How to Manage Business Process as Knowledge Assets based on Ontological Approach: Focusing on Sales Order Process

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Abstract

Considering our increasingly interconnected organizations heavily relying on business processes and the growing need for timely accurate knowledge to achieve greater agility in the enterprise, the idea of looking at business processes as a knowledge object is gaining momentum. Business process information is knowledge and should consequently be managed as a valuable organizational asset, particularly because organizations need to react in near real time to environmental changes and events. This paper provides an overview of the situation in this field arguing for a better definition of the intersections between knowledge and business process management. When business process is seen as knowledge, it should be managed as such. We assess and discuss some of the resulting benefits and considering the need for greater dynamic integration between the two domains, we look at ontologies as an interesting technical approach to bridging this gap showing an example for an ontology based sales order process.

Keywords:

Knowledge Management, Business Process Management, Semantic Web, Ontology.

1. Introduction

There is no doubt that in business fields, business process (BP) is precious and valuable. In 1990, Michael Hammer, a professor of computer science at MIT, wrote a paper in the Harvard Business Review about Business Process Reengineering (BPR), an idea which consists of eliminating non value adding work instead of automating it [1]. In the early 2000's, a new theory, BP Management, was introduced [2, 3]. This theory proposed reducing the gap between business divisions and IT divisions in an organization.

The motivation of the paper starts with the idea that BP is valuable knowledge. We look at BP as a knowledge object and try to approach this subject with a Knowledge Management (KM) perspective. However, some notions in management theories argue that BP is itself a process per se, not a valuable object. Even within the BPM discipline, there have been activities that recognized BP as a key element in achieving competitive advantage, but did not consider BP as a knowledge asset which could provide unique advantages.

We address why BP is a precious knowledge object, in which case there would exist many intersections between knowledge and business processes when defining the relationship between these two domains. If there is a possibility that BP could fall into the category of knowledge, it might be and should be managed in the domain of KM and the results of the benefits should be discussed. Researchers in the field of KM have a tendency to either differentiate between knowledge and BP, or overlook the link connecting the two. On the other hand, BPM focuses on the automatic execution of BP on the technical perspective rather than managing them (on the KM perspective) as knowledge assets.

However there are some limitations of managing BP knowledge with current KM systems and BP management systems. Not only does a BP have certain characteristics such as needing rapid responsiveness both dynamic and proactive, but also the nature of the current information systems limit the ability to capture valuable knowledge and execute concurrently. Therefore, new alternatives to address the problems are needed. In this paper, as an alternative, we introduce an ontological approach to this problem.

We discuss what knowledge and BP is, as well as conversing about the awareness of BP as an organizational asset while showing the benefits of BP when it is managed as a knowledge object. In the remainder of the paper, we introduce an ontological approach. This approach enables us to represent BP knowledge in machine understandable form, which facilitate to manage dynamically changeable process knowledge and to generate new process knowledge from process knowledge space. Subsequently, we show the ontology example for sales order process and suggest guidelines for how we can achieve BP KM using this ontology.

2. Knowledge and Business Process and their Relationship

In this section, we review the definition of knowledge (management) and knowledge categories, and business process (management). From the review, we define BP as knowledge.

2.1 Knowledge and Knowledge Management

In KM discipline, many researchers have attempted to define knowledge. Nonaka defined knowledge as "a justified true belief [4]." However, the definition seems to be too much of an absolute concept. We would like to bring it down to an organizational level. If we may accordingly redefine knowledge within an organization, it might mean a justified true belief in the organization. Tuomi [5] described knowledge as "information possessed in the mind of individuals: it is personalized information (which may or may not be new, unique, useful, or accurate) related to facts, procedures, concepts, interpretations, ideas, observations, and judgments." Moreover Davenport [6] mentioned that knowledge was explained as "information combined with experience, context, interpretation, and reflection. Knowledge is a high-value form of information that is ready to be applied to decisions and actions." Based on these notions and definitions, we define organizational knowledge as a set of information that contains meaningful know-how, experiences, and value-added interpretations, so it can be helpful with the decision making process in an organization.

When it comes down to its management and management system, it can be defined as the creation of knowledge networks [7]. Furthermore "KM systems refer to a class of information systems applied to managing organizational knowledge [8]." We would like to extend the view to KM, in that its methods and systems help to identify, create, represent and distribute knowledge in the organization to build competitive advantages.

Multiplicities of taxonomies of knowledge have also been defined by many researchers. Drawing on the work of [4, 9, 10] classifies knowledge in an organization into two dimensions: 1) tacit knowledge and 2) explicit knowledge. Tacit knowledge is "both cognitive and technical elements."[4] Further continues to define tacit knowledge as a subjective knowledge which is of experience (body), simultaneous knowledge (here and now), and analog knowledge (practice). Conversely, he categorizes explicit knowledge as objective, in that, it is knowledge of rationality (mind), sequential knowledge (there and then), and digital knowledge (theory). Another definition for explicit knowledge is "articulated, codified, and communicated in symbolic form and/or natural language."[8] Therefore, using these definitions as our basis, we can consider tacit knowledge as intangible and personal and explicit knowledge as tangible and capable of being written down. However, it is hard to have clear boundaries between these two dimensions.

As shown in Figure 1, Kalpic and Bernus [11] provided an understanding which is little different from earlier researchers. They used aware and unaware notions, instead of tangible and intangible notions, to indicate explicit knowledge and tacit knowledge. Furthermore there exists some overlapping in formalisable aware knowledge and formalisable unaware knowledge in tacit knowledge. Tacit knowledge is not necessarily considered non-formalisable.

2.2. Business Process and Business Process Management

Over the past decades, BP has been defined from various perspectives by many researchers. In [12], process is "a specific ordering of work activities across time and space, with a beginning, an end, and clearly identified inputs and outputs."

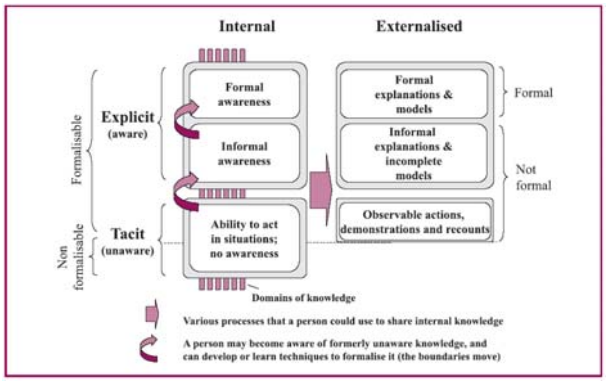

Figure 1 - Kalpic & Bernus' Knowledge Categories

[13] categorized processes in an organization into material processes, information processes, and BP, and defined BP as "market-centered descriptions of an organization's activities, implemented as information processes and/ or material processes." That is, a BP is engineered to fulfill a business contract or satisfy a specific customer need. Thus, the notion of a BP is conceptually at a higher level than the notion of information or material process. [14] defined BP as a "process carried out entirely by humans who manipulated physical objects. With the introduction of information technology, processes in the work place are partially or totally automated by information systems." [15] defined BP as follows: "…a BP consists of a sequence of activities. It has distinct inputs and outputs and serves a meaningful purpose within an organization or between organizations. An activity is a discrete process step performed either by a machine or human agent. An activity may consist of one or more tasks."

Based on the above definitions, we define organizational BP as follows: A BP is a sequence of specifically coordinated activities carried out by cooperating humans and information system to achieve an organizational business goal. The activities consist of one or more elementary or composite sub-processes as a discrete process. Elementary process is composed of one or more tasks to achieve processes. Composite process consists of one or more sub-processes. Our perspective of BP views a BP that is capable of encapsulating a broad range of activities, from a business function on an organizational level to a operating procedure on an operation level.

Organizations have made an effort to find a means to manage and improve such BP in order to survive from ever-increasing competition. For example, organizations have analyzed the BP of a leading company in the same industry to catch up with it, or they have tried to radically redesign their BP from scratch. Since the efforts such as benchmarking and BPR in the 1990's were not satisfactory, they evolved to Business Process Management (BPM) in the early 2000's. BPM offered the promise of a world that would provide the business world with suitable tools and techniques which would enable organizations to create, implement, execute and analyze business processes from the managerial perspective.

2.3. Business Process as Knowledge

There are numerous definitions for knowledge as well as BP and we see some common characteristics and overlap between these two. If BP is considered a higher level concept than information, process which has clear input and output activities, the outcome of the activities should be considered as newly created information which has a meaningful experience, context, interpretation impact to the organization. Should this be the case, it is safe to say that new information has been created, which can be consider knowledge. Knowledge should also be unique and personal to each specific organization, become wholly embedded in the organization and most importantly hard to imitate. With this interpretation, we argue that BP is knowledge.

3. Limitation of Managing BP as Knowledge

Some recent attempts for managing BP as knowledge have been tried by a few pioneering researchers [18, 19, 21, 22]. It may appears that in most cases the ultimate limitation of these attempts lie in not being able to provide uniform and standard specifications for managing BP as an organizational knowledge. Such a specification should cover all the knowledge from the entire phase for performing BP in an organization. Moreover, the specification should be able to capture in a flexible way for dynamically changeable characteristic of BP according to the changes in environment.

Furthermore, knowledge of BP is easily integrated into one consolidated knowledge and shared and reused between all the stakeholders associated with BP. The new knowledge from the lifecycle of BP should be attached into the knowledge space to evolve BP in a uniform and standard way.

However, the current state in academia and within the practice of managing BP as a knowledge object still focuses on the

integration of simple data in both KMS and BPMS. The simple integration and data sharing between KMS and BPMS would limit the functions and capabilities of management because these activities would not be able to reflect the characteristics of BP. Moreover, it does not provide a standard and uniform way in which to manage BP as knowledge, which brings about critical problems for stakeholders in representing, capturing, querying, reusing, and the analysis of BP-related knowledge from one consolidated knowledge space. Therefore, new alternatives to address these problems are needed.

4. Business Process as Organizational Knowledge

As mentioned above, BP hasn't been acknowledged as a knowledge object by IS researchers in the domain of KM despite its characteristics of being such a valuable asset. KM focus is on knowledge flows and the process of creation, sharing, and distributing knowledge [8]. KM researchers have focused mostly on what knowledge is, its taxonomy, and its life cycle process to manage KM systems. However the research that has been done is neither delineating conceptual and/or positioning the conceptual parts into a consistent framework. Researchers may pass over certain fields of operational knowledge, such as BP knowledge, although it may be a valuable asset which could provide untapped competitive advantages.

Put simply, IS researchers in the domain of BPM also do not concentrate on researching BP as an organizational knowledge since they would have to address and clear many problems which bygone BP management such as *BPR left behind and IT-business divide*. BPM researchers spend the majority of their time researching the effects of directly managing the automatic execution of business processes from a high level managerial perspective.

In order to realize BPM promise, researchers first defined a BPM lifecycle, and within that lifecycle they found the existence of various phases. Within every phase, there were tasks and problem solving that needed to be executed. For example, a generic BPM lifecycle as defined by many researchers includes the following phases or its alternatives: 1) modeling, 2) pre-analysis, 3) implementation, 4) execution, and 5) post-analysis [16, 17, 18, 19, 20].

Managing BP as a knowledge asset within organizations, BP can exhibit KM properties. As shown in Figure 2, the left loop is the knowledge creation cycle provided by [4]. The right loop is a simply variant of BP life cycle loop which is presented by [19]. The figure shows how these two life cycles could be articulated thus providing a two way link between KM and BPM. Looking at the BP life cycle process, we can see the starting point as the creation, as when an employee contributes knowledge. From this initial contribution, as it circulates through the flow of the BP cycle, by the time it reaches post-analysis, new knowledge may have emerged. This new knowledge then flows into the knowledge creation cycle thus influencing internalization. As this knowledge progresses towards the combination phase of the cycle, there is the possibility that new explicit knowledge, much more advanced than the original knowledge, will have emerged from this process which in turn may influence the creation stage of the BP life cycle thus resulting in a growing spiral effect.

5. New approach to Manage BP as Knowledge

In this section, we introduce an ontological approach to manage BP as knowledge and show how to manage BP as knowledge with an example case of Sales Order Process (SOP).

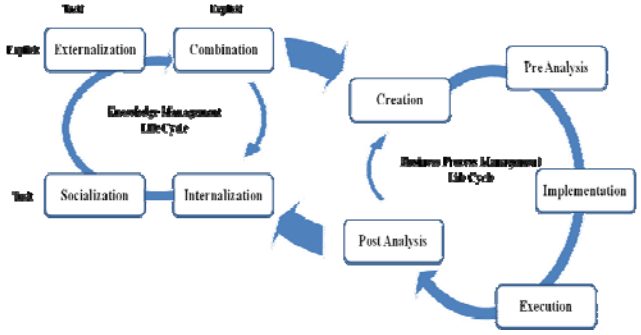

Figure 2 – Spiral Loop for Linking KM Lifecycle with BPM Lifecycle

5.1 Ontological Approach for Managing BP as Knowledge

Ontologies are a key technology of Semantic Web [23] which was proposed by Tim Berners-Lee as an extension of the current web leveraging semantics. Gruber defines ontologies as "a formal explicit specification of a shared conceptualization for a domain of interest [24]."

In other worlds, ontology is a specification which defines consensual knowledge in a specific domain. Such a definition of ontologies can be directly applied to manage BP as knowledge. Ontologies allow specifying knowledge associated with process such as a process model, model element, organization unit, physical resource, information resource, business rule, domain knowledge, etc. in formal semantic. In other words, the concepts and relationship between concepts associated with BP as knowledge can be explicitly represented in an ontology in a uniform way. Therefore Ontologies provide a standard and uniform framework to capture, externalize, share and analyze BP as knowledge during all the phases of the BP lifecycle.

5.2 How to Manage BP as Knowledge

In this section, we show how to manage BP as knowledge using reference process, sales order process which is a very general but well known process.

5.2.1 Reference Process: Sales Order Process

Figure 3 shows a sales order process in level 0. It consists of three sub-processes such as ***sales order entry process***, ***ATP (Available to Promise) check process*** and ***credit limit check process***. Sale order entry process is the process for entry of order information such as header data, order item data and etc. when an order is received. ATP check process is the process that checks if a quantity at the required delivery date is available. Credit limit check process is the process that checks if an order amount exceeds the credit limit of a customer.

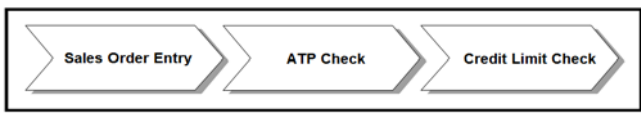

Figure 3 - Sales Order Process in Level 0

Figure 4 shows the sales order BP in level 1. The process is represented using the *Event-driven Process Chain* (EPC) modeling notation [25] which was developed at the Institute for Information

Systems of the Saarland University in Germany with SAP in 1992. An EPC represents a model as a directed and connected graph, whose nodes are ***events***, ***functions***, and ***logical operators***. Events are represented by hexagons and functions are represented by a rounded rectangle. Events may have three states; 1) external changes that initiate the process (e.g., sales order requested); 2) internal change of state as the process (e.g., ATP check completed); 3) the final outcome of the process (e.g., sales order created). With logical operator excluded or (XOR), the node makes the decision which path to follow. In Figure 4, there are two XOR; 1) XOR followed by the event "*Sales order header entered*" allows to loop on the items to order; 2) XOR followed by the function "*Is Sales Order Item Entry Finished*" decides if the entries for sales order items are finished.

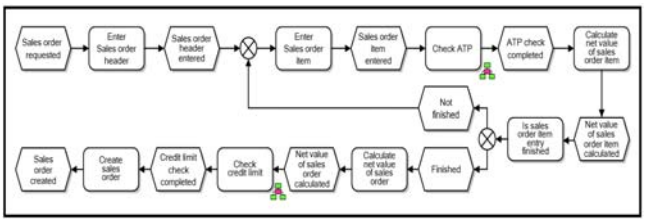

Figure 4 - Sales Order Process in Level 1

As shown in Figure 4, the event "*Sales order requested*" triggers the sales order process. A single order includes one sales order header and several sales order items. Once the header data of a customer's sales order is entered, then the details of several sales order items are entered. For each sales order item, ATP check is executed by the function "*Check ATP*", and then the net value of a single sales order item is calculated by the function "*Calculate net value of sales order item*". Net value being quantify items the unit price. After entries of sales order items are completed, the net value for single sales order is calculated. It is the sum of net values of a sales order items. Using the amount of single sales order, customer's credit limit check is executed. After all of these tasks, a sales order record is created in the database.

5.2.2. Building Sales Order Process Ontology (SOPO)

Our ontology, ***Sales Order Process Ontology (SOPO)***, consists of three sub-ontologies as shown in Figure 5. Theses are briefly described below.

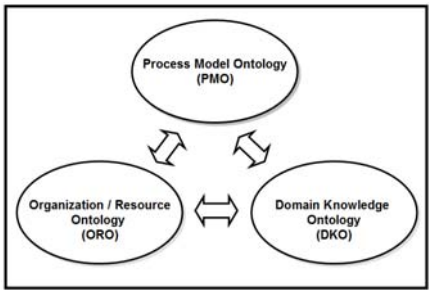

Figure 5 - Sales Order Process Ontology (SOPO)

PMO (Process Model Ontology) contains concepts associated with BP model such as *Model* and *Model Element. Model Element* contains sub-concepts such as *AND*, *OR*, and *XOR* for eliminating inveterate business-IT divide.

ORO (Organization & Resource Ontology) contains concepts associated with organizational units which perform the process tasks, and resources types which are consumed by an organization.

DKO (Domain Knowledge Ontology) contains a number of concepts for representing the domain knowledge which are actually required for sales business such as business rules, sales unit of measure, official terms for sales, currency, shipping condition, etc.

In order to build the SOPO, we used the OWL Language [26] which is the standard ontology language of W3C. It is based on *Description Logics* [27] which is a decidable fragment of *First Order Logic* and permits automated reasoning. Therefore it is possible to automatically compute the classification hierarchy and check for inconsistencies in ontologies.

In OWL, a concept corresponds to a class and a relationship corresponds to a property. A class defines a group of individuals which can be brought together. A property is used to define the relationship between two individuals or from an individual to a literal value. The former property is called *object property* and the latter is called *datatype property*. The class can be constructed into a hierarchal structure using the property *rdfs:subclassOf.* The prefix *rdfs* means that the namespace of the property *subClassOf* is RDFS (Resource Description Framework Schema) [28]. RDFS provides a mechanism for specifying the structure of a RDF [29] data model which was developed to facilitate automated processing of web resource in machine-understandable form provide and to interoperability between applications. However, due to the limitation of the expressive power of RDFS, the extended ontology language, OWL was developed by the Web Ontology Working Group of W3C. Therefore, OWL includes all the primitives of RDFS and has features.

Process Model Ontology (PMO)

Figure 6 shows the classes and object properties of PMO. Ovals represent classes and arrows represent object properties (*ObjectProperties* in OWL). The class *Model* represents the BP model as shown in Figure 6. It has two recursive properties *hasSubModel* and *isPreceededBy*.

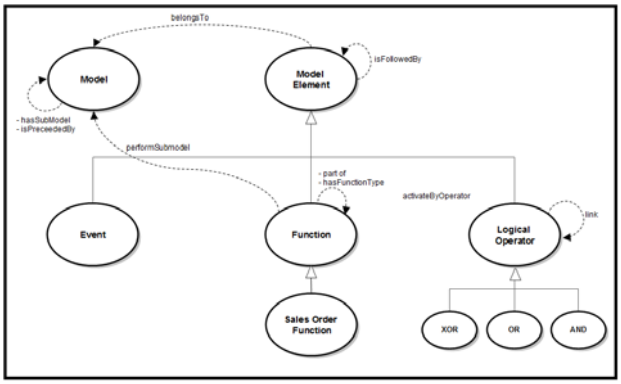

Figure 6 - Concepts and Object Properties of PMO

The former is used to states the relationship between upper-process model and sub-process model, the latter is used to sate the relationship between preceding process and following process.

A model is composed of a number of model elements such as events, functions and logical operators. We represent the relationship between the class *Model* and the class *Model Element* by using the property *belongsTo.* The class *Model* Element has three sub-classes; *Event*, *Function*, *Logical Operator.*

Organization and Resource Ontology (ORO)

ORO includes concepts representing organizational units which perform the process tasks and resources types which are consumed by organization. Figure 7 shows the classes and object properties of ORO. The class *Organization* has five sub-classes; *Company*, *Department*, *Plant*, *Sales Organization.* The class *Organization* has a recursive property *hasSubOrganization,* which means that an organization may have sub-organizations. Here, the property *hasSubOrganization* is the *transitive property* in OWL. Transitive means that if it holds for all *a*, *b*, and *c* in a set *X*, that if *a* is related to *b* and *b* is related to *c*, then *a* is related to *c*. The class *Location* from DKO represents the place where a specific organization exists physically.

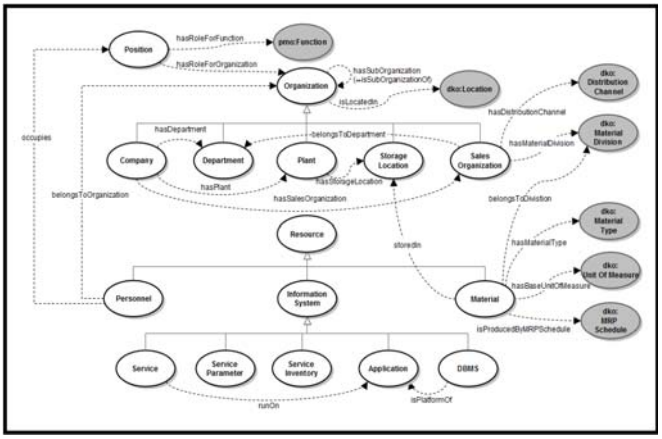

Figure 7 - Concepts and Object Properties of ORO

Next, the concept *Resource* has three sub-classes; *Personnel*, *Information System*, and *Material*. Personnel belong to an organization and may occupy more than one position. Here the concept *Position* represents a specific role preformed by individual people (e.g., 'Customer Service Advisor,' or 'Depart manager'). The concept *Information System* has five sub-classes; *Service*, *Service Parameter*, *Service Inventory*, *Application*, *DBMS*. Among them, the concepts associated with service are very important in the context of SOA and Web service. The class *Material* represents typical raw material or products. All the materials should belong to a specific material division, and should have a material type and unit of measure. Usually, material is produced by the material resource planning (MRP) schedule which is a firm's demand schedule for land based on a customer order request or demand forecast.

Domain Knowledge Ontology (DKO)

DKO represents concepts associated with the domain knowledge which are actually required for sales order BP such as business rule, sales unit of measure, official terms for sales, currency, shipment condition, etc. Looking at the domain knowledge in Figure 8, it contains a number of concepts. We will only describe major concepts due to limited space.

The major concepts are *Sales Order* and *Sales Order Item*. A single sales order should have one or more than one sales order item and each item should belong to a single order. A sales order is requested by a customer who is called '*sold-to-party*' in sales domain. Frequently, a customer can function as a different party as follows; *ship-to-party* to which goods are to be addressed, *bill-to-party* which the bill should be sent for payment, and *payer* by whom a bill should be paid.

The concept *Customer* represents such different functions of a customer by using the property *hasCustomerFunction.* In some case, each party can be a completely different customer in a single order. Therefore, who the customer is corresponding to each party in a single order should be defined. For this one, we use the properties *hasSoldToParty*, *hasShipToPary*, *hasBillToPary*, *hasPayer.*

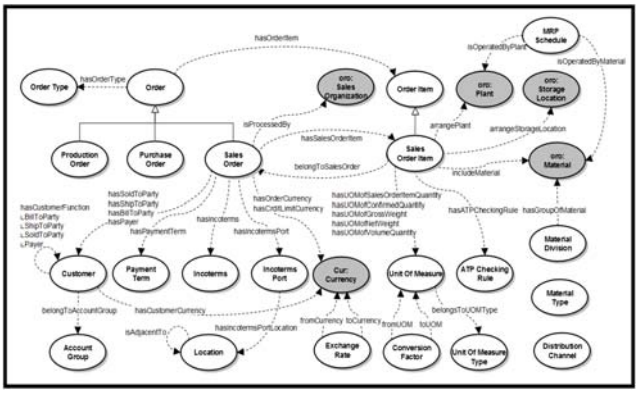

Figure 8 - Concepts and Object Properties of DKO

The class *Payment Terms* represents a condition under which a seller will make a sale. The terms specify as follows; the period allowed to a buyer to pay off the amount due, cash on delivery, deferred payment period of 30days or more, etc. The concept *class* represents the shipping condition such as *Incoterms* such as FOB (Free On Board), CIF (Cost, Insurance and Freight), etc. The class *IncotermsPort* represents the location where the goods are shipped. In a single order, the concepts may be specified. The class *Currency* is reused by importing from ontology in University of Southampton in UK**.** The class *Sales Order Item* represents each item of a single order. Every sales order item has to be checked with a predefined *ATP checking rule* in order to check whether the quantity of the item is available at the required date. The class *ATP Checking Rule* is used when ATP check is executed. Each sales order item is arranged by a Plant or Storage Location for delivery. The concept Material Division represents a specific group of materials from a sales point of view, and the concept *Material Type* represents a same type of material from a manufacturing point of view such as raw material, half finished goods, and trade goods.

5.2.3. Managing Sales Order Process as Knowledge using Ontology

Using ontology, an organization can construct a BP knowledge space which includes all the facts associated with intra-organization process and inter-organization process in a standard and uniform way. Knowledge space plays a crucial role for all stakeholders in the business world. Business domain experts (re)design BP by querying all the facts registered in the process space and reusing them. A process analyst analyzes the BP model and the result of the execution of BP for improving and optimizing the process. A manager checks process performance based on the performance indicator defined in BP knowledge space. Anticipated that BP knowledge source in an organization may provide a number of benefits to the stakeholder associated with BP as follows; 1) manage BP as knowledge in a uniform and standard 2) easy way integration of BP as knowledge 3) easy sharing and high interoperability between stakeholders in business world, 4) practical semantic query, 5) deriving new knowledge from existing knowledge stored in process knowledge space.

6. Conclusion

We have discussed what knowledge and BP is. While discussing knowledge and BP, we find that BP should be considered as knowledge and should be managed as such. Furthermore if BP can be managed as knowledge, it may anticipate having benefits that KM domain is able to offer and may have a growing spiral effect on their knowledge, which in turn can have a positive influence on an organization. However in the current systems, such as KMS and BPMS, there are limitations in managing BP and its knowledge. Characteristics of BP, such as dynamic changes, rapid responsiveness, and inflexibility of the current systems led us to look for alternatives such as ontology. Since ontology is a formal specification which explicitly represents shared concepts in the domain of interest, we see the possibility that ontology may realize the idea we provided in Figure 2. We show example that shows how to build a BP knowledge space which helps stakeholders share and reuse information between them and which can be accessed by all stakeholders related to the business process. This space contains knowledge that needs to be managed in KMS. In future research, the meta-level ontologies, which govern KM and BPM lifecycles as well as manage and control the growing spiral effects of knowledge and influence both ways, should be considered.

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