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A knowledge management UML-based framework to support collaboration in the supply chain management process*

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Abstract

In the most general cases, collaborative activities imply a distributed decision-making process which involves several supply chain nodes. Therefore in this paper, by means of a literature review, and by also considering the deficiencies of existing proposals, a collaborative knowledge management UML-based framework supported is proposed. In addition, this proposal synthesizes existing knowledge, and it not only fulfils, but enriches, each component with the modeller's own knowledge.

Keywords: Knowledge management (KM), UML, framework, collaborative supply chain (CSC)

1. Introduction

The supply chain (SC) management process encompasses the identification of goals, objectives and outlining policies, strategies and controls for its effective and efficient implementation (Smirnov and Chandra, 2000). In addition, Dubei *et al* (2002) establish that the SC considers a set of approaches utilized to efficiently integrate companies, which compose the workgroups, in order to correctly produce and distribute customer requirements. In this context, it is possible to support knowledge management (KM) in a collaborative manner by sharing the right information among the players of these workgroups. Then in order to train people, and by forming different workgroups and simultaneously working on different tasks, two types of sessions are used in the collaborative engine: user sessions to identify online users and collaboration sessions to represent a group of customers involved in the same collaboration (Ni *et al*, 2006), which enhances KM.

In this paper, a literature review has been carried out by considering the most relevant papers on this matter with a view to finding the main aspects and tools that are considered to support the KM in the SC. Thus, our review shows that the main aspects are related with the following subjects: new development software tools (ST) to support the KM process; decision-making processes; document management and SC management. Regarding the ST,

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Nuñez and Nuñez (2005) propose a classification to detect and understand their common applications. As a result, it has been found that the most considered aspects are those related to the decision-making process, which mainly uses information analysis tools. On the other hand, the least considered aspect is that regarding the SC as a whole. This is related to the fact that KM, in a SC context, tends to be modelled as a centralized concept in relation to each workgroup element. Thereafter, this paper proposes an architecture that considers, and also supports, collaboration among the SC nodes, which is supported by considering a modelling tool approach.

2. Background

2.1. Knowledge collaboration in the supply chain

Two main aspects are commonly considered in the study of the collaboration relationship in the SC: the first deals with the intensity of the relationships between partners whose considerations vary from simple information sharing to risk and profits information sharing; the second studies the extent of the collaboration across the SC (La Fome *et al*, 2007). Regarding this, Hall and Adriani (1998) establish a validation technique to analyze the role of the intangible resources in individual firms. Therefore, this technique establishes a code from tacit knowledge, allowing a good understanding of this kind of information, one which establishes a basis in order to join strategic developments. Related to this fact, the management process can be collaboratively developed among managers by exchanging perceptions and by also discussing alternative futures. In this context, Body *et al* (2000) highlight the fact that many managers are oriented to develop collaborative alliances with other organizations. But very often, these strategies cannot be easily implemented, and they are just as likely to fail as to succeed. Thereafter, the authors study this collaborative concept from an empirical study of one alliance type in the SC. As a result, a cooperative behavior may emerge from human action which considers interaction partnering as a main activity. Moreover from a buyer-supplier relationship context, Hoyt and Huq (2000) establish that this kind of relationship plays an important role in allowing for a good response to the dynamic and unpredictable change in the environment. Moreover, Dyer and Singh (1998) highlight the fact that under a collaborative context, this sharing of knowledge and resources could generate relational rents to SC partners. Therefore, as the exchange of knowledge may also be understood as an information exchange among partners, Simatupang and Sridharan (2002) establish that asymmetric information is always a problem among members of the SC, and that this is mainly because these partners often do not like to share their private information completely. Therefore when knowledge/information must be shared, it must be managed in such a way that it develops over a period of time (Sahay, 2003). Therefore, it is necessary that managers should not only be skilled in technical and operational areas, but should also develop relationships that favor the trust needed to encourage the information exchange.

Moreover, knowledge collaborations can be perceived from different degrees of collaboration. In this context, and regarding the nine steps suggested by VICS (voluntary interindustry commerce solutions), Skjoett-Larsen *et al* (2003) define collaborative relationships as: *collaboration where two or more parties in the SC jointly plan a number of promotional activities and work out synchronised forecasts, on the basis of which the production and replenishment processes are determined*. Then, Barrat (2000) establishes that there are many elements of collaboration in SC management, such as trust, mutually, information exchange, openness and communication. Therefore, it is possible to see that these collaborative elements are intrinsically oriented to support a collaborative knowledge management process. For instance, Ulieru *et al* (2000) propose a recursive multi-resolution collaborative architecture based on a multi-agent coordination mechanism. Then, the knowledge management process is assigned to agents which are able to retrieve information for specific applications from databases, made possible by considering mechanisms that use intelligent queries. Furthermore, those agents are also able to process the information by storing, transforming and transporting it.

Another perspective is that by Blanc et al (2007) who establish that the cooperation among the organizations is provided by the SC. So enterprises must interoperate. In this context, these authors establish that interoperability can be achieved by eliminating the heterogeneity present in the environment. Thereafter, Blanc et al. (2007) consider that the heterogeneity problem must be studied from two points of view, these being semantic and organizational. Additionally, the authors present an application of the ECOGRAI method, and they implement it by considering information technology (IT) in an interoperability application framework. In addition, Han *et al* (2007) consider the fact that the use of IT has effectively promoted the integration of fragmented information but, under a collaborative environment (specifically an Internet-based system), there are not enough standard formats to transmit contractual documents and project-related information by considering the issue of data compatibility. To solve this, Han *et al* (2007) consider the knowledge management function by implementing distributed databases containing the transactions of documents that are done during a project life cycle. This helps reduce the total time invested and the costs required. Linking enterprise models, mainly those related to the enterprise environment in which the enterprise goals and strategies are considered to be the first step in the software development process, and which involves establishing a requirements elicitation, is presently becoming a very common research trend (Grangel, 2007a; Grangel 2007b; Grangel 2008).

From another point of view, Lin and Harding (2007) study the languages, or information models, in order to obtain the ontology needed to favor knowledge representation. Therefore, a manufacturing system engineering ontology model is presented. This model has been created to enable an adequate sharing of communication and information with a language that is a web-service standard that supports the ontology model. Another example is that by Tan and Shaw (2007) who proposes a knowledge-based design support system under a collaborative modelling framework. Finally Gunasekaran *et al* (2008), with a collaborative knowledge management process and IT in the SC, establish several areas (or elements) that must be taken into account: strategy formulation, tactical management, operations control, and systems. Therefore, the authors establish that the selection of technologies depend on the strategies which meet most of the company's requirements.

3. Qualitative analysis of the background

From the literature review presented in the previous section, a qualitative analysis is presented in this section. Firstly, this analysis considers the following identified aspects (Table 1): (P1) development of new products, (P2) modelling, (P3) decision-based support, (P4) documental management, and (P5) SC management. Secondly, the classification by Nuñez and Nuñez (2005) is considered. This classification observes how the IT and software tools are involved. Thereafter, this classification considers (Table 2) the following seven aspects: (H1) tools oriented to search and recover information, (H2) customizing and filtering information tools, (H3) storage and information management, (H4) information analysis tools, (H5) flow and communication management systems, (H6) learning tools and (H7) enterprise management systems.

Table 1. Main aspects identified

Authors	P1	P2	P3	P4	P5
Barrat (2000)			■		■
Blanc et al (2007),	■	■	■		■
Body et al (2000)		■		■	■
Dyer and Singh (1998)		■			
Grangel et al (2007a)	■	■	■	■	
Grangel et al (2007b)		■	■	■	
Grangel et al (2008)		■	■	■	
Gunasekaran et al (2008)	■	■	■		■
Hall and Adriani (1998)		■	■		
Han et al (2007)		■	■	■	■
Hoyt and Huq (2000)		■		■	■
Lin and Harding (2007)	■	■		■	■
Sahay (2003)				■	■
Simatupang and Sridharan (2002)		■	■		■
Skjoett-Larsen et al. (2003)		■	■	■	■
Tan and Shaw (2007)	■	■	■	■	■
Ulieru et al (2000)	■	■	■	■	■
	35%	88%	71%	65%	71%

Table 2. Tool classification

Authors	H1	H2	H3	H4	H5	H6	H7
Barrat (2000)					■		
Blanc et al (2007),	■	■	■				■
Body et al (2000)					■		
Dyer and Singh (1998)				■	■		
Grangel et al (2007a)		■	■	■	■		■
Grangel et al (2007b)		■	■	■	■		■
Grangel et al (2008)		■	■	■	■		■
Gunasekaran et al (2008)	■	■		■		■	
Hall and Adriani (1998)		■		■			
Han et al (2007)	■	■	■			■	
Hoyt and Huq (2000)				■	■		■
Lin and Harding (2007)	■	■	■	■	■	■	
Sahay (2003)				■			
Simatupang and Sridharan (2002)				■	■		■
Skjoett-Larsen et al. (2003)		■		■			■
Tan and Shaw (2007)	■	■	■		■	■	
Ulieru et al (2000)	■	■		■	■	■	■
	35%	65%	41%	71%	65%	29%	47%

Table 1 shows that the aspect which presents more repetitions is the modelling aspect (P2), which is considered by 88% of the reviewed works. It is followed by decisional support (P3) and supply chain management (71%) (P5). This in relation to the fact that KM, which is mainly an intangible concept in a supply chain context, must be modelled in order to visualize it and to detect the critical process points which are related to the decision-making process since knowledge is information used to support this process. Moreover from the tool classification (Table 2), the information analysis tool (H4) is the most widely used concept (71%), followed by information filtering (H2) and the management flow system (H5), both with 65%. On the other hand, the least considered aspect is the development of new products (P1) with 31%. From the tool classification point of view, the least considered aspects are learning tools (H6) and storage tools (H1), with 29% and 35% of repetitions, respectively. In the light of these results, it has to be taken into account that an upgrading process of the existing products has existed for many years, and that knowledge presents more difficulties to apply these kinds of technologies or tools to be able to manage the knowledge process.

Another contribution to the analysis is shown in Table 3 which relates both dimensions (aspects and tools) and shows how the authors simultaneously consider them both. Green circles represent the combination with the most considerations; red circles represent the combination with the least considerations, while blue squares represent those options that are considered an average.

Table 3. Crossed table of tools and detected aspects.

	P1	P2	P3	P4	P5
H1	5	6	5	3	6
H2	6	11	10	8	7
H3	4	7	6	6	4
H4	4	11	8	8	7
H5	4	10	7	8	7
H6	4	5	4	4	5
H7	3	8	7	6	5

4. Collaborative knowledge management UML-based framework for the supply chain

4.1. Conceptual model to the knowledge management process of supply chain nodes

The knowledge management framework (KMF) proposal, whose objective it is to represent and understand SC-related interdependences, emerge as an extension of the work of Nonaka (1991), which indicates that the tacit and explicit knowledge flow generates four types of knowledge processes: **socialization**, **externalization**, **combination** and **internalization**. Additionally, the optimal development of this process will depend on the behavior of each enterprise. Under an optimal development process, the continuous learning process of the enterprise should be obtained. Regarding this, the socialization process is supported by people, which means that it is a process in which people transfer their tacit knowledge. Next, the externalization process turns tacit knowledge into explicit knowledge. This occurs when an idea is written on paper, which means that externalization turns individual matters into group matters. On the other hand, the combination process uses IT to transmit or share knowledge, and introduces more usability of the knowledge. Thereafter explicit knowledge becomes new explicit knowledge. Finally, the internalization process takes place and processes the explicit knowledge generated to transmit it to the corresponding workgroups, which will once again generate new tacit knowledge from it.

Therefore, the proposed KMF (see Figure 1) considers seven elements: inputs, outputs, environment, knowledge process and types, input/output connectors among the knowledge processes and technological information tools.

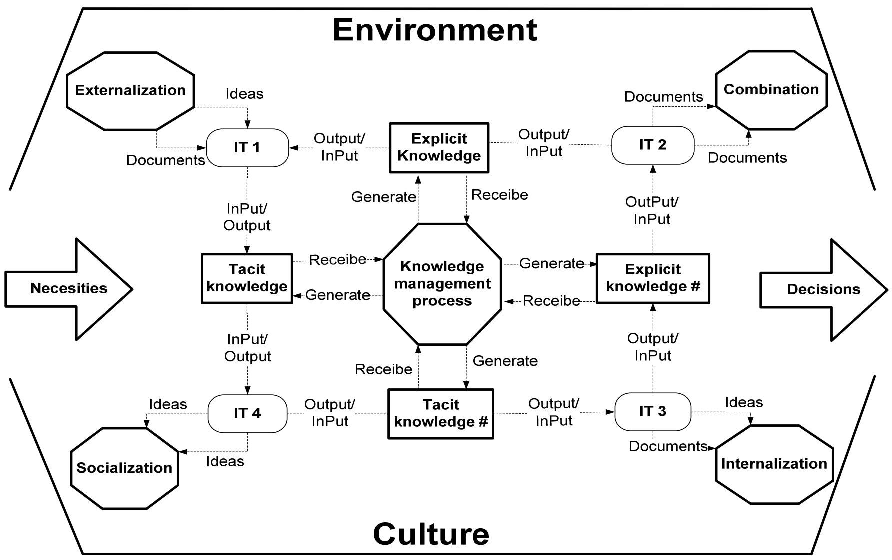

Figure 1. KMF proposal, a conceptual perspective (An extension of Nonaka (1991))

The proposed model combines the best works from the studied literature presented in the background, but incorporates new elements. Moreover this model, or framework, with its seven elements, links the KM process with the knowledge detected in companies or workgroups. As in Figure 1, the model considers the definition of the environment which consists in a series of knowledge processes and entities that interact with each another, but always under a labor environment and culture. These last two provide information related to the beliefs, desires and interactions of the entities which make up the environment. Then in relation to an adequate knowledge management process (which depends on the objectives and interests of the entities that make up the environment), it is possible to capture the right necessities which support the decisional-making process. Therefore, this management process consists in processing different types of knowledge which, through the information technologies, generate the four main and already known processes to be considered (socialization, externalization, combination and internationalization). In addition to supporting the development process of the model, two knowledge types are added to this model: tacit and explicit knowledge. These are related to the new knowledge generated from the knowledge management process, which allows a better understanding of the environment, and which supports continuous improvement in the workgroups.

Then, another contribution emerges from the proposed model which is related with the IT architectures. Therefore to obtain four types of knowledge (tacit, explicit, tacit# and explicit#), it is necessary to consider the right definition and configuration of the IT systems. Thus, four IT types are contemplated, those which are in charge of receiving, processing and generating new information which, at the same time, could be used as an information input for the other IT present in the environment. Should some IT systems of the SC nodes be the same, it could be possible to use a centralized system. In any case be it the same IT system or different ones, each SC node could have its own IT data process. Additionally with a series of protocols, a dialog could be established where data and information would add value to both the environment and the SC, which could be also defined.

4.2. A collaborative framework perspective through UML

According to Huang et al. (2007), the selected language to support this architecture is UML (2008). In this context, UML presents a high level of simplicity, a good level of formalism, and provides a well standardized modelling tool. Then, this formalism allows the concepts and ideas to be easily transmitted to different kinds of people belonging to the workgroup in a SC. Moreover, collaboration in a SC needs to solve conflicts among several decentralized functional units because each unit attempts to locally optimize its own objectives rather than the overall SC objectives. The KMF (Figure 2) is extended to support the information flow among the SC nodes as a KM process. Yesilbas and Lombart (2004) also detect three types of collaborative knowledge (pre, in and post) to support the process design. Therefore from the centralized view (Figure 1), and in relation to Grangel *et al* (2007a) (2007b) (2008), UML concepts are used to support the connection among the SC nodes. Then in the presence of a complete, partial or non collaborative process in the SC, it allows alternative views of the informational flow to be generated in relation to the corresponding KM process, and each one is based on this collaborative KMF proposal.

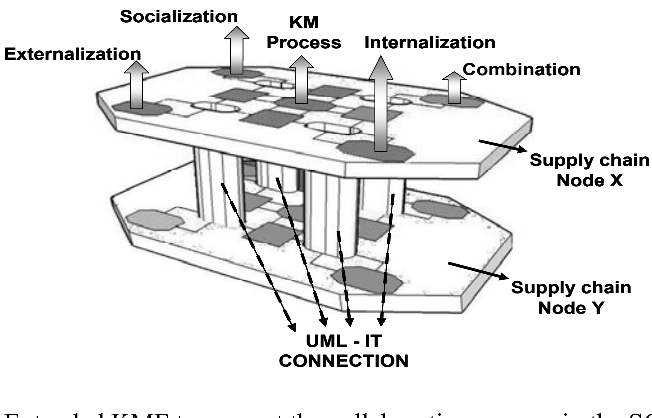

Figure 2. Extended KMF to support the collaborative process in the SC by UML

In order to support the corresponding IT connexion, the UML notation is used. Therefore, the proposed collaborative knowledge management framework (CKMF) uses this notation to establish and formalize the connection among the nodes in the SC. Moreover, it is assumed that each node is agreed to share information. Then each IT displayed in Figure 1 is related to one type. In this context, the selected UML diagrams are deployment, class and sequence, because their diagrams are the most representative to clearly manage and express the two types of knowledge defined by Nonaka (1991): tacit and explicit knowledge. In addition, and from a generic point of view (Figure 2), a dyadic supply chain (two nodes) is considered.

- **Knowledge management process**: from a centralized perspective, this process is represented by a UML component diagram in order to identify the main aspects of this process. Then as main attributes of this process, receiving and generating information are considered.

- **IT 1, the deployment diagram**: here the X and Y nodes are represented by an artefact where the information flow enters and exits the knowledge system node in order to represent tacit and explicit knowledge, respectively. In addition, a knowledge system is connected to another node which represents a database (BBDD) system by considering a one-to-one relationship in the light of the fact that there must be a correct correspondence with shared information (tacit and explicit).

- **IT 2, the class diagram**: with the idea of grouping the different categories present in the knowledge management process, the UML class diagram is properly considered to be used for processing explicit knowledge to obtain new explicit knowledge. Then two nodes are defined to cover, or support, the intrinsic knowledge process in the SC. Moreover, each knowledge process considers the rules and information from the information exchange process by considering a composition association to express which component classes are used to support the main knowledge class process. Next, the information class not only considers the availability and type of information as main attributes, but also the rules which apply either in the system or in the SC nodes.

- **IT 3, the deployment diagram**: here the Y and X nodes are represented by an artefact where the information flow enters and exits the knowledge system node to represent tacit and explicit knowledge, respectively. In addition, a knowledge system is connected to another node which represents a database (BBDD) system by considering a one-to-one relationship in the light of the fact that there must be a correct correspondence with shared information (tacit and explicit).

- **IT 4, the sequence diagram**: this diagram has been used to represent the actions related to transforming tacit knowledge into new tacit knowledge. Therefore, this diagram represents how node X receives information (tacit knowledge), transforms it, and then transmits it to node Y for it to be reprocessed to obtain new tacit information. As the product is intangible, the sequence diagram provides an accurate view to capture and transmit the activities regarding such intangible products, and to also understand how the process is carried out.

Finally, each IT is presented from a conceptual perspective (Figure 3) by extending the centralized model in Figure 1. Therefore, this conceptual framework represents the overall view of the proposal.

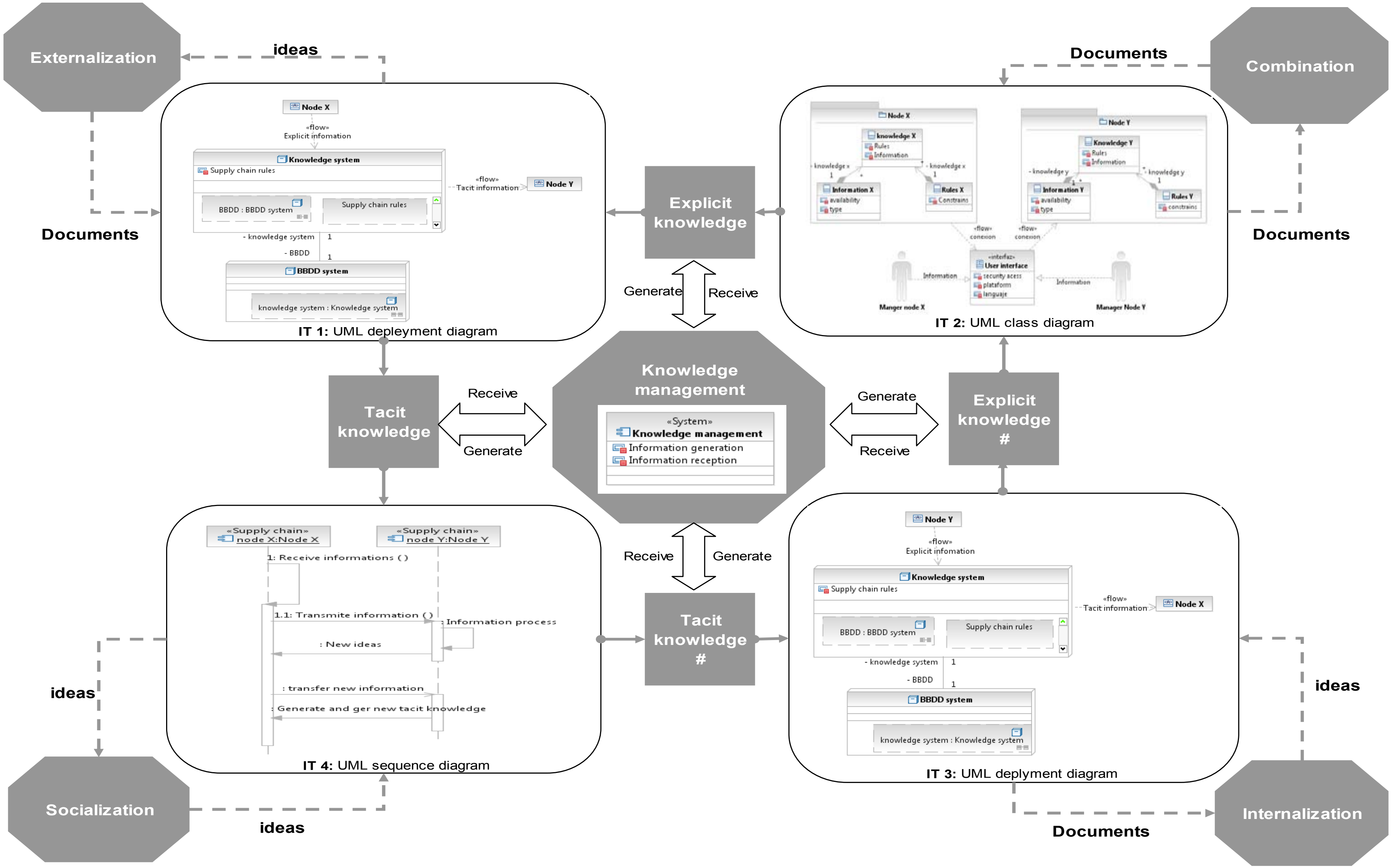

Figure 3. Collaborative knowledge management UML-based framework. A conceptual perspective

5. Conclusions

In most general cases, collaborative activities imply a distributed decision-making process which involves several SC nodes. In this paper, a collaborative UML-based KMF architecture is proposed. In addition, this proposal synthesizes existing knowledge, and it not only fulfils, but enriches each of its components with the modeller's own knowledge. For future research, the model will be extended to solve interoperability matters in a real environment by considering technologies and standards in an open-source context to implement the proposed collaborative framework, and by also considering other languages than UML for each IT presented in the CKMF.

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