution* – have been managed independently, buffered by large inventories. However, increasing competitive pressures and market globalization are now forcing firms to develop supply chains that can quickly respond to customers' needs. As a result, to remain competitive, these firms must reduce operating costs while continuously improving customer service.