International Journal of Management Technology
Vol.4, No 2, pp. 13-21, October 2017
Published by European Centre for Research Training and Development UK (www.eajournals.org)

INNOVATION CHAIN INTELLIGENCE (ICI)

Sotirios Zygiaris

College of Business Administration, Department of Management Information Systems, PMU, Prince Mohammad Bin Fahd University, Al Khobar 31952, Kingdom of Saudi Arabia

ABSTRACT: *The innovation chain is an added value horizontal process that interacts continuously with the external environment, when new products or services are developed. This immense dynamicity influences the decision-making process throughout the idea generation, product design and market exploitation links of the innovation chain. These dynamic information sources could be exploitable by innovation managers, when they are processed through the knowledge base in an iterative mode across the innovation chain. This paper combines business intelligence and knowledge management techniques to conceptualize a logical framework of modelling the innovation chain intelligence. The methodology that is used is the ontological framework for information extraction, knowledge representation and knowledge update related to innovation chain intelligence. This paper conceptualizes the necessary information extraction mechanisms for semi-structured data, using web semantic ontologies to introduce the initial stage of the innovation intelligence chain.*

KEYWORDS. Business Intelligence, Innovation, Ontology, Semantic Web

INTRODUCTION

Once the business objectives for innovation are set, an efficient innovation chain must be placed in order to optimally utilize all the available corporate and external resources, when ideas are about to be turned on into marketable outcomes.

The innovation chain is a process of transforming ideas into high-end commercial products, as an integrated cross- functional flow. The outcomes of the innovation chain must be definite and measurable in regards to their attribution on the corporate value chain (Hansen and Birkinshaw, 2007), (Zygiaris, 2010). This paper concentrates on the ultimate goal of the innovation process, as an end-to-end innovation view, which is the creation of new products or services.

The innovation chain's nodes are defined in a series of three links (Hansen and Birkinshaw, 2007), (Roper et al., 2008). The first link is the idea generation that includes also the screening of initial ideas to select the optimal ideas for further developing into products or services. Product design is another important link of the innovation chain. The last link of the chain value is product or service commercialization. All these links iterate more as an integrated set of "system in systems" rather than as a linear process sequencing from one link to the next. This iterative process of knowledge creation, transformation and exploitation of valuable knowledge comprises the innovation value chain, transforming ideas into commercial exploitable products or services (Roper et al., 2008), (Hom, 2005).

The formulation of an innovation process in an enterprise creates a series of state change events as initiating ideas are transforming into market high end products (Hom, 2005), (Pittaway et al., 2005) Early work on innovation knowledge acquisition maps three distinctive but

ISSN 2055-0847(Print), ISSN 2055-0855(Online)

interrelated subsystems: (i) the knowledge creation and (ii) knowledge transformation and (iii) the knowledge exploitation subsystems (Zygiaris, 2010), (Roper et al., 2008), (Cassiman and Veugelers, 2002). The first subsystem creates the knowledge foundation for innovation; the second transforms the knowledge into a new product or service and the latest exploits the results into the market. For example PayPal®was created as an idea to capture the need for secure e-payments. The design concept has built around a service for secure credit cards transactions and it became marketable collaborating with major e-commerce sites, refining the initial ideas through various design concepts.

At the idea generation node innovation managers must perform the critical task of internal sourcing for new ideas across the company. This task is expanded at the enterprise level across the supplier side (backward sourcing) and the customer's side (forward sourcing). These sourcing types provide the initial stock of ideas for new product development in the enterprise sphere (Shneiderman, 2000). Companies also need to assess whether they are sourcing enough good ideas from outside the enterprise sphere tapping into the insights and knowledge of competitors, universities, independent entrepreneurs, investors, inventors, scientists and Intellectual Property Rights (IPR) managers (Hansen and Birkinshaw, 2007), (Shneiderman, 2000).

Previous work (Pittaway et al., 2005), (Cassiman and Veugelers, 2002), (Shneiderman, 2000) has shown that sourcing for creating knowledge around a new idea generation field resigns in internal and external R&D, market needs and existing IPR and technological resources. New idea stock taking at the enterprise sphere could be structured using data mining, formal methods and natural language processing tools. Taking under consideration the vast amount of available information from external sourcing through the web requires semantic information extraction tools.

At the knowledge transformation node of the innovation chain a breakpoint issue is the selection of ideas that will proceed for concept development and product design. The external knowledge sourcing aims towards technology watch to optimize design, by inducing emerging technologies into the product concept design. Innovation managers need to acquire external information about patents, design concepts, technological advancements pertaining to the design conceptualization (Atuahene-Gima and Evangelista, 2000), (Chiva and Alegre, 2009). The third knowledge acquisition recourse links to innovation exploitation subsystem, which extensively depends on the wider knowledge of eco-system, where products must grow and be delivered to the market (Shneiderman, 2000), (Roper et al., 2008). During knowledge exploitation sourcing, market watch systems retrieve external sources critical to justify the financial merit and market demand requirements for new products or services (Chiva and Alegre, 2009), (Gronlund et al., 2010)

Innovation Chain Intelligence (ICI)

Business Intelligence (BI) requires the acquisition and aggregation of key pieces of critical business knowledge from multiple data, internal and external sources to support decision-making.

From business to innovation intelligence

The knowledge creation process requires the use of analytical tools to support decision-making. BI pertains to a high-end value when the actionable knowledge is made assessable

ISSN 2055-0847(Print), ISSN 2055-0855(Online)

proactively preceding the managerial decision-making (Negash, 2004). The analytical tools are made available to users on-line for the immediate access of up to date knowledge units. These tools include real-time data warehousing, data mining, automated anomaly and exception detection, proactive alerting with automatic recipient determination, seamless follow-through workflow, automatic learning and refinement, data visualization and On-line Analytical processing (OLAP) (Langseth and Vivatrat, 2003). All major Enterprise Resource Planning (ERP) systems, such, SAP, Oracle, provide the enterprise with BI analytical tools. Business intelligence is mainly applied to databases pertaining to data from the company, suppliers, clients, financial markets, competitors or retailing consumer (Negash, 2004), (Langseth and Vivatrat, 2003).

Business intelligence is a key enabler for managers and knowledge workers to reach informed real time decision-making. As organizations develop a mind set for intelligence, they initiate efficient reporting capabilities. As reporting improves, they move to performance assessment methods against plans using planning models to improve business agility. At a more advanced level, they leverage forecasting and apply predictive analysis models. BI analytical tools are resourceful knowledge engines when they are applied to controlled and structured databases using structured decision making scenarios or rule based systems. Following these evolutionary stages of BI, innovation chain intelligence is considered as an enabling information retrieval mechanism that supports the transitioning of the organizational into an innovative mindset (Negash, 2004), (Langseth and Vivatrat, 2003).

At the initial stage of innovation chain intelligence correlations between information and innovation artifacts are identified to improve efficiencies in each one of the links (i) knowledge creation (ii) knowledge transformations and (iii) knowledge exploitation. In the process of improving these efficiencies the retrieved information must be transferred into a knowledge object associating the newly extracted information with relevant historical knowledge base items. These added value knowledge objects would be used in turn to enhance the decision-making capacity in each one of the three links of ICI.

When we examine the innovation chain as a knowledge system, we conceptualize the dynamics and interrelationships between individual knowledge units and the three chain links. Past decisions in the chain's links could be affected by new knowledge acquisitions. Also a change in the new product design status of a specific link could modify the status in the other two links. This iteration acts recursively until no changes in status are reported in any link. For example, competitive intelligence knowledge about a new product that is supposed to be launched in the market by a competitor could cause chain reaction in the idea generation, concept design and marketing strategies. The iterative process is illustrated in figure 1.

Figure 1. The chained iterative innovation process.

ISSN 2055-0847(Print), ISSN 2055-0855(Online)

The information retrieval system is responsible of retrieving information from structured sources (such as on-line databases) or unstructured information through the web. This information updates the knowledge system, which in turn becomes available to the innovation manager. The new knowledge is used iteratively in each phase of the innovation process to access any potential changes that could be imposed throughout this process. This iterative process runs recursively meaning that any changes in status modify the knowledge base alerting the innovation manager to repeat the assessment process again from the idea generation phase (Hansen and Birkinshaw, 2007), This chained iterative assessment process will terminate when the innovation manager does not configure any status changes in any of the three phases of the innovation process.

This chained iterative process reflects the complexities and dynamics of innovation. Any valuable information must be accessed in every phase of the innovation process. Changes in product design or market demands might cause a redesign of the product starting over the idea generation phase. Many times this chained iterations might cause aborting the development of new product when technological or time to market conditions threaten its feasibility (Hom, 2005), (Chiva and Alegre, 2009). This chained iterative process is implemented through the following functions:

- Retrieve information: the innovation manager, as a primary actor receives information from structured data or semi-structured semantic data. Such an information object can take many forms: R&D result, IPR, new technology or market change.

- Transform information into a knowledge object: The retrieved information is frame worked as a knowledge object by relating the new information with accumulated organizational knowledge.

- Assess the ICI link status: The status changes can take two forms: update_info(), when the knowledge objects updates the information depository and update_status (), when a status ICI link is modified. The update method implies valuable information to the knowledge base that does not depict any changes in the status of three ICI links. The modify_status() method refers to changes in the initial idea, the design concept or the market prospective of the new product. The cycled arrow indicates an iterative process for each status change. For each occasion of modify_status() method in an ICI link all other links are checked for changes that the specific method call could derive. These iterations will stop only when all three links return null through modify_status() method.

Update the knowledge base: The change status conditions are recorded as rule based instances in the knowledge base. ICI presents the following dynamic modeling characteristics:

1. New retrieved information is viewed in the retrospect of knowledge acquired by the organization, handling similar typologies of information. Thus new information is enhanced with links to behaviors and related information stored in knowledge base.

2. Following the dynamics in the systemic view of innovation systems, rather than the linear approach, all knowledge units are accessed against the existing status of each ICI link in an iterative backward and forward movement within the innovation chain. Each change in status could result in changes in the other two links.

3. Updating the knowledge base. For each iterative assessment step the knowledge base is updated with the new acquired knowledge.

ISSN 2055-0847(Print), ISSN 2055-0855(Online)

3. Result -The innovation chain intelligence ontology

Knowledge representation can be articulated when current web resources are enabled with sharing concepts definitions and interrelationships between them formulating semantic ontologies are notions for generating specialization of conceptualization to leverage semantic web. Following the study of formal methods, a semantic ontology combines concept taxonomies, metadata, and semantics into a formal system of rules defining the relationships among them. To implement ontology the basic concept template must be generated as a set of classes along with superclass–subclass hierarchies. Each class is defined in terms of its properties (Zorrilla and Mazon, 2013), (Kiryakov et al., 2004).

Classes are used as templates to generate instances (objects) of a particular class. Instances create knowledge given specific properties and rules. Following the behavioral modeling of ICI, from the user-centric view of innovation manager, the structural components of ICI must be defined as templates that create instances or knowledge objects. In a semantic world a concept may have several views. An innovation concept has a different view in the eyes of a researcher and different on in the eyes of a venture capitalist. Thus, it is important to define the scope and potential users of the ontology in this initial concept specialization phase.

- ICI ontology domain: Representation of innovation knowledge, interlinking new information with relative themes in the ICI knowledge base.
- Users: Innovation managers
- ICI ontology scope: To enrich knowledge resources for decision making in the three innovation's chain's links: (i) knowledge creation (ii) knowledge transformation and (iii) knowledge exploitation.
- ICI semantic ontology class hierarchy:
- ICI_class: It represents the status of a specific innovation theme. Such as, new mobile applications for smart parking. See figure 3.

The objects that have been created by this class will have the following attributes:

- ICI.id: The unique identification number of an innovation theme: for example, ICI-101.
- ICI.title: for example, mobile parking reservation
- ICI.description: A description of the innovation theme. For example, the mobile application allows users to identify available parking services as they approach a city's center and make remote reservation for a parking space.
- ICI.owner: the assigned innovation manager.

All the attributes of the ICI objects are kept private. Special assessors are assigned to get() and modify () each one of the attributes with appropriate access rights management.

- ICI.active: it is set on if the innovation process is active, and off if the same process has been aborted.
- ICI_CreateK, ICI_TranformK, ICI_ExploitK classes: They represent the innovation

status in each one of the innovation chain links. For each one of the three classes the representing objects have a common field that denotes the status of the link:

- ICI_CreateK.status: Holds the idea initiated the innovation management chain reaction.
- ICI_TranformK.status: Holds the design concept of the new product.
- ICI_ExploitK. Status: Holds the commercialization plan of the new product.
- ICI_CreateK.Attachment, are objects holding supporting files for the idea generation status. The same types of objects are the rest two-chain links. (ICI_TranformK. Attachment, ICI_ExploitK. Attachment).

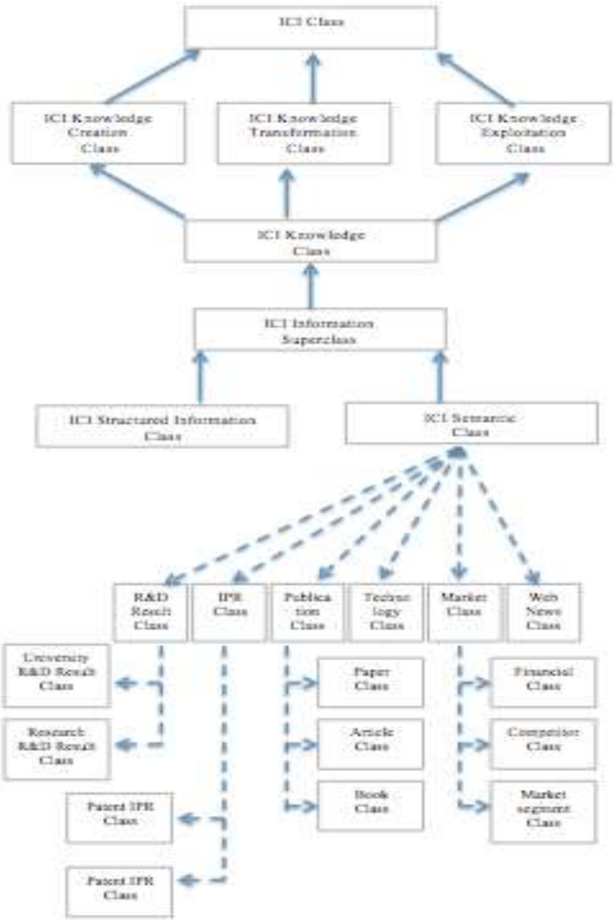

Figure 2. ICI's class hierarchy ontology.

The innovation manager may modify the status of an object, when a new ICI knowledge object is received using the Change_Status() operation. In cases that the feasibility of the new product is at risk the manager might also set the ICI.active field off. All changes in status are stored in objects created by the class ICI_Status_Change, which stores changes in status and contains as attributes ICI_Status_ID, Klink_ID (the knowledge object that created change in status) and Date_ Modified. The ICI_Knowledge class is a container of related knowledge to the

ISSN 2055-0847(Print), ISSN 2055-0855(Online)

innovation theme (e.g. a mobile application for parking reservation). It contains all links to the knowledge base categorized as R&D results, publications, IPR, technologies or market feeds. Each link of ICI_knowledge is an object of the class ICI_Klinks that contain the following attributes: Klink_ID: the ID of the link, Relates_to_links: other related links, Creation_date, Last_updated, Author. It also contains the Klink_ID attribute that links to an ICI_Status_Change object.

The ICI_Information superclass is an abstract class that generalizes an innovation information component. The class contains two generic attributes II-id (Innovation Information ID), KS-id (knowledge source ID) and II-title (innovation source title). The class operations are considered to be general assessors such as Extract-II (Extract Innovation Information) and Display-II (Display Innovation Information). ICI_Information does not generate any objects. The specialized classes, such as the IPR class, create the corresponding objects. In each specialized class methods Extract-II and Display-II are overloaded to provide the specialized meaning that must be attained in each specific information type. Since the searching over the web for innovation resources provides a vast amount of related or unrelated outcomes, users must allocate significant effort to identify and collect the useful information content. OBIE in ICI is implemented using the ISI Semantic Class.

The semantic web in ICI has been conceived as a vehicle to build semantic spaces over the web published contents for R&D results, IPR, publications, new technologies, market data and web news, which are related to the core innovation theme. The explosive growth of the publicly accessible content on the web as well as the high multiplicity of available forms of web information sources, is limiting the web information retrieval to browsing and searching. Advancing from information retrieval, Information Extraction (IE) is described as a system that extracts information into the knowledge system. Ontology-Based Information Extraction (OBIE) has recently emerged as a specialization of information extraction. The ontologies are used to extract information and present it using again the ontological framework (Zorrilla and Mazon, 2013), (Kiryakov et al., 2004).

CONCLUSIONS

Moving one-step further, semantic web enables a different description of ICI related web content based on knowledge representation and reasoning and enhancing web available data related to innovation with abstractions. To create meta-data structures that define data on the Web and to retrieve and interpret semi-structured web data, RDF has been taken as the optimal choice, since it has become the W3C recommended standard of both XML and SOAP. RDF is composed of Triples: (1) the subject (the web page), (2) a property or predicate (an attribute name) and (3) an object (the actual value of the attribute for the web page).

ISSN 2055-0847(Print), ISSN 2055-0855(Online)

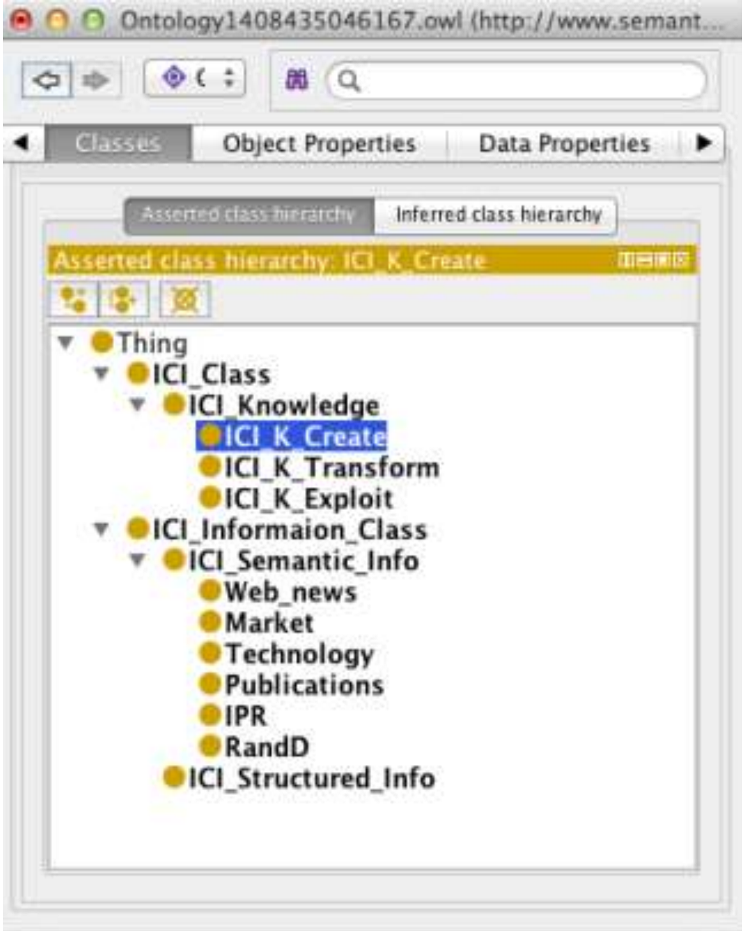

Figure 3. ICI ontology classification in Protégé 4.0

For each exercise of generating ideas for a new product or service a new set of objects will be generated from each of the class sets of figure 2. Classes are used as templates for generating objects. The ICI ontology is used as a knowledge base for retrieving and expressing information related to specific new product/service development challenges. For example from the ICI_class an object set could be generated, as Smart_Parking-ICI, for collecting knowledge for smart parking mobile technologies. The innovation manager retrieves structured data related to mobile parking services from various databases. Semantic data could also be retrieved over the web. These data must be converted into knowledge objects, which in turn will improve the decision making process in the three innovation chain links. The lifespan of the objects extends up to the date the innovation manager decides to terminate the new product development process.

REFERENCES

Atuahene-Gima, K., & Evangelista, F. (2000). Cross-functional influence in new product development: An exploratory study of marketing and R&D perspectives. *Management Science, vol. 46, pp. 1269-1284.*

Cassiman, B., & Veugelers, R. (2002). R&D cooperation and spillovers: some empirical evidence from Belgium. *American Economic Review, vol. 92, pp. 1169–1184.*

Chiva, R., & Alegre, J. (2009). Investment in design and firm performance: The mediating role

ISSN 2055-0847(Print), ISSN 2055-0855(Online)

of design management. *Journal of Product Innovation Management, vol. 26, pp. 424-440.*

Gronlund, J., Sjodin, R., & Frishammar, J. (2010). Open innovation and the Stage-Gate Process: a revised model for new product development. *California Management Review, vol. 52, pp106-108.*

Hansen, M., & Birkinshaw, J. (2007). The Innovation chain. *Harvard Business Review, pp. 1-4.*

Horn, M. (2005). The changing nature of innovation. *Research Technology Management vol. 48, pp. 28–33.*

Kiryakov, A., Popov, B., Terziev, I., Manov, D., & Ognyanoff, D. (2004), *Semantic annotation, indexing, and retrieval. Web Semantic, vol. 2, pp. 49–79.*

Langseth, J., & Vivatrat, N. (2003). Why Proactive Business Intelligence is a Hallmark of the Real-Time Enterprise: Outward Bound. *Intelligent Enterprise, vol 5, pp. 34-41.*

Negash, S. (2004). Business Intelligence. *Communications of the Association for Information Systems, vol. 13, pp. 177-195.*

Pittaway, L., Robertson, M., Munir, M., Denyer, D., & Neely, A. (2004). Networking and innovation: A systematic review of the evidence. *International Journal of Management Reviews, vol. 5/6 pp. 137–168.*

Roper, S., Du, J., & Love, J. (2008) Modeling the innovation value chain. *Research Policy, vol. 37, pp. 961-977.*

Shneiderman, B. (2000). Creating creativity: user interfaces for supporting innovation. *ACM Transactions on Computer-Human Interaction vol. 7, pp. 114-138.*

Zorrilla, M., Mazon, J., Ferrández, O., Garrigos, I., Daniel, F., & Trujillo, N. (2012). Business Intelligence Applications and the Web: Models, Systems, and Technologies. *Business Science Reference, pp.311-332.*

Zygiaris, S. (2010). A systemic framework for the analysis of regional innovation systems. *International Journal of Innovation and Regional Development, vol. 2, No. 4.*

ISSN 2055-0847(Print), ISSN 2055-0855(Online)