Enterprise Competency Modeling - A Case Study

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Abstract. The purpose of this paper is analyzing the crucial play in carrying out enterprise competency within the enterprise. This study uses the method of case study and has directed the survey on Chika Food Industry (ChFI). It is anticipated through the case study of this company that it will be possible to implement the finding of enablers concluded by other papers, thus showing the inter-relationship between organizational management and information technology management perspectives.

Keywords: Enterprise knowledge modelling, enterprise competency, modelling, case study

1 Introduction

In recent years, the artificial intelligence and enterprise modelling communities have developed important enterprise models and/or ontologies, including: the Toronto Virtual Enterprise (TOVE), the Open Information Model (OIM), Computer Integrated Manufacturing Open System Architecture (CIMOSA), IDEON, Business Process Modelling Language (BPML), and Collaborative Network Organisation (CNO) [1]. Furthermore, there exist a number of frameworks to model Collaborative Networked Organizations (CNO) in general [2] including the Zachman's Frameworks, GERAM – Generalized Enterprise Reference Architecture, and ARCON - A Reference Model for Collaborative Networks. In particular, ARCON consolidates existing frameworks through generic abstractions to model basic elements of CNO [2].

In addition to the enterprise model, it is important to capture and manage the knowledge and skills of enterprises' internal competencies [4]. Enterprise Competency is a crucial factor in business scenarios, in that it provides a more nuanced description of an enterprise's [5] or individual's [6,7] profile. Such a profile demonstrates the knowledge, skills, experience, and attributes necessary to effectively implement a defined function [1,8].That Competency is an essential component of enterprise engineering, acting as a new means to consider knowledge capitalisation [9], associated with a new vision of performance [7,10], as well as new forms of ontology [11,12]. First, the understanding and auditing of competencies acquired, required, and desired by a company and second, representing them in a structured manner, are beneficial steps for enhancing the company's performance. These issues motivate the co-author of this paper to propose a PhD thesis to the author.

The main aims of this research thesis are: (a) understand capability and competency concepts (b) introduce an approach to store, manage and maintenance capability and competency of an organization in different levels of abstraction (c) suggest some criteria for using competency as ontology for organization integration. The central research questions which are addressed in this research thesis;

RQ1) how to model an enterprise with its existing competencies?

RQ2) what are the templates, procedures and methods to store, maintain and manage competency of an organization?

This study uses a case-study of one organization to examine the dynamics of successful competency modelling practices, and to consider the extent to which such practices can be generalized and adapted by others. Therefore, the overall effect of this theoretical approach is to bridge a gap between the abstract concepts that we employ to understand enterprise competency and the practical, context-dependent realities facing business organizations.

2 Contribution of the Paper to "Collective Awareness Systems"

Competency modeling is an approach for configuring an organizations knowledgebase scheme. In contrast to the other organizational knowledge modeling approaches that covers only the information and knowledge of the organization from only one perspective, competency modeling has the capability of providing an organizational knowledge model from different viewpoints. Similar to the other organizational data models, it can be used on BtoB context in order to provide a platform for sharing information among the stockholders of a network. Furthermore, the competency-based knowledge model can provide an appropriate context for doing better collaboration. The authors believe is that, competency modeling approach, can be employed as an appropriate infrastructure for developing a robust "Collective Awareness System" on organizational management context.

3 Sector's Capability - Concepts and Model

The formalization of sector capability is as follows. Let's consider for subsequent modelling a set of sectors at an enterprise E= {S1, S2, S3, …}.

Definition 1 (Sector capability)- Capability can be understood as sector's ability to perform activities, tasks, acts or processes possible through corresponding resources and knowledge, aimed at achieving a specified number of outcomes.
For modelling the remaining concept, let's consider the set of capabilities at sector α: $C_\alpha = \{ C_{\alpha 1}, C_{\alpha 2}, \ldots, C_{\alpha n} \}$ in which each element $C_{\alpha i}$ stands for a capability. The following definition introduces the concept of capability, which is built upon three building aspects. It can be specified as a set
$C_{\alpha i} = \{X_{\alpha i}, R_{\alpha i}, K_{\alpha i}\}$, i=1…n; Such that:
$X_{\alpha i} = \{x_{\alpha 1,} x_{\alpha 2}, x_{3\alpha}, \ldots, x_{\alpha j}\} = \{x_{\alpha j} | x_{\alpha j} \text{ is a activity for } i^{th} \text{capability at sector } \alpha\}$,
i=1,…,n , j=1,…,m
$R_{\alpha i} = \{r_{\alpha 1,} r_{\alpha 2}, r_{3\alpha}, \ldots, r_{\alpha j}\} = \{r_{\alpha j} | r_{\alpha j} \text{ is a resource for } i^{th} \text{capability at sector } \alpha\}$,
i=1…n,
j=1,…,m ; $K_{\alpha i} =$
$\{k_{\alpha 1,} k_{\alpha 2}, k_{3\alpha}, \ldots, k_{\alpha j}\}\{k_{\alpha j} | k_{\alpha j} \text{is a knowledge for } i^{th} \text{capability at } \alpha\}$,i=1…n, j=1,…, m

Definition 2 (Sector's task-oriented capability) – is a sub-set of a sector capability set, this sub-set represents capabilities which are needed to run a specific outcome or specific goal. For sector α it can be shown as C^*_α where: $C^*_\alpha \subseteq C_i$; $C^*_\alpha = \{C_{\propto 1}, C_{\propto 2}, C_{\propto 3}, \ldots, C_{\propto n}\} = \{C_{\propto k} \mid C_{\propto k} \text{ is a selected capability at sector } \alpha \text{ for a specific task } \}$; k=1,…, n

4 Cross-functional Coordination and Integration Processes

Cross-functional co-ordination of capabilities of a sector has been identified as a key operation for enterprise competency creation process [13]. The successful achievement of the enterprise's global goals depends not only on the appropriate co-ordination of sectors' capabilities, but the proper integration of the capabilities at enterprise level is also vital. Additionally, a potential defect in one node (sector capabilities) may jeopardise the enterprise competency model [10,14]. The interdependencies (sequence/parallelism, synchronisation, data flow, precedence conditions) among capabilities, at the various sectors, must be properly integrated in order to achieve the enterprise global goals. 'Cross-functional co-ordination' and 'Cross-functional integration' of capabilities is defined as:
Definition 3 (Cross Functional Co-ordination (CFC) of capabilities) – is a link among capabilities within a sector, this link seeks to fund relations between the activities of the capabilities using sector's 'product/service workflow diagram.' CFC is act as union for the other component of the capability (i.e. resource$\{R_{\alpha 1} \cup R_{\alpha 2} \cup R_{\alpha 3} \cup \ldots \cup R_{\alpha n}\}$, knowledge$\{K_{\alpha 1} \cup K_{\alpha 2} \cup K_{\alpha 3} \cup \ldots \cup K_{\alpha m}\}$,). CFC is the set of ordered pairs$(x, \mathfrak{x})$; where x is the independent activity and the $\mathfrak{x}$ is dependent on x. $CFC(C) = \{(x, \mathfrak{x}) \mid x \in C \text{ and } CFC(x) = \mathfrak{x}\}$;

$$\mathrm{FC(x)}\begin{cases} = 0\ ;\ \text{if a is not sector to the other activities} \\ = \ \mathcal{x}\ ;\ \text{is reachable from product/service workflow diagram} \end{cases};$$

where: C- is a capability set; x, $\mathfrak{x}, \mathcal{x}$- is a activity, task, act or process

Definition 4 (Cross Functional Integration (CFI) of capabilities) - CFI is a link among capabilities of sectors within an enterprise. This link seeks to fund relations among the activities of the capabilities at the enterprise using enterprise's 'product or service structural model'. CFI acts as union for the other component of the capability between sectors (i.e. resource$\{R_{\alpha1} \cup R_{\alpha2} \cup R_{\alpha3} \cup \ldots \cup R_{\alpha n}\}$, knowledge$\{K_{\alpha1} \cup K_{\alpha2} \cup K_{\alpha3} \cup \ldots \cup K_{\alpha m}\}$,).

$\mathrm{CFI}_{\alpha\beta}\left(C_\alpha, C_\beta\right) = \{(x_\alpha, \mathfrak{x}_\beta) \mid x \in C_\alpha \text{ and } \mathrm{CFI}(x_\alpha) = \mathfrak{x}_\beta\}$

$$\mathrm{CFI}(x_\alpha)\begin{cases} = 0\ ;\ \text{if } x_\alpha \text{ is not sector on the other activities at sector } \beta \\ = \ \mathcal{x}_\beta\ ;\ \text{is reachable based on product/service structural model} \end{cases}$$

Definition 5 (Enterprise's competency) –Is defined as cross functional co-ordination and integration of task-oriented capabilities aimed at achieving a global outcome or goal. Enterprise's competency definition can be formulated as:

$$\text{Competency}\ |_G^{1,2} = C_1^* \otimes C_2^* = \mathrm{CFI}_{12}\ [\mathrm{CFC}\left(\bigcup_{i=1}^{n}\{C_{1i}^*\}\right), \mathrm{CFC}\left(\bigcup_{i=1}^{m}\{C_{2i}^*\}\right)]$$

$$\text{Competency}\ |_G^{1,2,3} = C_1^* \otimes C_2^* \otimes C_3^*$$
$$= \mathrm{CFI}_{12}\left[\mathrm{CFC}\left(\bigcup_{i=1}^{n}\{C_{1i}^*\}\right), \mathrm{CFC}\left(\bigcup_{i=1}^{m}\{C_{2i}^*\}\right)\right], \mathrm{CFC}\text{Competency}\ |_G^{1,2,..,n}$$
$$= C_1^* \otimes C_2^* \otimes \ \ldots\ \otimes C_n^*$$
$$= \mathrm{CFI}_{12\ldots(n-1)}[\mathrm{CFI}_{12\ldots(n-2)}[\ldots[\mathrm{CFI}_{12}[\mathrm{CFC}\left(\bigcup_{i=1}^{n}\{C_{1i}^*\}\right), \mathrm{CFC}\left(\bigcup_{i=1}^{m}\{C_{2i}^*\}\right)], \ldots], \mathrm{CFC}\left(\bigcup_{i=1}^{k}\{C_{ni}^*\}\right)]$$

Where: G- Represents a specific outcome or goal; 1, 2, 3,…, n- Is an index for representing sectors; C_m^*- Task-oriented capability for Sector m as defined previously; $\bigcup_{i=1}^{n}\{C_{\alpha i}^*\} = \{C_{\alpha1} \cup C_{\alpha2} \cup C_{\alpha3} \cup \ldots \cup C_{\alpha n}\}$;$\otimes$ cross functional integration and co-ordination; CFI_{nm}- Cross Function Integration between sector n and sector m; CFC- Cross Function Co-ordination.

5 Case Study

The competency modeling implementation is a part of knowledge management strategy for a corporation and with knowledge as an intangible asset, the usefulness of it usually cannot be seen in the short run. Therefore, this research uses the method of a case study and has directed our survey on Chika Food Industry (MFI). The reason that we have chosen this company is that it has already carried out knowledge management strategy so a part of knowledge for competency modeling proposes is accessible for the enterprise knowledge base system. (A)Identify and list required capabilities of sector: In this example the goal of the sectors is producing a conserve base 'Macaroni &Sauce' food. After identification process, the listed capabilities are then sequenced so that they follow the order in which they will be performed. Successful completion of these attempts often requires a good knowledge of process planning, manufacturing features and manufacturing resources. 'production' and 'Laboratory' of ChFI have sets of capabilities: C_{Pro}={'Cooking','Mixing','Filling','Weighing','Freezing','Sealing','Palletizing'} ; C_{Lab}={ 'Microbiologic test' }Since the goal is producing 'Macaroni & Sauce", 'Production' and 'Laboratory' sectors' task oriented capability set is as: $C^{*}_{Pro(M\&S)}$={ Cooking' ,'Mixing', 'Weighing', 'Sealing', 'Palletizing'}; $C^{*}_{Lab(M\&S)}$={ 'Microbiologic testing'}. (B)Assign resources, activities and knowledge to the sequenced capabilities: For the resources, activity and knowledge assign processes of acquired capabilities, interviews of personal appreciation, samples, references is used. For instance, the 'Cooking' and 'Mixing' capabilities at 'Production' sector also 'Microbiological test' at 'Laboratory' sector has the following sub elements (raw ingredients Code are:

1,2,3,4,5): 'Cooking$_{@Pro.}$'=

$$\left\{\begin{array}{c}\{\text{Combine}\&\mathit{Cook}(1,2),\ \text{Combine}\&\mathit{Cook}\ (3,4,5)\}\\ \{\text{Cooking kettleA, Cooking kettleB, Technician1}\}\\ \{\text{Manuals/KettleA, Manuals/KettleB, Recipe1, Recipe2, Bill of Material1}\end{array}\right\} = \left\{\begin{array}{c}\{x_{C1,}x_{C2,}\}\\ \{r_{C1,}r_{C2,}, r_{C3,}\}\\ \{k_{C1,}k_{C2,}k_{C3,}k_{C4,}k_{C5,}\}\end{array}\right\};$$

$$\text{'Mixing}_{@Pro.}\text{'}=\left\{\begin{array}{c}\{\text{Draining, Mixing}\}\\ \{\text{Mixinging kettle, Draining kettle, Technician2}\}\\ \{\text{MixingKettleManuals, Recipe3, Bill of Material2}\end{array}\right\}=\left\{\begin{array}{c}\{x_{M1,}, x_{M2}\}\\ \{r_{M1,}r_{M2,}r_{M3}\}\\ \{k_{M1,}k_{M2,}k_{M3}\}\end{array}\right\}$$

'Microbiological test$_{@Lab}$' =

$$\left\{\begin{array}{c}\{\text{Microbiologic testing}\}\\ \{\text{Sample Precreation Machine, Oven, Testing Machine}\}\\ \{\text{Manual1, Manual2, Manual2, Worksheet}\}\end{array}\right\}=\left\{\begin{array}{c}\{x_{MT1}\}\\ \{r_{MT1,}r_{MT2,}r_{MT3}\}\\ \{k_{MT1}, k_{MT2}, k_{MT3}, k_{MT3}\}\end{array}\right\}$$

(C)Interactions of capabilities within sectors and between the sectors: The sequence diagram in Fig.1 demonstrates the interaction of capabilities among these sectors.

(D)Capability modeling: A capability knowledgebase is developed to assure that the knowledge of capabilities at the sectors is capitalized. At present, the knowledgebase is developed under ACCESS and is operational. The relational model of the capability knowledgebase is represented by Fig.3. The use of a standard incoming application adds knowledge gathering process to the capability knowledgebase system. (E)'Cross-functional co-ordination' and 'Cross-functional integration' of capabilities :The 'cross-functional co-ordination' and 'cross-functional integration' sub-categories concerns the linking of enterprise competency aspects. The 'Cross-functional co-ordination' process (definition 3) was adapted to all the identified capabilities at the sectors. For do this, the sector's capabilities sequence diagram (figure 1) is used. As an example: Cross Functional Co-ordination (CFC) Cooking→ Mixing: $\left\{ \begin{array}{c} \{(x_{C1},x_{M1,}),(x_{C1},x_{M2}),(x_{C2},x_{M2})\} \\ \{r_{C1},r_{C2,},r_{C3,},r_{M1},r_{M2},r_{M3}\} \\ \{k_{C1},k_{C2},k_{C3},k_{C4},k_{C5,},k_{M1},k_{M2},k_{M3}\} \end{array} \right\}$ Using the capabilities sequence diagram among the sectors (figure2), the 'Cross-functional integration' process (definition4) was adapted to the identified capabilities at the enterprise. As an example:

$$\text{Cross Functional Integration (CFC) Cooking} \rightarrow \text{Microbiological test: } = \left\{ \begin{array}{c} \{(x_{C1},0),(x_{C1},0),(x_{C2},x_{MT1})\} \\ \{r_{C1},r_{C2,},r_{C3,},r_{MT1},r_{MT2},r_{MT3}\} \\ \{k_{C1},k_{C2},k_{C3},k_{C4},k_{C5,},k_{MT1},k_{MT2},k_{MT3},k_{MT3}\} \end{array} \right\}$$

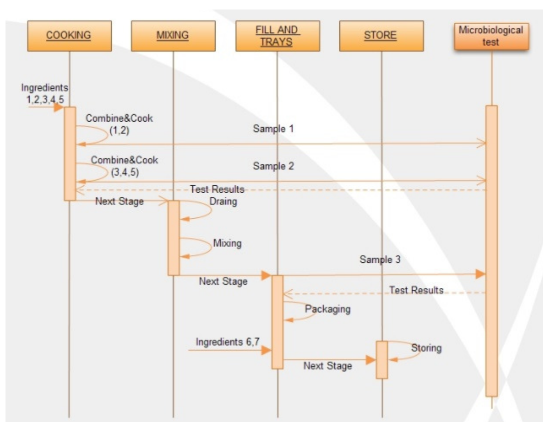

Fig. 1. Interactions of capabilities among the design and manufacturing sectors

(F)Enterprise competency representation: At this stage all the competency aspects were stored, and all the competency associated sub-categories were linked as well; the next step is to represent enterprise competency. Using enterprise competency definition (definition 5) the example blow depicts competency creation process at the enterprise. For simplification in this example only three capabilities ('Cooking' and 'Mixing' from 'Production' sector and 'Microbiological test' from laboratory department) are taken in to consideration. Competency (Cooking, Mixing) →(Microbiological test):

$$\left\{\begin{array}{c} \{(x_{C1}, x_{M1}, 0), (x_{C1,}x_{M2}, 0), (x_{C2,}x_{M2}, x_{MT1})\} \\ \{r_{C1}, r_{C2}, r_{C3}, r_{M1}, r_{M2}, r_{M3}, r_{MT1}, r_{MT2}, r_{MT3}\} \\ \{k_{C1}, k_{C2}, k_{C3}, k_{C4}, k_{C5}, k_{M1}, k_{M2}, k_{M3}, k_{MT1}, k_{MT2}, k_{MT3}\} \end{array}\right\} ;$$

Fig.2 depicts the dialog boxes in which the competency are shown. The dialog boxes also show the features of the competency stored in the knowledgebase. The experimental software developed can show capability attributes by clicking on the particular sign beside each row.

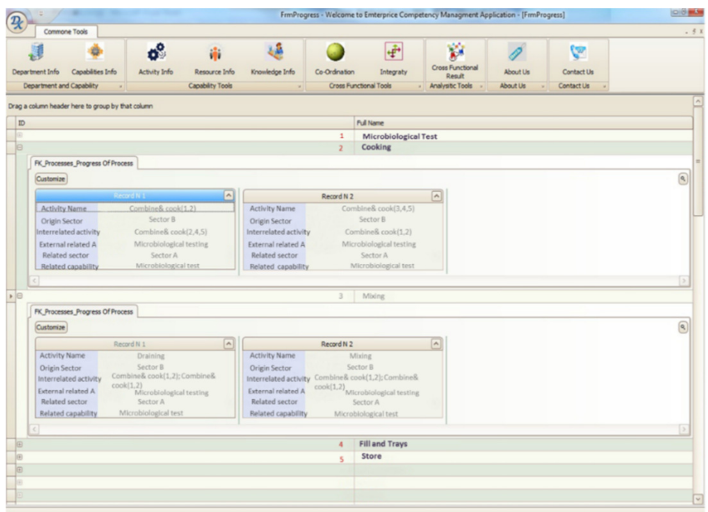

Fig. 2. Enterprise competency representation

6 Conclusions

Under the influence of the enterprise engineering paradigm with enterprise's productability, companies need to start to actively implement competency management with the goal of obtaining important information for their future decision making processes. This research first concluded that 'cross-functional co-ordination', 'cross-functional integration', and 'sector capability' are three of the sub-categories in enterprise competency modelling. Furthermore, based on past published papers, resource, activity, and strategy (knowledge related resource and activity) are three of the aspects for sector capability modelling. A generic sector capability model is proposed; also cross-functional co-ordination and cross-functional integration of the capabilities are defied as major advancements for intra-enterprise competency modelling. Through the case study of ChFI, we implement the academic 'enterprise associated' concepts with real practice in the industry. The developed experimental system for the case study of ChFI offers four benefits, in that they a) enhance the organizations willingness to collaborate, b) boost the organization's competitiveness, c) facilitate appropriate decision-making, and d) finally help to integrate the entire organization.

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