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RESEARCH PAPER

# Methodology for the Implementation of Knowledge Management Systems 2.0

## A Case Study in an Oil and Gas Company

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**Abstract** Web 2.0 and Big Data tools can be used to develop knowledge management systems based on facilitating the participation and collaboration of people in order to enhance knowledge. The paper presents a methodology that can help organizations with the use of Web 2.0 and Big Data tools to discover, gather, manage and apply their knowledge by making the process of implementing a knowledge management system faster and simpler. First, an initial version of the methodology was developed and it was then applied to an oil and gas company in order to analyze and refine it. The results obtained show the effectiveness of the methodology, since it helped this company to carry out the implementation quickly and effectively, thereby allowing the company to gain the maximum benefits from existing knowledge.

**Keywords** Knowledge · Knowledge management · Web 2.0 · Web 2.0 tools · Big data · Big data tools · KMS 2.0

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## 1 Introduction

Knowledge management (KM) helps enterprises to provide customers with better products and services, in response to their ever-increasing demands as to flexibility, speed and quality (Ipe 2003). Thus, an important part of overall business administration is the management of knowledge, which comprises the systematic analysis, planning, acquisition, creation, development, storage and use of knowledge (Nakamori 2003).

A key factor for achieving correct KM in an organization is the development and implementation of a knowledge management system (KMS) to manage the knowledge of organizations automatically (Alavi and Leidner 2001; Day 2001). KMS have three common applications: (a) to codify and share best practices, with the aim of transferring them internally; (b) to create directories of corporate knowledge by identifying, classifying and codifying existing internal abilities, since organizations possess a great deal of knowledge that remains hidden and uncoded; and (c) to create knowledge networks which allow users to communicate in a quick and simple way (Alavi and Leidner 2001).

Since they emerged in the mid-1990s, the majority of KMS have concentrated on identifying and capturing explicit and tacit knowledge related to the company and centralizing it in a widely available company platform. According to Ernst and Young (2001), the main kinds of KMS platforms are Intranets and corporate portals, data warehouses or knowledge repositories, decision support tools and document management systems. However, the results show that the expected outcomes have not been achieved (Serenko et al. 2010). Two main causes for this have been identified (Davenport 2005). One is the difficulty in finding what users need, and the other is that the abovementioned platforms do not allow knowledge to be captured, shared and applied easily. As a result of this, the greater part of the knowledge of company best work practices, relevant experience, tacit knowledge and outputs remain invisible to most people (McAfee 2006).

In addition to these KMS (which could be called traditional), in recent times also KMS 2.0 have appeared. KMS 2.0 are KMS that use Web 2.0 and Big Data technologies and are focused on facilitating collaboration in order to enhance knowledge (Kakizawa 2007; McAfee 2006; Shimazu and Koike 2007). KMS 2.0 have generated renewed expectations for the way in which they might help organizations to improve their KM (Pawlowski et al. 2014). KMS 2.0 are based on the participation of people who generate new knowledge and are not limited to just consuming it, i.e., users are active contributors (Razmerita et al. 2009). Therefore, in contrast to traditional KMS, which concentrate only on capturing knowledge, KMS 2.0 are focused on the practices and output of knowledge workers (McAfee 2006). KMS 2.0 provide the framework, while the content is provided by users (Omerzel 2010). Another difference is that traditional KMS are highly structured from the start and users have little opportunity to influence this structure. This increases the difficulty involved in capturing highly unstructured knowledge work that has to be fitted and recorded in a database of unflexible categories (Trimi and Galanxhi 2014). However, in KMS 2.0, companies build an initial structure and hierarchy, and users can constantly change this structure, thus creating new content, links and tags as a part of their regular daily routines. Nevertheless, both types of KMS work on similar principles, which allow them to manage knowledge within the enterprise (Levy 2009; Paroutis and Al Saleh 2009; Schneckenberg 2009).

On the one hand, KMS 2.0 use Web 2.0 technologies because they offer a variety of tools that make it possible to communicate with others more effectively, encourage collaboration, and facilitate social interaction and the sharing of knowledge (Kirchner et al. 2009; Wu et al. 2013). Nowadays organizations are very interested in Web 2.0 tools, since these (1) act as a harbinger of how people will behave in the future (Abramowicz et al. 2010) and (2) increase agility (new ideas, suggestions and opportunities are shared), flexibility (work elements are broken down) and productivity (they provide faster and easier communication, collaboration and content management within and across companies) (Trimi and Galanxhi 2014). These Web 2.0 technologies can be provided by the companies, which develop and integrate them into company social software platforms to foster employees' collaboration and communication, or they can be developed by external companies and open to everybody (Kügler et al. 2015).

On the other hand, KMS 2.0 can also take advantage of Big Data, since recent technological revolutions such as Web 2.0 technologies make it possible to generate data much faster than in the past (McAfee and Brynjolfsson 2012). To describe Big Data, the Vs framework have emerged as a common structure. Hence, Big Data can be defined as follows: "Big Data is high-volume, high-velocity and high-variety information assets that demand cost-effective, innovative forms of information processing for enhanced insight and decision making" (Gartner IT Glossary 2016). Three futher Vs have been added, subsequently, to the previous ones: Veracity, which represents the unreliability inherent in some sources of data; Variability (and complexity), which refers to the fact that Big Data are generated through a myriad of sources; and Value, which refers to the fact that data in their original form usually have a low value relative to their volume, but a high value can be obtained by analyzing large volumes of such data (Gandomi and Haider 2015). Regarding the fundamental question of how big the data have to be to qualify as Big Data, there is little consensus on the issue. The limits depend upon the size, sector and location of the company and these limits evolve over time (Gandomi and Haider 2015). In this sense, Kaisler et al. (2013) defined these limits as the amount of data just beyond the capacity of traditional data management and analysis technologies to store, manage and process it efficiently.

Big Data allows knowledge to be extracted (with few hardware resources) from large amounts of data, such as machine-generated data, log files, e-mail messages, unstructured text, video, images, audio posted on public/company social networks, and other types of information sources (Wieczorkowski and Polak 2014). Based on the characteristics of collected data, different methods and technologies can be applied to discover knowledge (Gandomi and Haider 2015). Organizations view Big Data as a valuable asset and a source of competitive advantage in many business settings (Schermann et al. 2014; Shao and Lin 2016), and they are making important efforts to develop and optimally use Big Data technologies in order to take the appropriate decisions (Zhao et al. 2015). Big Data technologies allow to monitor key factors for strategic decisions, such as customer opinions about a product, service or company, by mining social media data (Tan et al. 2013).

The development and implementation of a KMS 2.0 in an organization is a complex task that requires the participation of users (who need to acquire skills in selecting, reflecting and redistributing knowledge online while ensuring its quality) and of the organization (which needs to acquire the organizational capacity to react adequately to the content generated by users) (Schneckenberg 2009). Significant technological and cultural changes also need to be carried out within the organization, since this is not just a technological improvement but involves a new interpretation of knowledge management based mainly on the contribution made by users (Bebensee et al. 2011). Therefore, Pawlowski et al. (2014) identify four categories of challenges related to KMS 2.0 development: social and cultural dimensions, organizational dimensions, technical dimensions, and knowledge protection and legal dimensions.

Similar to other IT projects, organizations also need a methodology that shows them how to deal with the innovation and change involved in implementing advanced software, in order to shorten the time needed to obtain business benefits and reduce the risk of failure in the implementation (Fichman and Moses 1999). This KMS 2.0 development methodology can be defined as a framework for applying KMS development practices, and should establish the phases of system development along with the proper sequence of applying them, the human roles in each phase, the products of each phase, and guidelines and metrics for progress monitoring and quality assurance (Razieh and Raman 2015).

The literature, however, does not contain any specific methodologies to help with the development of KMS 2.0 (Mariscal et al. 2010). The literature that does exist on the topic of KMS 2.0 technology focuses primarily on the characteristics, opportunities and benefits they offer (McAfee 2006; Musser et al. 2006; O'Reilly 2005; Schneckenberg 2009) but does not offer any methodological guidelines regarding phases, human roles, products or metrics of the KMS 2.0 development process.

On the other hand, the methodologies that are oriented towards traditional KMS Development (KMSTD) could be considered. The most comprehensive methodologies which exist in this context are those presented by Amine and Ahmed-Nacer (2011), Chalmeta and Grangel (2008), Iglesias and Garijo (2008), Moteleb et al. (2009), Rubenstein-Montano et al. (2001), Sarnikar and Deokar (2010), and Smuts et al. (2009). However, currently existing KMSTD have the following weaknesses that make it difficult to develop a proper KMS 2.0 (Razieh and Raman 2015): they do not fully cover the basic phases of KMS development (requirements engineering, analysis, design, implementation, test, deployment and maintenance); planning activities have been neglected; they lack feasibility-study activities; they lack a clear and accurate specification of the activities of each phase and their execution sequence, prescribing an activity without suggesting specific techniques for performing it; some of these methodologies have not been used in practice; some of these methodologies are of a more theoretical nature rather than practice-based; there is poor user involvement, restricted to validation; they lack an accurate specification of the appropriate technologies and tools, not taking into account the possibilities of Web 2.0 and Big Data technologies to support KM; they lack attention to distinguishing tacit KM from explicit KM; there is absence of periodical validation; the enterprise model 2.0 is not considered; no mechanisms are established for promoting the cultural change needed in order to foster the sharing of knowledge; they failure to determine managerial responsibilities and their assignment to the right individuals; they failure to manage the financial resources properly; lack of attention to user requirements at different organizational levels; and they do not allow the business processes and jobs to be redesigned so that they can use the knowledge that resides in the KMS 2.0 and generate new knowledge.

Consequently, there are a number of problems concerning the methodologies for managing KMS 2.0 development and implementation projects that remain unsolved. Hence, there is still room for significant improvement as regards both their theoretical aspects and their practical applicability (Šajeva 2007).

To help solve this problem, this paper proposes a step-by-step methodology, called Web 2.0 Knowledge Management (W2KM) methodology, which can guide the entire process of developing and implementing a KMS 2.0. This W2KM methodological guide is composed of phases, each of which contain different activities, and these activities are in turn made up of several tasks. In order to improve and debug the W2KM methodology, it was applied in a large oil and gas company.

This paper is organized as follows: Sect. 2 presents a review of the literature related with Web 2.0 tools, Big Data tools and knowledge management 2.0. Section 3 outlines the W2KM methodology proposed here for the implementation of a KMS 2.0, which is applied in a case study that is described in Sect. 4. Finally, the main conclusions and the limitations of this work are analyzed and discussed in Sect. 5.

## 2 Literature Review

The term Web 2.0 was first used by O'Reilly Media and MediaLive International in 2004 as the name of a series of conferences held by them (Antonova et al. 2009; Lee and Lan 2007; Levy 2009). There is no generally agreed definition of Web 2.0. One of the most widely used is the one proposed by Tim O'Reilly, who defines it as "a set of economic, social, and technology trends that collectively form the basis for the next generation of the Internet – a more mature, distinctive medium characterized by user participation, openness, and network effects" (Musser et al. 2006, p. 4). Web 2.0 applications are constantly updated and improved as more and more people use them, thereby consuming and mixing information from multiple sources. Users provide data and services in a way that allows others to blend them again, thus creating a network of effects through the "architecture of participation" (O'Reilly 2005). Web 2.0 is not only a new generation of technologies, but also a change in the way in which users access the Internet in order to mutually interact and collectively create knowledge. The characteristics of the knowledge managed by means of Web 2.0 tools are as follows (Lee and Lan 2007):

- Contribution: Each user has the opportunity to freely provide his or her knowledge.
- Sharing: Knowledge contents are freely available for others (through security mechanisms).
- Collaboration: Knowledge contents are created and maintained by means of collaboration among the suppliers of knowledge.
- Dynamism: Knowledge contents are constantly updated to reflect changes in the environment and the situation.
- Trust: The contribution of knowledge must be based on trust among the suppliers of knowledge.

Web 2.0 consists of a set of emerging tools that provide the basis for a more mature Internet, in which users collaborate, share information and create networks in large communities (McAfee 2006; Musser et al. 2006; O'Reilly 2005). Some of the most common Web 2.0 tools include: Wikis, Group chat, Social bookmarking, Mashups, Blogs, RSS, Folksonomy, Podcasts, and Social Networks.

From the users' point of view, to be able to manage knowledge in an organization successfully the Web 2.0 tools must possess certain fundamental features (Dai et al. 2007), including:

- System functionality: Users must experience the system the system as "friendly", easy-to-use and under control.
- Quality of the content: The core of all online information systems is the content, which must therefore be reliable, relevant, timely and appropriate.
- Exchange and accessibility of the content: The system must motivate the user to exchange useful information and to share knowledge.
- Sociability: The system must possess a high level of social integration, since this is crucial for the success of any online community.

Normally, emerging technologies emerge in enterprises and are then passed on to consumers. But in the case of the Web 2.0 the flow was inverted, since they appeared first among consumers and were later transferred to enterprises (Kakizawa 2007). Thus, Web 2.0 tools have already successfully proved their capacity to manage knowledge related to people's leisure. To validate the claim that Web 2.0 tools are appropriate for managing the knowledge in an enterprise, Levy (2009) compared Knowledge Management and Web 2.0 on the basis of four aspects: (a) concepts, (b) principles, (c) functional skills of tools and applications, and (d) organizational culture. The conclusion that was reached was that Web 2.0 tools are perfectly well suited for managing the knowledge of any enterprise, but it must be borne in mind that the Web 2.0 is focused on people, while knowledge management is centered on the organization. Hence, to take advantage of the characteristics of the Web 2.0, enterprises need to change the approach they took with the traditional KMS.

Therefore, during the development of a KMS 2.0 for an enterprise it is essential to take into account the common elements that characterize all the Web 2.0 technologies used in the enterprise. These elements were first identified by McAfee and referred to by the abbreviation SLATES, which stands for: Search (providing search query capabilities that allow content to be located easily, quickly and automatically); Links (guiding the user towards what is really important and also structuring the online content); Authorship (allowing any user or any group of people to create contents); Tags (offering a new collaborative way of categorizing contents by means of folksonomy); Extensions (using suggestions and recommendations to speed up searches); and Signals (receiving notices when a site that is of interest to the user is modified) (McAfee 2006). One year later, Dion Hinchcliffe proposed a different mnemonic to represent the elements that characterize Web 2.0 technologies in the enterprise. The abbreviation in this case is FLATNESSES, which consists of the same elements as SLATES plus four new elements: Freeform (the system must be capable of evolving freely, so as to become what users want it to be); Network-oriented (the content of the applications must be Web-oriented, as well as addressable and reusable); Social (it must allow users to share their social information); and Emergence (something complex can arise from relatively simple interactions) (Hinchcliffe 2007).

Traditional KMS are closed systems that store answers to issues that may possibly arise in the course of a job, supposing that workers are carrying out tasks that have previously been anticipated and described. Such an assumption creates a barrier which hinders innovation because it prevents workers from sharing their new ideas with their colleagues, so that they can be discussed, debated or generated. Closed systems do not allow communities to take control over their own knowledge – instead they separate creation from integration. Innovations therefore take place outside the systems and the systems contain information that is passed on chronologically, which reflects a point of view from outside the work itself (Brown and Duguid 2000; Fischer and Ostwald 2001).

The Web 2.0 has reinvented the concept of knowledge management by basing itself on the idea of facilitating the interaction, cooperation and exchange of knowledge among individuals, groups and communities. In the Web 2.0, there is no distinct differentiation between individual and collective knowledge. The Web 2.0 focuses on the exchange of knowledge and collaboration among employees, who are the knowledge workers in the organization. The aim of such an approach is to take advantage of collective intelligence and speed up the flow of knowledge among people through formal and informal communication, collaboration and social networking. Web 2.0 tools cover the different facets of knowledge management well (Kirchner et al. 2009).

Knowledge is one of the most valuable resources for an organization, and the most important type of knowledge is located inside people's heads: it is *embrained* (Blackler 1995). To reflect this, KMS 2.0 makes it necessary to change the way knowledge is managed, since management must now be person-based. Furthermore, the use of Web 2.0 tools to manage knowledge enables organizations to obtain important benefits at a lower cost than by using traditional KMS (Razmerita et al. 2009). When it comes to promoting products and services, Web 2.0 tools enable organizations to reach a high communication visibility more economically, as well as providing them with valuable feedback (Kirchner et al. 2008): They make it possible to capture the "wisdom of the crowd" (Surowiecki 2004).

Moreover, KMS 2.0 can also be complemented by Big Data tools, since these tools allow enterprises to extract and generate new knowledge from large amounts of structured and unstructured data (Syed et al. 2013). In recent years there has been a decrease in the cost of data storage and data processing, and an increase in data sources (social networks, mobile devices, machine-generated data, etc.), which has caused the exponential growth, availability, and use of information (Jeong and Shin 2015). Big Data refers to data sets that are too large and complex to be processed using traditional means of storage like relational database technologies and analysis technologies (Debortoli et al. 2014). Big Data tools summarize technological developments and techniques in the area of data storage and data processing that allow the handling of exponential increases of data in terms of volume, variety, velocity, value and veracity (Schermann et al. 2014). Big Data could be seen as an evolution of business intelligence which focuses on obtaining reports, mainly as indicators to measure past business performance, from structured internal company databases. Thus, Big Data focuses on extracting value from semi-structured and unstructured data originated in data sources like the Web, mobile devices or sensor networks. Another difference is the types of questions they answer, which, in the case of Big Data, are related to exploration, discovery and prediction (Debortoli et al. 2014).

Companies have far more data available to them, and they want to take advantage of that amount of data. Big Data is able to generate knowledge from these data (Erickson and Rothberg 2014) and can do it with speed and accuracy, which can be very relevant and valuable for the performance of the enterprise in various dimensions, as well as for the support of decision-making (Dutta 2015; Song et al. 2015). Not only is Big Data able to extract knowledge from data generated by the enterprise itself (e–mail messages, machine-generated data, log files, transaction records, sensor data, internal Web 2.0 tools, and so on), but it can also extract knowledge from data generated by external applications (messages posted on public Social Networks, data in public repositories, data published on websites, GPS signals, and so forth) (Wieczorkowski and Polak 2014). This knowledge will enable the organizations to achieve a competitive advantage over their competitors, develop new products and/or services, make strategic and operational decisions, identify what has happened, and predict what will happen in the immediate future.

Nevertheless, despite their benefits, the chances of failure in the implementation of KMS 2.0 in organizations are high. According to Šajeva (2007), there are five types of barriers that restrict knowledge management in organizations, and they also appear when Web 2.0 technologies are used:

- Barrier 1: Individual barriers are the barriers related to users. The main types are: Fear, for example, of losing authority and power, or of becoming replaceable; Lack of motivation, for example, lack of commitment or the refusal to do intrusive and extra work; and Personal characteristics, for example, poor communication and interpersonal skills, or lack of awareness of KM strategies and tools.
- Barrier 2: Organizational context related barriers refer to behavioral and organizational aspects. The main ones are: Cultural barriers, for example, closed corporate culture or resistance to change; Structural barriers, for example, rigid hierarchies, or lack of formal and informal tools to collaborate, reflect and generate knowledge; Management related barriers, for example, lack of motivational and reward systems, or lack of management commitment; and Strategic management related barriers, for example, lack of a proper KM strategy or lack of specific business objectives.
- Barrier 3: Technological barriers are related to technology and tools. In order to use the tools properly and take advantage of all the benefits offered by technology, it is necessary for users to have easy access to the tools and to feel comfortable using them. Examples of

this kind of barriers are: cumbersome or complicated use of tools, or a lack of training, familiarity and experience with the tools.

- Barrier 4: Project management related barriers are those affecting the proper development of the project. Examples are: lack of user commitment and involvement in the project, lack of suitability of training and reward systems, lack of time and resources for KM activities, or lack of staff with the required technical and business expertise.
- Barrier 5: Knowledge nature related barriers refer to the fact that each type of knowledge has different features and different management difficulties. For instance, explicit knowledge is easy to find and recognize, and it is therefore easy to share. However, tacit knowledge is hard to express, and difficult to share. It is this latter type of knowledge that offers more complexity and difficulties when it comes to managing it. Examples of such barriers are difficulties in identifying and extracting knowledge, or difficulties in knowledge evaluation.

## 3 W2KM Methodology

The aim of this paper is to present a methodology that is capable of offering guidance throughout the process of developing and implementing a KMS 2.0 using Web 2.0 and Big Data tools. The Web 2.0 Knowledge management (W2KM) methodology consists of phases that can be broken down into activities, which in turn are made up of tasks. The W2KM uses the traditional phases of an information system project. It is the tasks that must be carried out in each phase that make the difference, because these tasks cover all the steps concerning organization, analysis, design, development, control, modification, and updating that are needed to complete a KMS 2.0 project.

The W2KM methodology can help to collect, generate, manage and apply the knowledge generated both inside the organization and by the external relationships of the organization, and then transfer it to the right people easily and quickly. During the development of the W2KM methodology, the five barriers to knowledge management defined by Šajeva (2007) were taken into account. Furthermore, it can be applied both by members of staff who work in the organization and by those who work for an external consulting service. It is also valid regardless of the number of users and the number of branches the organization has.

The procedure used to develop the W2KM methodology is as follows. Initially a preliminary version of the W2KM methodology was developed based on the authors' previous experience in knowledge management projects and knowledge management 2.0, as well as on the review of the existing literature. A final version was later produced using the case study method. This case study was carried out by applying the preliminary version of the W2KM methodology in a big oil and gas company, with the aim of using the conclusions from the study to improve it.

The final version of the W2KM methodology is divided into seven phases (similar to those of a classical software development methodology), as shown in Fig. 1. We have simplified the description of phases and activities in the waterfall model. However, the processing stages may not be executed sequentially, because the KMS 2.0 development can be split into knowledge blocks. Therefore, a company can decide to follow an iterative model, and carry out series of mini-waterfalls from the analysis phase. Then, all the phases of the waterfall are completed for a knowledge block, since inside a knowledge block development each phase depends on the results obtained in earlier phases. In the following, each phase of the W2KM methodology is described in greater detail.

### 3.1 Phase 1: Draft

The aim of this phase is to study the feasibility of the project for the organization, that is to say, whether it is in the organization's interests to undertake it and if it is going to be cost effective. It also makes those running the organization aware of the benefits that can be obtained from using Web 2.0 and Big Data tools to manage knowledge, as well as of their limitations.

### 3.2 Phase 2: Planning

Several tasks are performed in this phase: to build commitment within Management, obtaining a proactive attitude towards the project at the Management level; to set up the project management team, whose members will make the decisions throughout the project, and also the project coordinator and the Community Manager who will have to manage and negotiate between the communities that exist within the organization; to establish specific aims by using SWOT analysis and mechanisms of control; to determine the technological and the human resources that will be needed to carry out the project, that is, the technical human resources that will be in charge of carrying out the different activities and tasks in the project, and the future users who are going to participate in the identification, extraction and codification of the knowledge that the organization wishes to manage; to define the internal communication policy of the KMS 2.0 project, trying to make the communication flow in both directions rather than just the traditional "from top to bottom"; and to draft a work schedule containing all the tasks that are needed to implement the project,

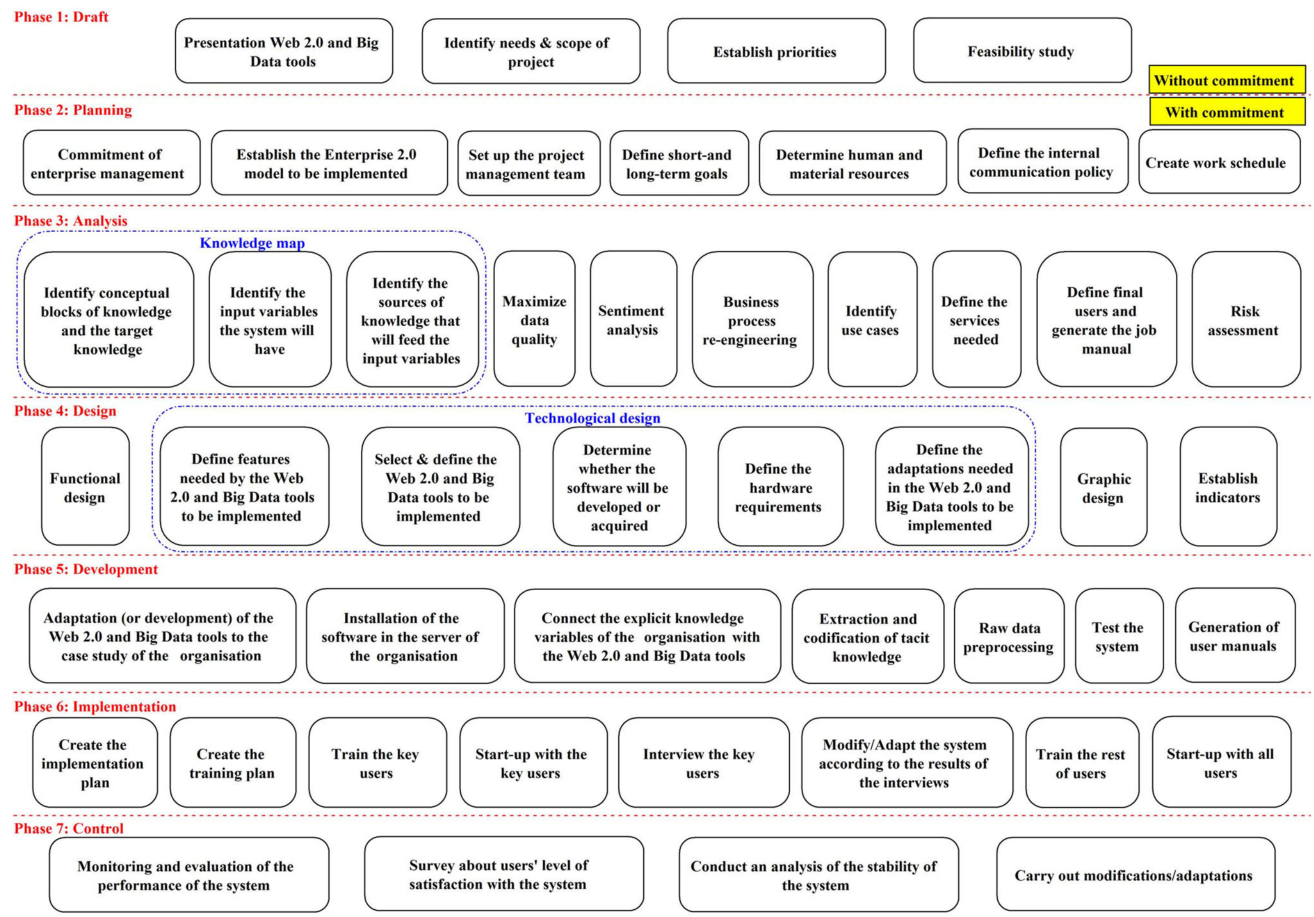


**Fig. 1** Phases and activities in the methodology

including the people in charge of each task and the dates on which these have to be carried out. Together with the timeline, it is also necessary to establish the quality control mechanisms and draw up the plan for change.

### 3.3 Phase 3: Analysis

The first thing to be undertaken in this phase is to identify the target knowledge, that is, all the knowledge that the company wants possess because it is useful to the organization and will provide an added value when utilized. This target knowledge will be processed, generated, stored and distributed by the KMS 2.0. To make it easier to identify it in an organized fashion, it is best to begin by identifying the conceptual blocks of knowledge which are the basic entities of the organization or of its environment and contain a particular type of target knowledge (Chalmeta and Grangel 2008). These conceptual blocks of knowledge are different for each type of organization, since such blocks can only be defined by taking into account the strategic objectives of the organization and its core activities. Examples include owners, suppliers, customers, employees, administration and trade unions, organization, products or services, processes, and resources, etc. The next stage is to identify the input variables that will make it possible to obtain the target knowledge inside each knowledge block. These input variables may be data, documents, video, audio, text, posts, etc. and information or knowledge held by people related to the organization. Furthermore, it is also necessary to identify the sources of knowledge (both internal and external) that will supply the input variables. Sources of knowledge can be tacit, such as employees, customers, etc., or explicit, like social media, archived documents, records of stakeholders correspondence, company applications, public Web, machine log data, sensor data, etc. For example, a company launches a new product and is interested in knowing its customers' opinion about the price. In this case, the knowledge block is the product, the knowledge target is the product price, the knowledge source are the customers and the input variables can be, for example, the customers' tweets about the price of the new company product.

In order to take advantage of Big Data tools, it is necessary to ensure the good quality of the data (input variables in this case). This can be achieved by maximizing the following properties (Chiang and Sitaramachandran 2015): (1) Existence: the organization has or can get the data; (2) Validity: the data values are within an acceptable range; (3) Consistency: the same data have the same values regardless of where they are located; (4) Integrity: completeness relationships between data elements; (5) Accuracy: the data describe the properties of the model; and (6) Relevance: the data are appropriate to achieve the proposed objectives.

The publication of opinions in the Web allows customers to share their point of view about a product or service. These electronic word-of-mouth statements are very important for organizations, because it is a way to know how customers perceive their products and/or services. Therefore, in the following stage it is necessary to perform sentiment analysis (several techniques can be used, such as Natural Language Processing, Information Retrieval, and structured and unstructured Data Mining), in order to extract and analyze the public's mood and views (Ravi and Ravi 2015).

The next step is to re-engineer the business processes that need it. This is accomplished by redesigning the work processes while taking advantage of the possibilities that the KMS 2.0 offers to optimize them. The understanding of the processes of the organization that is generated as a result of the re-engineering of processes may modify the knowledge map of the organization.

In the following, the use cases, which are actions (access/generate knowledge) that the users will be able to carry out in the KMS 2.0, are identified for each activity in the business processes that is modified as a consequence of the implementation of the future KMS 2.0. Several different use cases can occur in one activity. The services that are needed, which are the capabilities that will be included in the KMS 2.0, are then defined. Then each of the final users that will interact with the system must be identified. To end this phase, an evaluation is performed of the possible risks that can arise and which may prevent the goals of the project from being reached, so that if they do occur, the organization is ready to react.

### 3.4 Phase 4: Design

This is the phase in which the functional, technological and graphic design of the KMS 2.0 is carried out. First of all, the functional design of the Web 2.0 and Big Data tools is defined. For each Web 2.0 and Big Data tool that is going to be used in the KMS 2.0 it is necessary to specify the way in which the input variables are going to be managed in order to obtain the target knowledge of each conceptual block of knowledge. This includes the procedure of extracting and calculating each variable, language, format of the variables (templates, types of documents, images, etc.), periodicity, norms of conduct, standards of development, and so forth. Furthermore, the format of all the different types of electronic documents and data that each Web 2.0 and Big Data tool will work with must also be defined. It is important to consider that Big Data tools also need to manage human information, which is characterized by being complex, unstructured, ubiquitous, multi-format, and multi-channel.

The technological design is then carried out. To do so, first the characteristics of the Web 2.0 and Big Data tools that are going to be implemented must be defined. After that, a decision must be made as to whether the software will be custom built or if the (commercial or free-distribution) application will be acquired and later tailored to meet specific needs. The next step is to define the hardware requirements as regards both the server where the Web 2.0 and Big Data tools are installed and the terminals to be made available to users and for communications. Lastly, an analysis is conducted of the modifications that must be made to the Web 2.0 and Big Data tools so that they cover the organization's needs. The application interface, which is the link between the capabilities of the application and the user, is then designed. The graphic design must be ergonomic, intuitive and in line with the message that the organization wishes to transmit. Finally, indicators are established for each Web 2.0 and Big Data tool with the aim of managing them in an efficient way.

### 3.5 Phase 5: Development

In this phase, the Web 2.0 and Big Data tools are installed, developed/customized and tested, and the corresponding user manuals are produced. First, the Web 2.0 and Big Data tools are adapted (if they are acquired either as commercial or open-source applications) or developed (if they are custom-built). The final graphic appearance has to be effective and both allow and foster interaction and collaboration among users. It also has to comply with the fundamental characteristics of Web 2.0 tools discussed in the literature review section as regards functionality, quality, accessibility and sociability.

Once the KMS 2.0 has been developed and installed in the organization's server, it has to be filled with some initial contents that will later be expanded with the new knowledge provided by the final users during the course of their day-to-day work. Therefore the initial structure of the KMS 2.0 will be evolving dynamically due to the users' interactions. The new knowledge is obtained by processing the input variables. To do so, on the one hand, the explicit variables of the knowledge of the organization must be linked automatically with the corresponding Web 2.0 and Big Data tools. On the other hand, all the input variables within tacit sources (Nie et al. 2010) must be connected, extracted, codified, and parameterized. The new knowledge will be distributed through the Web 2.0 tools or the company/external computer systems.

Sometimes raw data from certain sources needs to be preprocessed previously, in order to be analyzed properly. There are several preprocesses that can be performed on the raw data, such as parts of speech tagging, tokenization, stemming, stop-word removal, and feature extraction and representation (Ravi and Ravi 2015).

Figure 2 shows the computer framework proposed to support the KM 2.0. The framework is composed of four modules: Content, Transfer, Enrichment, and Decision Support. In this framework the flow of information is cyclic because the producer of knowledge (the knowledge source) can be also consumer of processed knowledge (for example, social networks users). The role of each module is explained below.

*Content Module* includes the different type of knowledge sources, both tacit and explicit. These knowledge sources can also be consumers of the knowledge generated by the KMS 2.0.

*Transfer Module* is based on company/external Web 2.0 tools, and it works as a collector of the *raw material*. This *raw material* can be experiences, feelings, opinions, etc. that the different tacit knowledge sources of the Content Module introduce in the Web 2.0 tools (in KMS 2.0, the codification of tacit knowledge is performed by the sources

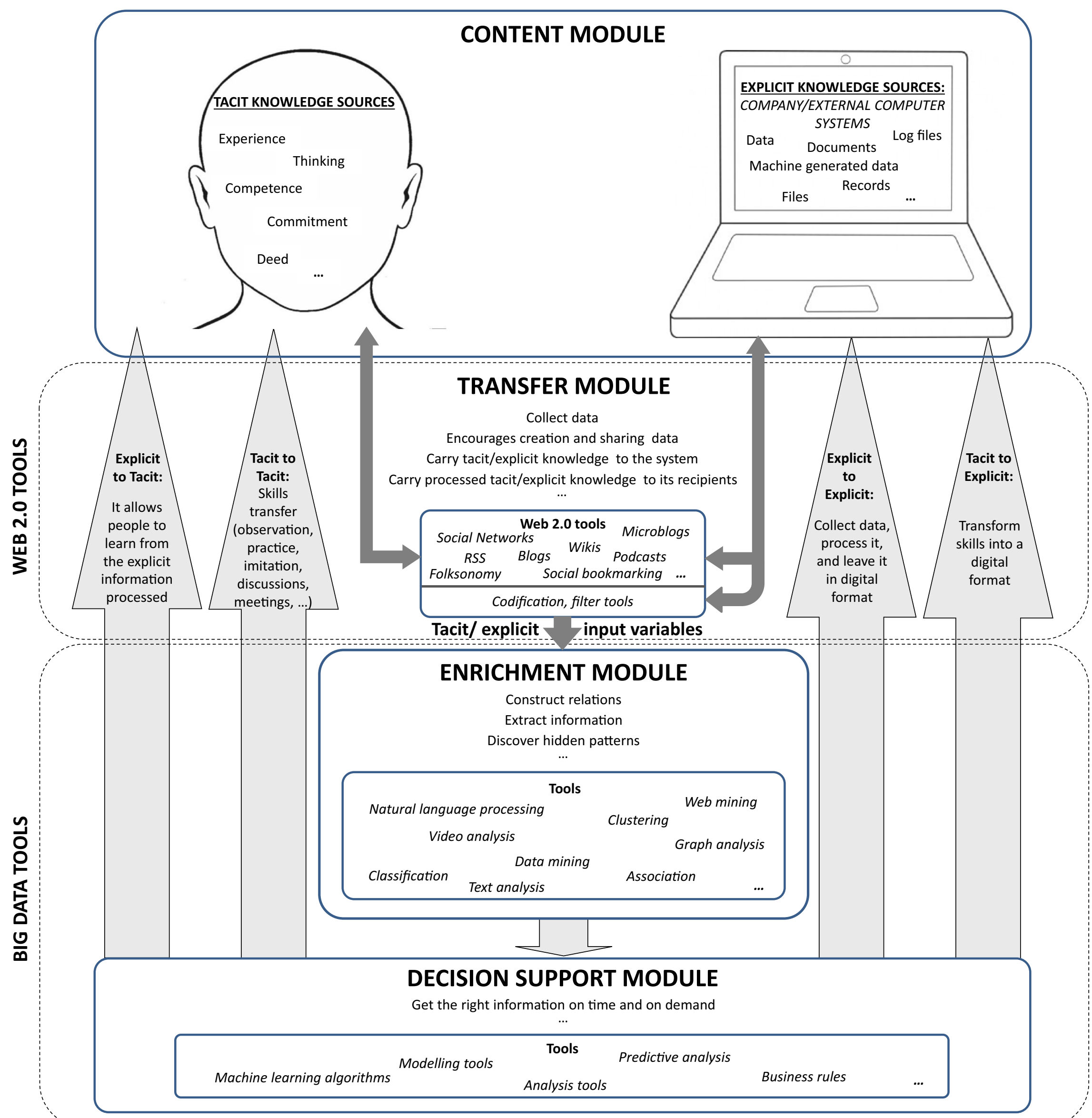


**Fig. 2** KMS 2.0 computer framework proposed

themselves), as well as data, documents, logs, etc. stored in company/external computer systems of the Content Module that the company links automatically to the Web 2.0 tools or directly to the codification and filter tools of the Transfer Module. Then, that collected *raw material* is filtered in order to identify only the tacit and explicit input variables needed to generate the target knowledge. Finally, the tacit and explicit input variables are inserted in the Enrichment Module to be processed and stored. Therefore, as these input variables are stored, they become permanent, even if they are removed from their original sources.

*Enrichment Module* is responsible for the processing of the input variables supplied by the Transfer Module and the generation and storage of new knowledge. Input variables are organized and analyzed using Big Data tools and machine learning techniques.

As data are acquired and generated from different sources and formats (video, text document, audio, image, etc.), they are analyzed separately based on their format using their corresponding machine learning algorithms. For instance, data coming from social media channels may be analyzed by using text mining, sentiment analysis, natural language processing (NLP), and so on, to manage and categorize human information. The use of machine learning techniques in this module allows the system to discover hidden patterns, extract meanings and relevant information, categorize or classify information from each individual source.

After data from the different sources have been analyzed and categorized, they are aggregated and integrated to create the new enriched metadata sets. That is, the newly discovered knowledge is used to add value to the original data. As a result, the enriched metadata will contain information about several topics, opinions, likes, reviews, features, etc. Although data from each source can provide useful insights by themselves, the combination of data from the different sources (enriched metadata) may help to significantly improve the performance of the prediction models in the next stage (Decision Support Module).

*Decision Support Module* is also based on a Big Data platform and contains machine learning algorithms. The main objective of this module is to support decisions, by generating new knowledge from the information obtained in the Enrichment Module using supervised and unsupervised prediction models, such as decision trees, logistic regression, artificial neural networks, clustering, etc. The suggestions of the prediction models are combined with business rules to support/generate the final decisions.

The use of these machine learning algorithms makes it possible to discover new trends and insights on data, examine new business opportunities, find inefficiencies in order to improve or innovate in services or products, etc. based, for example, on user preferences, wishes, actions, behavior, etc.

The new knowledge generated in this module is distributed through the Web 2.0 tools of the Transfer Module and other company/external systems (for example, to act directly on advertising banners, personalize advertising, add special offers, etc.), in order to provide the knowledge that each consumer needs when they need it.

In the case that the producer (knowledge source) and consumer of the knowledge are the same, four possibilities can happen, according to Nonaka's theory of organizational knowledge creation (Nonaka 1994):

- Produce tacit knowledge and consume explicit knowledge: People learn (acquires tacit knowledge) from the appropriate explicit knowledge processed by the system.
- Produce tacit knowledge and consume tacit knowledge: System allows that Tacit Knowledge like skills are transferred and learned, by observation, through practice, by imitation, etc.
- Produce explicit knowledge and consume explicit knowledge: Explicit knowledge is collected and processed by the system, and then the processed knowledge is also expressed explicitly.
- Produce explicit knowledge and consume tacit knowledge: Tacit Knowledge is transformed explicitly into a digital format.

### 3.6 Phase 6: Implementation

In the implementation phase, the system is put into operation. At first the system is only used by a subset of the final users (called "key users") of each Web 2.0 and Big Data tool. The purpose is to take advantage of their own experiences or impressions to debug and refine them. The key users of a tool are the people in charge of implementing, customizing and debugging it. They are also responsible for solving all the basic issues or doubts about the tool that any user may have (more important problems are solved by the Community Manager). It is then put into operation with all the final users.

The first step is to create an implementation plan that identifies all the users involved and indicates, for each of the Web 2.0 and Big Data tools to be implemented, the dates on which each of them will be put into operation, with both the key users and all the other users. Then the training plan is created.

### 3.7 Phase 7: Control

The control phase spans the whole useful life of the system. In this phase the system is monitored and, if necessary, capabilities are adapted or modified to solve errors and improve the system or adapt it to new ways of working in the organization.

## 4 Case Study

A case study was carried out by applying the methodology in a big oil and gas company, in which the qualitative data that were collected were submitted to an inductive analysis. The work plan that was followed in order to carry out the case study was based on Runeson and Höst (2009) and consists of five phases: Case study design and planning, preparation for data collection, collecting evidence, analysis of collected data, and validation of collected data. The results obtained in each phase are outlined in the following section.

What brought the enterprise to undertake such an implementation was mainly the need to gather and organize the knowledge of its customers and employees, as well as to take advantage of the large amount of data, both internal and public, that are of interest to the enterprise. They also aim to optimize the search for knowledge for their employees, so that, besides placing the knowledge they need at their disposal, they can also access it quickly and easily, thereby minimizing the time invested in getting it. Moreover, regarding the knowledge from external sources, they intend to keep it stored in a database located in a local server, in order to be able to access the knowledge faster and when they wish, regardless of the availability of such information at the source of origin at the time it is needed. In order to achieve this, it is necessary to gather and organize all the available information (both public and private) to allow the company to take the right decisions in the shortest possible time.

### 4.1 Case Study Design and Planning

The timespan of the case study was set to 12 months. The goals of this case study were: (a) to test the methodology developed to guide the implementation of Web 2.0 and Big Data tools for managing knowledge, while also verifying and confirming its usefulness, rigor and quality; (b) to analyze the result in order to determine the improvement offered by the methodology; and (c) to refine and improve the initial methodology with the aid of the experience gained and the conclusions drawn from the case study.

Two research questions, which will be examined while the case study is being carried out, were formulated: (a) Are Web 2.0 and Big Data tools suitable for managing the knowledge in this organization? and (b) Does this methodology facilitate the development and implementation of a KMS 2.0 in this organization?

### 4.2 Preparation for Data Collection

To apply the W2KM methodology, a mixed work team was set up with members coming from both the IRIS Research Group and the company Knowledge Project Management Team (KPMT). This KPMT was made up of three members of the Knowledge Management Department, who were a manager, a technician and a freelance consultant that had worked for the company for many years (who would also be the Project Coordinator), and three other representatives of the company, one from each of the following areas: Internal Communication Area, Intelligence and Investigation Area, and Marketing Area. The purpose of the KPMT was to be responsible for making decisions about all issues related to the work.

The data used to conduct this case study are qualitative and were collected by both direct and indirect methods. The direct method that was used consisted in interviews, where data are collected in real time and, additionally, the interviewer (one member of the IRIS Research Group) is in direct contact with the interviewees. The indirect method involved the analysis of different documents used in the enterprise. Moreover, the data obtained from the interviewer's observations were also taken into account.

### 4.3 Collecting Evidence

Data were collected through interviews after the execution of each phase of the methodology, using an assortment of questionnaires and templates, as well as copies of the documents and reports utilized in the enterprises. After each interview was completed, the answers were reviewed by another researcher from the IRIS Research Group, which provided another point of view. The reason for conducting the interviews after the execution of each phase was to be able to solve any problems and/or apply the improvements identified before starting the execution of the next phase. The interviews were carried out with each member of the KPMT, they lasted about 30 min, and they were individual, open (allowing interviewees to give any response) and semi-structured (the questions were used as a guide, not to be asked in that same order, and both the interviewer and the interviewee were allowed to improvise). The objectives of the interviews at each stage were: to analyze the execution of the phase, to detect errors and problems encountered, to obtain feedback from the experience of the interviewees, and to collect proposals for improving the W2KM methodology. The questions asked in the interviews were the same for each interviewee, but were different for each phase, as they were adapted to the specific characteristics of each phase.

Finally, when the methodology had been fully applied and the KMS 2.0 was implemented and working properly,

**Table 1** Analysis and design of the knowledge from the intelligence and investigation area

| Target knowledge | Input variables | Sources of knowledge | Web2.0/ Big Data tools | Users (permissions) | Format of the variables |
|---|---|---|---|---|---|
| External media information | Web documents | Subscriptions to newspapers and other external organizations | IDOL | All department users (read) | HTML documents |
| | RSS documents | | | | HTML documents |
| | Video files | | | | Any video format |
| | IMAP messages | | | | E-mail texts |
| External social media information | Publications on Twitter | Twitter API | IDOL | All department users (read) | Text published on Twitter |
| | Publications on Facebook | Facebook API | | | Text published on Facebook |
| Security risk level classification by country | Analysis of documents ingested in IDOL | Documents ingested in IDOL | Wiki | All department users (write); all area managers (read) | Text with graphics published on the Wiki |
| Security investigation reports | Analysis of documents ingested in IDOL | Documents ingested in IDOL | Blog | All department users (write); user requesting the investigation (read) | Text with graphics published on the Blog |

a questionnaire was distributed among the KPMT members and the key users in order to analyze their impressions about the features of the KMS 2.0.

The following subsections outline some of the more significant results obtained from applying the W2KM methodology to the enterprise in which the case study was conducted.

### 4.4 Phase 1: Draft

The Web 2.0 and Big Data tools were presented to four representatives from the enterprise, with special emphasis on the features, advantages and disadvantages of each one. The Web 2.0 tools that were proposed to cover the enterprise's needs were the Wiki, the Blog and the Social Network. Regarding the proposal for Big Data tools, the IDOL software and the Hadoop ecosystem were selected.

### 4.5 Phase 2: Planning

The enterprise representatives decided that the KPMT would be made up of three members of the Knowledge Management Department, who were a manager, a technician and a consultant plus the representatives of the Internal Communication Area, Intelligence and Investigation Area and Marketing Area. In addition, four analysts/programmers would be responsible for the required configurations and parameter settings. The cross-functional Enterprise 2.0 model was therefore followed. The enterprise representatives also defined the internal communication policy and they told everyone involved in the project to give high priority to the tasks related to it.

### 4.6 Phase 3: Analysis

When they were to identify the conceptual blocks of knowledge, which are the basic entities of the organization or of its environment that contain the knowledge the organization is interested in managing (Chalmeta and Grangel 2008), the following blocks were found within the scope of the case study project: Internal Communication Area, Intelligence and Investigation Area, and Marketing Area. The target knowledge that had to be managed by each conceptual block of knowledge was (a) Internal Communication Area: Internal documents; Employee information; Project information; Customer information; Working procedures; Information about the competences in each job; Notice board for suggestions and opinions from employees; Internal collaboration and solving doubts; Internal knowledge sharing. (b) Intelligence and Investigation Area: External Media information; External Social Media information; Security risk level classification by country; Security investigation reports. (c) Marketing Area: Information about competitors; Comparison of the prices of products and services; Customers' characteristics; Evaluation of customers; Reviews on public Social Media regarding products and enterprise image; Sector innovations.

The first four columns in Table 1 show the target knowledge, the input variables, the sources of knowledge, and the Web 2.0 or Big Data tool chosen to manage the knowledge from the Intelligence and Investigation block. The sources for External Media information and External Social Media information were selected by members of the Intelligence and Investigation department based on their needs. Initially 54 External Media information sources and

2 External Social Media information sources (Facebook and Twitter) with 62 different filters (accounts, hashtags, keywords, etc.) were selected. The company aims to increase the linked sources in the future. The sources for External Media information generated an average of 489 documents per day. The sources for External Social Media information generated an average of 963 documents per day. Considering the entire project, 146 data sources were linked, and they generated an average of 2254 documents per day.

With regard to the re-engineering of business processes, the processes affected by the KMS 2.0 were analyzed and some of them were modified. The main processes modified were: Analysis of information about competitors; Analysis of the prices of products/services; Analysis of products/services and company image in public Social Media; Ingestion of external Media information; Ingestion of external Social Media information; Analysis of customers; and Internal content management.

The services that the final users could carry out in the KMS 2.0 were then defined. For example, some of the services that it had to offer included: Writing, modifying and reading an article; Attaching a document to an article; Commenting on an article; Making a comment to a user; Posting important events on a calendar; Consulting active users; Tagging a file; Printing the articles on paper or in PDF format; Consulting the values of the indicators; Controlling for correct use and vandalism; and Reviewing the proper ingestion of the content of the feeds.

After defining the services, the profile of users that could have access was established together with the corresponding permissions. Column five in Table 1 shows an example of the permissions that were set for each input variable of the Intelligence and Investigation knowledge block.

Both the indicators and the frequency of the KMS 2.0 were established. Some of the indicators that were defined in order to control the use of the KMS 2.0 were: Number of accesses (daily); Number of new articles published (daily); Percentages of accesses for reading, modification and creation (weekly); Number of comments made (weekly); Number of doubts published (weekly); Percentage of doubts settled (weekly); Number of files tagged (weekly); Users' satisfaction (quarterly); and Number of IDOL queries (weekly). The indicators per user were: Number of accesses (daily); Number of new articles published (daily); Number of files tagged (weekly); Percentages of accesses for reading, modification and creation (weekly); Number of comments made (weekly); Number of doubts or problems proposed to other users (weekly); Number of doubts or problems from other users that have been settled (weekly); and Number of investigation reports generated (weekly). Once all the indicators had been defined, a reference value was established for each of them so as to allow their results to be evaluated.

## 4.7 Phase 4: Design

The functional design also included defining the format of the variables with which the KMS 2.0 would be working. Column six of Table 1 shows this format for the block of Intelligence and Investigation knowledge. In addition, it was decided that the KMS 2.0 would run in an open environment, so that the employees could access it both from within the facilities of the enterprise and from anywhere else in the world.

The features of the Web 2.0 and Big Data tools to be implemented were defined in the technological design. For example, in the case of the IDOL system, it was agreed that it should have: the standard capabilities of IDOL; Sentiment analysis; Social Media connector; IMAP connector; HTTP connector; RSS connector; Eduction; Conceptual search; and Automatic categorization.

With regard to the software to be implemented, the decision was made to acquire IDOL software, and also to acquire other free-distribution software and customize it to meet the needs of the enterprise.

## 4.8 Phase 5: Development

The Web 2.0 and Big Data tools were installed and customized. The explicit variables were then connected and the tacit variables were extracted, codified, parameterized and connected, and the system was tested. After that, the final integration trials were conducted by inserting fictitious data over the backup that was created for the tests, with the aim of ensuring that everything would work properly. Lastly, the KMS 2.0 user and administrator manuals were produced.

## 4.9 Phase 6: Implementation

In this phase both the implementation plan and the training plan were created; the latter told users who were going to have specific training, when they would receive it, and the syllabus that would be taught. In this case, one training course was given for the key users, who were 10 users in all: 5 from the Internal Communication Department, 3 from the Marketing Department, and 2 from the Intelligence and Investigation Department. The course lasted 4 h and was given in two 2-h sessions. For the remaining users, manuals were created to guide them in the use of the system.

After the key users had used the system, they realized the possibilities that Web 2.0 and Big Data technology could provide to their company. In the interviews that were carried out, these users identified different business processes of several departments that could also benefit from this technology, and which are listed in Table 2. Some of those business processes were modified and/or adapted following the instructions of these users, and as a result, a high degree of optimization was obtained. The remaining business processes that were identified will be improved in future projects, as they were not included within the project scope of the case study.

### 4.10 Phase 7: Control

This phase is carried out while the KMS 2.0 is actually working. It was established that the Community Manager has to monitor the system every week to ascertain the performance of both the KMS 2.0 and its users. This is accomplished by comparing the value obtained in the indicators with that of the reference criterion of each of them. Once the indicators have been evaluated, a report is drafted and submitted to the appropriate managers of the enterprise, who then make suitable decisions based on that information.

Every quarter, the Community Manager gives all the users a survey about their level of satisfaction as regards the KMS 2.0, in order to determine the degree of acceptance as well as to gather proposals for improvement. The survey is anonymous and voluntary for users. The information thus obtained is studied and, if necessary, appropriate modifications are made. The Community Manager also conducts an analysis of the stability of the system every quarter, which involves reviewing the KMS 2.0 and carrying out tests to ensure that it is working properly and that it is also being used properly. A system of rewards was also set up for users who participated on an active basis. This reward system is modified every 3 months.

All the users of the KMS 2.0 were told that as soon as they detected an error or identified a proposal for improvement they should inform their superiors, who would notify the Community Manager so that he or she could study them and carry out appropriate modifications if needed.

### 4.11 Analysis of Collected Data

After each interview with the members of the KPMT, the answers were compiled and analyzed. Most of the comments were positive, noting that the W2KM methodology guided them in all the steps required for each phase, and that the implantation was faster and more comfortable than other implantations in computer system projects in which they had previously participated. They also indicated that the methodology allowed them to better identify the needs, consequences, scope and opportunities of the project. Among the main points that they highlighted were the fact that they realized the importance of data quality in order to achieve an optimal system performance, and the ease with which they could re-engineer existing business processes. They were also amazed with the amount of information that they could use and were not exploiting so far. Moreover, once they knew the potential offered by Web 2.0 and Big Data technologies, they thought about more ideas for future projects. Not all the comments were positive, but negative comments were considered to improve the methodology. Examples of this type of comments can be the need to identify the profiles of end users of the system, or the need to deliver a presentation to the managers in the first phase of the methodology, explaining the potential offered by Web 2.0 and Big Data tools, so that they could understand the benefits that these tools can offer to the company.

Once the case study had finished, the questions posed in the case study planning and design phase could then be answered:

(a) *Are Web 2.0 and Big Data tools suitable for managing the knowledge in this organization?* Yes, they are. Both Web 2.0 and Big Data tools have some very interesting features that make them excellent candidates for application to knowledge management, since they make it possible to collect the different types of existing knowledge (both tacit and explicit) while also fostering the generation of new knowledge. Due to the characteristics of the information managed by organizations, they can benefit greatly from the opportunities offered by those tools. Big Data tools can extract knowledge from a large amount of structured and unstructured data that are generated by businesses. Moreover, Web 2.0 tools for use by private individuals are viewed favorably by Internet users and, as has been seen in the case study, this implies that they can also be well accepted in organizations and users can adapt to them quickly. This is especially true in the case of the younger employees, who are more likely to use this kind of tools for their own particular purposes. Thus, the users' attitude in this case study was far more positive and collaborative than in implementations of other types of tools carried out by the same researchers.

(b) *Does this methodology facilitate the development and implementation of a KMS 2.0 in this organization?* Yes, it does. The results obtained in the case study were satisfactory, as all the goals set out at the beginning were achieved, and the timespan initially established was accomplished without deviations. The development and implementation of the KMS 2.0 were swift and straightforward. Additionally, the members of the KPMT indicated that the methodology allowed them to have greater control over the project implementation, since it clearly defines all the steps that need to be carried out in each phase of the

**Table 2** Business processes identified in the case study that can be improved with the KMS 2.0

| Department | Business process |
|---|---|
| Strategic management | Real-time analysis of the competitive environment |
| | Detection of changes in the competitive environment |
| | Data-driven decision-making |
| | Strategic planning |
| Purchasing | Identification of suppliers |
| | Investigation of suppliers |
| | Gathering information about products and/or services |
| Operations | Troubleshooting in the services offered |
| | Increasing the quality of the services offered |
| | Offering an efficient catalogue of services based on sales trends analysis |
| Research and development | Monitoring the performance and quality of the services offered |
| | Monitoring of scientific publications |
| | Detection of scientific advances for topics of interest |
| | Monitoring the granting of patents |
| | Production of technological maps and scientific publications |
| | Acquisition of technical knowledge applied to products and services |
| | Innovation and process improvement |
| | Identifying the needs of customers of new services |
| | Identification of improvements in the services offered |
| Marketing/sales | Analysis of customer information |
| | Identification of potential customers |
| | Identification of the most valuable customers |
| | Analysis of competing companies |
| | Gathering information about customers' needs |
| | Research about the company image |
| | Service acceptance analysis |
| | Monitoring social networks |
| | Price monitoring |
| | Detection of new releases by competing companies |
| | Analysis of relations in social networks |
| | Predicting customer behavior |
| | Accurate prediction and awareness of customers' needs |
| | Making real-time customized offers |
| | Encourage participation and interaction in every channel |
| | Quick reaction to market opportunities |
| | Analysis of sales trends |
| Finance | Risk measurement |
| | Improvement of budgeting and forecasting |
| Human resources | Conducting investigations about employees |
| | Conducting investigations about potential employees |
| | Staff selection |
| | Monitoring of employees at work (through their computer and mobile) |
| | Detection of applications that are most used by each employee |
| | Detection of misuse of applications by each employee |
| | Investigation of what time the employees are most productive |
| | Discovery of teamwork patterns |
| | Predicting when employees are undergoing periods of stress that affect their productivity |
| | Identification of the leaders |
| | Employee retention |
| | Analysis of the effectiveness of recruitment campaigns |
| | Measurement of employee morale |
| Customer assistance | Identifying customers who are at risk of ceasing to be customers of the company |
| | Analysis of how customers use the company website |
| | Monitoring how customers use the services offered by the company to detect potential problems and/or improvements |
| Security | Performing security investigations |
| | Improvements in intelligence and surveillance |
| | Forecasting and mitigating real-time cyber attacks |
| | Crime prediction and prevention |

project. Furthermore, those responsible for the implementation did not need to be experts in Web 2.0 and Big Data tools or in knowledge management because the methodology provided them with detailed guidance at each step in the process.

Additionally, the members of the KPMT highlighted the following benefits resulting from the use of KMS 2.0 in the company:

- Centralization of the knowledge of the enterprise in an accessible and easy-to-use system, which helps to keep it flowing steadily.
- Fast and efficient settlement of doubts among members of the enterprise with the involvement of as few employees as possible.

- Fast and efficient communication, using the knowledge network that enables users to communicate in a fast, straightforward manner.
- Less time spent on meetings.
- Record all the doubts or problems with the solutions that were adopted so that they can be consulted in the future; hence, when new problems arise, they will take less time to solve it.
- Employees access the information they need when they need it.
- Access is gained to knowledge that remained hidden and uncoded, through the directories of corporate knowledge that are generated, which identify, classify and codify existing internal skills.
- Reduction in the number of internal e-mails sent.
- Knowledge generation from external Media and Social Media information.
- Sending real-time alerts about certain information received (both internal and external).

Hence, the KMS 2.0 that was implemented (1) covers the three basic capabilities that, according to Alavi and Leidner (2001), a KMS must have; (2) possesses the four fundamental features needed to be able to manage knowledge (Dai et al. 2007); and (3) helps to overcome the five barriers hindering a KMS 2.0 project that were identified by Šajeva (2007) and which have been described earlier in the introduction section. The following shows how the W2KM methodology helps to overcome the different barriers and to achieve the four fundamental features:

Barriers: *Barrier 1, Individual barriers*. Phase 6 (implementation) is focused on making users aware of the opportunity they are being afforded, through these tools, to create, retain or transfer knowledge and the benefits to be gained from it. Furthermore, interviews are held with key users in order to modify and/or adapt the system to their needs, thus involving them and making them part of the development of the system. On the other hand, in Phase 7 (control) satisfaction surveys are also carried out on all the users of the system with the aim of solving problems and adapting the system to their requirements; *Barrier 2, Organizational context related barriers*. Phase 2 is oriented towards motivating the human resources by means of a suitable communication plan that will identify the benefits they will obtain, as well as highlighting management's commitment and defining the long- and short-term objectives; *Barrier 3, Technological barriers*. Phase 4 (design) ensures that the graphical, functional and technological design of the system is adapted to the needs and characteristics of its users, thereby allowing them to use it easily; *Barrier 4, Project management related barriers*. The set of all phases of the W2KM methodology provides an excellent overview of the needs, scopes, consequences and opportunities of the project. It also allows good control over the project, since all the steps that must be taken are all clearly defined for each phase, activity and task. Specifically, Phase 2 (planning) ensures the managers' commitment to the project, and selects the necessary user profiles, while Phase 6 (Implementation) trains the users, thus involving them in the project; *Barrier 5, Knowledge nature related barriers*. Phase 3 (Analysis) performs an analysis of the knowledge map where each of the conceptual blocks of knowledge, input variables and sources of knowledge, both tacit and explicit, to be considered in the system are analyzed individually. This facilitates the identification, location, extraction and evaluation of the managed knowledge.

Fundamental features: *Feature 1 System functionality*. In the activity "Graphic design" of Phase 4 (design) the system is adapted to the needs and capabilities of the end users; *Feature 2, Quality of the content*. The activity "Maximize data quality" of Phase 3 (analysis) ensures the good quality of the data managed in the system; *Feature 3, Exchange and accessibility of the content*. The activity "Functional design" of Phase 4 (design) establishes how the system will work, what data will be used, and how they will be managed in the system. If the system provides useful information to the users, they will use it and therefore share knowledge; *Feature 4, Sociability*. The activity "Functional design" of Phase 4 (design) also takes into account the fact that the system has to encourage users to be socially integrated in the community by managing information of common interest, and facilitating contact and the sharing of data among users.

Finally, in order to check, from the users' point of view, that the KMS 2.0 that results from the application of the W2KM methodology possesses the fundamental features to be able to manage knowledge and that the methodology also helps to overcome the different barriers of a KMS 2.0 project that were identified by Šajeva (2007), a survey was conducted among the KPMT members and the key users 6 months after the launch of the system implemented in the case study. This survey transformed the features and barriers into questions that made it possible to measure that the extent to which the users thought that the KMS 2.0 implemented in the company had these features and that the barriers had been overcome.

Appendix 1 (available online via http://springerlink.com) shows the average of the values obtained in the survey. The values assigned for answers were: 1 = Completely Disagree; 2 = Disagree; 3 = Neutral; 4 = Agree; and 5 = Completely Agree. As can be seen from the results in Appendix 1, only one question obtained an average result lower than 3, which was "The time allocated to the system in the project is adequate". As a measure to solve this, the company undertook the commitment to ensure that more time will be allocated in the projects for the management of this system.

### 4.12 Validation of Collected Data

Because the data collected were qualitative, they were analyzed using qualitative data methods of analysis. The analysis was inductive and was carried out in parallel to data collection, as it was performed after finishing each of the phases of the W2KM methodology. The purpose of this was to be able to react quickly to the problems and improvements encountered during the analysis of each phase and thus solve each of the problems and take advantage of these improvements before starting the following phases.

Threats to the validity of the case study were reduced by using the Lincoln and Guba model (Robson 2002). This model proposes five strategies to be used in the collection of data to deal with three types of threats to validity. The three types of threats considered were *reactivity* (the researcher's presence can affect the setup of the study), *researcher bias* (the researcher's preconceived ideas can affect the way the researcher asks questions or interprets answers) and *respondent bias* (the researcher's influence on the attitude of the people being studied) (Karlström and Runeson 2006).

With regard to the five possible strategies, in the present case study they were considered in the following way in order to make the results valid: (1) *Prolonged involvement*: the researcher is familiar with the environment being studied (in this case study, the researchers and the company had already been collaborating in previous projects). (2) *Triangulation*: the application of several methods in the study of a single object. In this case study, four types were considered: (i) *Spatial triangulation of data* (three sources of data were considered: observation, interviews and documentation); (ii) *Personal triangulation of data* (all the members of the company KPMT were interviewed in order to obtain information from each of them); (iii) *Investigator triangulation* (the interviews were conducted by a researcher and reviewed by another researcher); and (iv) *Theoretical triangulation* (the different points of view of the members of the KPMT were taken into account). (3) *Member checking*: obtaining feedback from the people who are interviewed (in the case study, after each interview, a report containing the relevant information from the interview was checked by each interviewee). (4) *Negative case analysis*: attempting to find another explanation that differs from the one initially assumed for the observed phenomenon [here, the researchers were working separately (investigator triangulation)]. (5) *Audit trail*: keeping a record of all the documentation of the project so as to make it available in the future.

## 5 Conclusions

In this paper the authors have presented a methodology, based on recent achievements reported in theoretical references and related models, which helps to develop and implement a KMS 2.0. The methodology has been tested and debugged by means of a real-life case study. The findings demonstrate the value of the proposed methodology in terms of efficiency and effectiveness. Therefore, the KMS obtained from the application of the methodology possesses the fundamental features to be able to manage both explicit and tacit knowledge, and the methodology also helps to overcome the different barriers hindering a KMS 2.0 project. Our research contributes to the body of scientific knowledge on KM by using big data and web 2.0 tools, a novel and rapidly expanding field, where in terms of methodologies there is a need for more experimental studies as well as theory-based research (El Ouirdi et al. 2015). Likewise, as regards knowledge, it is necessary to investigate how tacit knowledge can be created and shared using web 2.0 technologies (Antonius et al. 2015).

The findings are useful for practitioners, who will be able to benefit from a series of advantages that cannot be gained by using previous KM methodologies, such as better planning and management of the project, an improved definition of the vision and strategy of the project, choosing the most suitable Web 2.0 and Big Data tools, and an estimation of the potential benefits to be achieved, as well as a higher probability of being successful.

Big Data tools are a very powerful way to clean and process large amounts of data to generate knowledge, since there is a lot of hidden knowledge in the Big Data that could be considered tacit knowledge. Users are accustomed to using Web 2.0 tools for their own personal purposes in an unregulated way. Yet, in the business setting this philosophy must not be applied as it stands because it would have a negative effect on the performance of the Web 2.0 tools for managing knowledge, since we would not be optimizing it to the full extent of its possibilities. The knowledge could be diffuse, difficult to find and control, and so on, yet with the suggested methodology the knowledge of the enterprise can be structured and stored, while also allowing new knowledge to be channeled into the most appropriate Web 2.0 and Big Data tools. But at the same time it also enables users to employ each tool freely within the area previously established by the enterprise.

It is important to state the limitations of the study, which are related with the qualitative research methodology of a case study. Since this is a case study in which the methodology was applied to a single organization (an oil and gas company), its validity has not been tested in other kind enterprises or sectors, like manufacturer enterprises. Moreover, although the qualitative data of the case study were complemented by quantitative data, no statistical significance could be obtained given the small sample size. Therefore, the benefits obtained by the company from applying the methodology were not measured objectively because they are achievements that are perceived by the people involved in the implementation. Nevertheless, their experience and professionalism make us trust the honesty of their claims regarding those achievements. This is an important limitation because a single case study is not good for generalization purposes, due to the heterogeneity of companies. Therefore, comparative studies of multiple cases that maximize the variation of companies (each potentially with many observations) can increase the possibilities of validating the usefulness of the W2KM methodology for other kinds of companies or other kinds of web 2.0 or big data tools.

As regards possible lines of work in the future, some of the challenges related with the W2KM methodology that have still to be dealt with are: adapting the W2KM methodology to the peculiarities of KM 3.0 tools. KM 3.0 tools are semantic tools that improve access to information and reuse the knowledge in semantic wikis (Oren et al. 2006) and semantic blogs (Cayzer 2004). They can also use the Web as a source for knowledge acquisition (Java et al. 2007), and they are able to recycle data and transform it into explicit knowledge (Kohn et al. 2010). In addition, they also interconnect people and content in a significant way using semantic social networks (Breslin and Decker 2007). Another possible line of work to be followed in the future is to solve the problem of semantic interoperability, since it is essential that both senders and receivers interpret the knowledge in the same way (Brannen and Wilson III 1996). Including ontologies (Boissier et al. 2013) in the W2KM methodology may be a solution to this issue. Finally, the W2KM methodology could address the problems related to the protection of data and the security of information so that sensitive data about the enterprise is not disclosed.

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# Methodology for the Implementation of Knowledge Management Systems 2.0 – A Case Study in an Oil and Gas Company

**Sergio Orenga-Roglá, Ricardo Chalmeta**

Business & Information Systems Engineering (2017)

**Appendix (available online via http://link.springer.com)**

## Appendix A

| Fundamental Features | | Average |
|---|---|---|
| System functionality | The system is easy to use. | 4.1 |
| | The use of the system is similar to that of other systems you know. | 3.8 |
| | The system is flexible. | 3.5 |
| | The system is adapted to the needs of the company. | 4.5 |
| Quality of the content | The system contains accurate information. | 3.9 |
| | The system contains relevant information. | 4.7 |
| | The system contains trustworthy information. | 4.2 |
| Exchange and accessibility of the content | The system facilitates information sharing. | 4.6 |
| | The system facilitates the search for information. | 3.7 |
| | The system facilitates the retrieval of information. | 3.7 |
| Sociability | The system allows users to comment on the content. | 4.8 |
| | The system allows information that has something in common to be related. | 3.2 |
| | The system encourages social interactions among users. | 4.0 |
| **Barriers** | | **Average** |
| Individual barriers | The system enables a quick integration of the new members of the company. | 3.7 |
| | The use of the system is beneficial for the members of the company. | 4.2 |
| | The system improves collaboration among employees. | 4.8 |
| | The system helps members of the company to solve their problems. | 4.5 |
| | It is satisfying to help colleagues through the system. | 3.2 |
| | The use of the system poses no threat to the jobs of members of the company. | 3.4 |
| Organizational context-related barriers | The system strengthens ties between me and existing members of the company. | 4.1 |
| | The system expands the scope of my association with other members of the company. | 4.6 |
| | The system enables strong relationships to be created with members who have common interests in the company. | 4.8 |
| | The system creates new business opportunities for the company. | 3.5 |
| | The system improves work process in the company. | 3.2 |
| | The system helps the company to achieve its performance objectives. | 3.4 |
| | The company rewards users who make better use of the system. | 4.1 |
| | The use of the system is beneficial for the company. | 4.3 |
| | The system encourages people to suggest ideas for new opportunities. | 4.3 |
| | The system provides open communication among colleagues. | 4.0 |
| | My superiors make proper use of the system. | 3.7 |
| Technological barriers | The system prevents the same questions from being asked several times. | 4.2 |
| | The system provides a large amount of information. | 4.6 |
| | The system allows you to get information quickly. | 4.1 |
| | The system allows you to access the information you need at the time when you need it. | 4.5 |
| Project management related barriers | The project staff has the appropriated technical expertise in the system. | 3.2 |
| | The resources allocated to the system in the project are adequate. | 3.1 |
| | The time allocated to the system in the project is adequate. | 2.7 |
| Knowledge nature related barriers | The system facilitates the identification of valuable knowledge. | 3.8 |
| | The system facilitates the evaluation of valuable knowledge. | 3.8 |
| | The system facilitates the extraction of valuable knowledge. | 4.2 |

**Table 1** Survey questions to analyze KMS 2.0 fundamental features and project barriers