Deriving Object-Based Business Process Architecture using Knowledge Management Enablers

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Abstract: *This paper discusses a semantic-driven approach to deriving an object-based Business Process Architecture (BPA) using Knowledge Management Enablers (KMEs). The semantic enriched Riva BPA (srBPA) ontology has been selected as an object and ontology based BPA to be derived by the Abstract Knowledge Management Enablers' Ontology (aKMEOnt). The aKMEOnt includes six KMEs: information technology, leadership, organisation structure, culture, business repository and knowledge context. The aKMEOnt has been utilised in order to generate the Essential Business Entities (EBEs) of the srBPA ontology. A link between these two artefacts, i.e., the srBPA ontology and aKMEOnt, is demonstrated using a typical example of the deposits department in banking. In conclusion, this new ontology-based approach between KMEs and BPA has informed the effectiveness of using semantic KMEs and Semantic Web Rule Language (SWRL) rules in the semi-automatic identification of representative EBEs. These EBEs characterise the business of deposits in banking and constitute the first essential building block of the Riva BPA method which drives the development of Units of Work and the subsequent 1st and 2nd cut Riva process architectures.*

Keywords: *Business process architecture, knowledge management enablers, srBPA, riva method.*

Received October 6 2018; accepted January 22 2019

1. Introduction

Ontologies are defined as a set of well-founded constructs that can be leveraged to build meaningful higher-level knowledge. Theyalso contribute in knowledge management basic processes, namely integration, communication and reasoning [39].

A semantic representation of the Business Process Architecture (BPA) using ontology supports an understanding of the BPA and conceptualises its elements and their relationships. It also identifies a useful approach to linking BPA with other domains such as Knowledge Management (KM) and its enablers. Furthermore, it provides more automated functions such as reasoning, discovering services and information [22], which are necessary to reasonably identify, generate and reconfigure new BPA elements with flexibility in its adaptation.

The semantic Riva Business Process Architecture (srBPA) ontology developed by Yousef R. and Odeh M., [41] is a significant example of a semantic object-based BPA developed using the Ontology Web Language-Description Logic (OWL-DL), the standard recommended by the World Wide Web Consortium (W3C) [34]. srBPA is considered as the first remarkable work to semantically enrich the object-based Riva BPA method. The srBPA ontology conceptualises the elements of the Riva-based BPA and their relationships. This conceptualisation facilitates an understanding of the relations between its basic elements: Essential Business Entities (EBEs), Units of Work (UOWs),Case Processes (CPs) and Case Management Processes (CMPs) but not Case Strategy Processes (CSPs) which the srBPA has not included in its ontology. However, the srBPA ontology still does not support automating the discovery and generation of its initial elements, such as the EBEs, in order to create a dynamic BPA. This disadvantage can be overcome by applying semantic Knowledge Management Enablers (KMEs).

In this paper, we describe the linkages between the ontologies of Abstract Knowledge Management Enablers' Ontology (aKMEOnt) [35] and the srBPA which has led to introducing the new research framework, namely, the Knowledge Management Enablers Ontology Business Process Architecture (KMEOntoBPA) framework. These linkages are used to derive the EBEs from semantic KMEs and drive the development of the srBPA.

The remainder of the paper is organised as follows; section 2 briefly presents the Riva method steps for building an organisation's business process architecture, section 3 presents the KMEs that are used in this research, section 4 discusses how to link semantic KMEs to the srBPA using Semantic Web Rule Language (SWRL) rules, section 5 demonstrates the linkages in a typical example of the deposits department in banking. Section 6 concludes this paper.

2. The Riva Method

An object-based BPA method can be appropriate in developing BPA using KMEs. It captures the entire business objects of the organisation and distinguishes their interrelations. These business objects are more important than other approaches in providing a comprehensive understanding of the enterprise's knowledge resources and capabilities. Other approaches define goals, functions and actions; however, they are still not sufficient in covering all the knowledge resources which can be used to derive aBPA. Thus, an object-based method needs to be investigated in order to inform whether the extracted knowledge objects or resources from KMEs can be sufficient to utilise in developing an effective BPA.

Ould [29] developed Riva as a methodological approach to deriving object-based process architectures from candidate essential business entities. Building an organisation's process architecture using Riva is accomplished using the following steps:

- Identify the organisation and its boundary.
- Characterise the organisation.
- Find the essential business entities.
- Identify the units of work.
- Identify dynamic relationships between units of work.
- Transform the unit of work diagram into a first-cut process architecture.
- Transform the first-cut process architecture into a second-cut process architecture.

The Riva method provides a clear and practical approach for developing a business process architecture. The Riva BPA represents the blueprint of organisational processes and their relationships using the three types of processes: CPs, CMPs, and CSPs.

As a consequence, this paves the way to modelling the workflows of each of these processes using role-based business process modelling languages such as Role Activity Diagrams (RADs) [30] or Business Process Modelling Notation (BPMN) [28]. In addition, Ould [29] asserts that the Riva BPA is an invariant for an organisation that remains in the same business.

3. The Knowledge Management Enablers

Knowledge management enablers are facilitators that stimulate the creation of knowledge in organisations in addition to its sharing and protection [40]. KMEs stem from the resource-based theory [4], which suggests a knowledge-based view for strategy formulation and stimulates the consideration of KMEs as factors that should be used to manage the flow of knowledge resources in an organisation [25]. KMEs are also utilised by different knowledge management models in order to generate a dynamic system that enhances an organisation's core competences [19]. Using ontologies with KMEs can achieve a generic overview of the KMEs and the connections between them. It also facilitates an understanding of each KME concepts and their semantic relationships. Moreover, it will assist organisations responding to a rapidly changing environment in addition to inference reasoning over the ontologies' different elements [6].

Leadership, Information Technology (IT), organisation structure, culture, business repository and knowledge context are the main KMEs that represent the KMEs' domain in the aKMEOnt. They are key infrastructural capabilities that are necessary for KM implementation and organisational success [16].

3.1. Information Technology

IT refers to the capabilities of the technology infrastructure that supports the building of KM architecture [2]. IT infrastructure is an enabler that comprises resources and tools which acquire processes and store and disseminate knowledge [23].

A comprehensive infrastructure involves the effective management of a critical type of knowledge which includes knowledge mapping, knowledge discovery, collaboration, security and business intelligence [16]. Technology tools can incorporate communication technologies such as video conferencing and emails, or decision-aiding technologies such as decision support systems [37].

IT supports knowledge management in two directions [10]:

1. Formal systems which are designed to identify and share knowledge based on structured rules.
2. Interactive IT applications which provide an informal context to share knowledge between groups and individuals.

IT is based on different functions that are covered by the main processes and business modules of the organisation; any changes in these technologies or their input data can affect these dependent processes and modules [18]. Therefore, IT is essential in driving changes and developing a BPA.

3.2. Leadership

Leadership refers to the process of influencing others to understand and agree about what needs to be done and how to do it, and the process of facilitating individual and collective efforts to accomplish shared objectives [42]. Leadership plays a critical role in generating crucial knowledge for decision makers; moreover, it provides individuals with a vision through an appropriate presentation [27]. Leadership requires leaders to integrate KM processes with an organisation's strategy, support the value of KM and promote the evolution of a learning organisation [12].

Leaders should also support the dissemination of knowledge and new ideas, encourage the use of KM programs, record past learned lessons and ensure the use of relevant knowledge which is essential when applying a successful KM system [42].

Leadership has an important role in the development of business processes and their strategies in order to succeed in a dynamic environment [5]. It also sets goals and provides resources and team members with the knowledge and skills in order to enable task accomplishment [26]. These leadership roles can have an essential impact on the creation and reconfiguration of process architecture elements.

3.3. Organisation Structure

An organisation structure is the formal relationships and allocation of activities and resource among people [2]. It defines how roles are formally grouped, divided and integrated. Six elements need to be addressed by managers when building an organisation structure: centralisation and decentralisation; formalisation; work specialisation; departmentalisation; chain of command; and span of control [33].

Organisation structure can encourage employees to socially interact, which improves sharing and application of knowledge [31]. There is less probability to share knowledge in highly structured, hierarchical and multi-layered organisations. On the other hand, flat organisations which are not restricted to communication that flows in one direction are more likely to share knowledge [32]. A less-centralised (or more decentralised) and less-formalised structure also supports employees' collaboration, and the sharing of information and builds channels of communication to exchange knowledge and expertise [8].

Organisation structure has a critical impact on business performance. It helps organisations better communicate and share information and knowledge and hence achieve their organisational goals. Furthermore, an organisational change implies a continuous matching between its structure and processes [38]. Thus, organisation structure is significant while building a dynamic BPA.

3.4. Culture

Culture is defined as shared motives, values, beliefs, identities, and interpretations or meanings of significant events that result from common experiences of members of collectives and are transmitted across age generations [20]. Culture can be recognised at three levels; these levels range from tangible artefacts such as visible structures and processes to underlying assumptions such as thoughts, beliefs and feelings. Among these two levels there are espoused beliefs and values such as strategies, goals and rules of behaviour [36].

Culture was considered the biggest barrier to creating a knowledge-based organisation and was described as an active or passive hindrance for producing and developing KM programmes and strategies [7]. Three culture components were found significant in order to achieve an effective KM programme:

1. Trust.
2. Cooperative involvement.
3. Incentives [11].

An effective organisational culture establishes an appropriate environment that stimulates knowledge creation, sharing and dissemination, and supports teamwork and collaboration. Furthermore, it motivates individuals and employs reward systems [2].

Organisation culture is involved in process management, specifically with regard to the right way in which processes are accomplished or problems understood in an enterprise [24]. These methods or assumptions can have an important effect on how process architecture is developed in an organisation.

3.5. Business Repository

A business repository is a computer-based warehouse of documentation, knowledge and experiences about a particular domain, where knowledge is collected, summarised and integrated across sources, and referred to as corporate memories or experience bases [15].

A business repository is crucial in order to use and store all available knowledge assets in an organisation. It facilitates defining, implementing and managing organisational processes and activities. Furthermore, it reduces effort and improves productivity [14].

A repository requires users to seek knowledge through search queries; however, it limits the scope to ease this process [9]. Business repositories can be classified into three types [13]:

1. External repositories such as competitive intelligence.
2. Structured internal repositories such as work procedures and business reports.
3. Informal internal repositories such as lessons learned, news and important announcements.

A business repository is distinguished from information technology in its importance as a storage of organisational memory or experience [15]. A description of business processes and work procedures are found in its repository. Any changes in the business repository should be implemented in the BPA.

3.6. Knowledge Context

Context is an essential component in understanding knowledge and sharing it with other relevant knowledge in an organisation. Contextual knowledge is defined as the capacity to do what it takes in a situation [3]. It is related to the surrounding environment and cannot be viewed in isolation of the wider system of relations between individuals, activities and their understanding [17].

Knowledge context can be classified into two types [1]:

1. Context-based proactive delivery of knowledge.
2. The capture and utilisation of contextual knowledge.

The first shares knowledge with users based on the context, such as activities, business roles and outputs. The second one, the knowledge context itself, is captured and applied instead of being used as a means for knowledge identification and dissemination.

The development of different models and business processes will not be productive without understanding the context of knowledge in organisations [17].

Therefore, it is essential to understand the context of process while developing a BPA.

4. Linking aKMEOnt to srBPA Ontology

In order to link the aKMEOnt to the srBPA, some extensions to the aKMEOnt are required. The aKMEOnt is extended by adding Candidate Essential Business Entities (CEBEs) and SWRL rules in order to drive the instantiation of the srBPA ontology.

The business entities are the factors that one cannot escape in any business and they are called 'essential' because they are part of the essence of the business [29]. A number of filters are applied to the entire list of the CEBEs and are tested to examine whether each CEBE is truly an entity that could be deemed part of the core of the business. These filters, to be used by business analysts, are necessary in order to determine the EBEs after extracting or generating the CEBEs. An example of one of the filters is the testing of each CEBE by putting the word 'a' or 'the' in front of each one. If the output makes sense then the CEBE is considered an EBE.

The srBPA ontology is semantically enriched, however, it still needs to automate the generation of EBEs in order to drive the development of the Riva BPA. In this regard, the aKMEOnt leads the instantiation of the srBPA ontology by identifying CEBEs, which provide new dynamic features in their automated generation and reconfiguration. The new feature will keep the semantic Riva-based BPA up-to-date in order to facilitate the self-dynamic updating of the BPA per the flow of knowledge in the organisation. Thus, the aKMEOnt is the core building block that will drive the development of the srBPA.

Since the KMEs are presented in different disciplines other than the BPA, the aKMEOnt requires particular customisation in relation to the Riva BPA.

This customisation implies new elements that link the two ontologies, the aKMEOnt and srBPA. The new elements include CEBEs and SWRL rules.

4.1. The CEBEs

Building the BPA using the Riva method requires brainstorming the EBEs as an initial step. These EBEs are critical in driving the development of the BPA through selecting the UOWs then generating the first and second cut process architecture diagrams. The srBPA assumes that the list of EBEs is already provided by business analysts before deriving the list of UOWs. This step in the Riva method involves a few concerns:

- Difficulty of having a team for a long duration from different departments to check the BPA or brainstorm and revise the EBEs on a regular basis, especially in dynamic businesses such as banking.
- Lack of a dynamic BPA that reflects the changes in the business environment and keeps the BPA up-to-date.
- Missing the know-how, which means knowing how these entities are created from their sources; and
- The need for an automated system to create and track the EBEs and select the appropriate ones to build the Riva BPA.

Accordingly, the KMEs have been investigated to address these concerns since they track the flow of knowledge and explain how organisations' business entities are created. These business entities are defined as a set of capabilities and knowledge assets [21] that may become EBEs.

Thus, the aKMEOnt utilises KMEs to derive CEBEs. Each KME in the aKMEOnt has a formal representation of different concepts and their relationships. The overall KMEs' concepts are combined to construct the concept map of the KMEs [35]. Instances or occurrences of each KME concept play a role in identifying potential CEBEs in relation to other KMEs.

The ontology of IT KME defines the instances of the integrative tool concept which can retrieve and access the stored knowledge in an organisation. These kinds of tools can be applications that characterise the business in different fields such as healthcare, education and the banking sectors. The IT KME tools are classified as CEBEs provided that they have an integrative type and used by agents (or employees) who are followers or leaders in the leadership KME ontology.

The ontology of the leadership KME does not provide instances that are considered as CEBEs. The instances of this ontology are the agents or the persons in the organisation who can be leaders or followers. However, the instances of the leadership KME ontology can be aligned with other KMEs or provided as restrictions in order to extract the CEBEs from other KMEs.

The ontology of the organisation structure KME provides instances of different concepts.

Some instances can characterise the business of the organisation and are considered as CEBEs. These instances are individuals of the position and business behaviour concepts in the ontology of the organisation structure KME. Position instances are organisation positions that define the roles and their potential resources. A lecturer in a university is an example of a position instance. Business behaviour is a new concept that has been substituted for the concept of business function in the aKMEOnt [35]. Business behaviour instances are different business behaviours that cover services, business function, interaction and events. Services and business function are the main business behaviour types that can characterise the business of the organisation and become CEBEs. A service such as flight booking in a travel agency and a business function such as customer service in a telecom company are examples of these CEBEs.

The ontology of the knowledge context KME has concepts that represent factors or conditions of a unique business situation. Therefore, a number of these factors can provide CEBEs. The factors are the instances of the customer and restriction concepts in the knowledge context ontology. Customer or restriction instances are described as external ones since they are more likely to be in the essence of the business rather than the internal ones. The internal ones can be designed entities which are not essential and they are there because we have chosen to work in a particular way, or they can be roles which are not of the essence of the business [29]. Health and safety standards and patients are sequential examples of restrictions and customers that represent CEBEs that characterise the business of a hospital.

The ontology of a culture KME is concerned with the external adaptation problems that can be solved through a pattern of shared assumptions. External adaptation problems are related to environmental changes, new possibilities and challenging situations.

The instances of an external problem concept are deemed to be CEBEs. Medical mistakes or flight delays are suggested problems that can be sequential CEBEs that characterise the business of a hospital or airline.

The ontology of a business repository KME is mainly related to the e-documents in an organisation, e-documents can imply descriptions of previous CEBEs such as tools, positions, services, functions and problems. However, the number of these documents can be large and extracting or identifying CEBEs through them is difficult.

Moreover, e-documents alone do not achieve a real application of knowledge management in organisations and fail to notice how these CEBEs are created or classified as a knowledge resource in an enterprise.

Therefore, the e-documents will be limited to extracting only the contracts that are signed by customers. Contracts are essential object entities that can represent many of organisations customers related processes. They are also easy to identify and to use through their types and names in order to derive CEBEs. Different insurance forms such as auto and health insurance policies are examples of contracts that are CEBEs.

The previous CEBEs represent different knowledge resources that are produced by the semantic KMEs. The Riva BPA method is an object-based approach that can embrace these knowledge resources and use them as business blocks or objects in order to build a BPA from a business perspective. Therefore, the Riva BPA and its semantic approach can be well aligned with semantic KMEs, which can be utilised in order to characterise the business of an organisation (or generate CEBEs) and continue Riva's remaining steps. Automating the extraction or generation of previous CEBEs requires using some rules associated with logic. The ontology development environment, Protégé tool, supports using Semantic Web Rule Language (SWRL) which can be used to derive the CEBEs. SWRL can process ontology elements and express processing rules as well as logic. These SWRL rules can enrich the generic process of CEBEs' identification.

4.2. The aKMEOnt SWRL Rules

After the CEBE concept has been defined, the aKMEOnt SWRL rules are utilised to extract the CEBEs from the individuals of the aKMEOnt. Constructing SWRL rules is designed through an algorithm which is identified after an overview of the aKMEOnt concepts and their potential individuals. Individuals are the instances of the KMEs' concepts such as units, positions and customers which are generated using a case study.

The algorithm can be used to clarify how to automate the step of extracting the CEBEs from the KMEs. The KMEs' output(s) will be used as inputs to identify CEBEs using the CEBEs Identification Algorithm 1.

CEBEs identification algorithm

Input: The set of Tool instances, nTool = {$nTool_0$, $nTool_1$... nToolj}. The set of Agents instances, nAgent= {$nAgent_0$, $nAgent_1$... nAgentj}. The set of Problems instances, nProblem= {$nProblem_0$, $nProblem_1$... nProblemj}. The set of E-Documents instances, nE-Document= {$nE\text{-}Document_0$, $nE\text{-}Document_1$... $nE\text{-}Document_j$}. The set of Customers instances, nCustomer= {$nCustomer_0$, $nCustomer_1$... nCustomerj}. The set of Restrictions instances, nRestriction = {$nRestriction_0$, $nRestriction_1$... nRestrictionj}. The set of BusinessBehavior instances, nBusinessBehavior = {$nBusinessBehavior_0$... $nBusinessBehavior_j$}. The set of Position instances, nPosition = { $nPosition_0$... $nPosition_j$}.
Output: The set of candidate essential business entities (CEBEs), CEBE = {$cebe_0$, $cebe_{1...}$cebej}.
Begin
Define the new candidate EBEs List (nCEBE);
For each $nBusinessBehaviour_i$ in nBusinessBehaviourList
//SWRL No. 1
{

Set instance nBusinessBehaviour$_i$ as new instance cebe$_v$in the CEBE set, where $0\leq v\leq j$;
Set v++;
}
For each instance P_i in Position list
//Identify SWRL No. 2
{
If (instance $U_i$hasPosition(P_i)) { Set instance P_i as new instance nPosition$_v$in the new Position set, where $0\leq v\leq j$;
Set v++; }
}
For each nTool$_i$ innTool List
//Identify SWRL No. 3
{
If (nTool$_i$usedby(Agent$_i$) in nAgent List) {
Set instance nTool$_i$as new instance cebe$_v$in the CEBE set, where $0\leq v\leq j$;
Set v++; }
}
For each nE-Document$_i$in nE-DocumentList
// Identify SWRL No. 4, 7
{
For each nCustomer$_i$in nCustomer List {
Set instance nCustomer$_i$as new instance cebe$_v$in the CEBE set, where $0\leq v\leq j$;
If (nCustomer$_i$signsDocument(nE-Document$_i$) in nE-DocumentList) { Set instance nE-Document$_i$as new instance cebe$_v$in the CEBE set, where $0\leq v\leq j$; }
Set v++ ; }
}
For each nRestriction$_i$ in nRestriction List
// Identify SWRL No. 5
{
Set instance nRestriction$_i$ as new instance cebe$_v$in the CEBE set, where $0\leq v\leq j$; Set v++;
}
For each nProblem$_i$ in nProblem List
// Identify SWRL No. 6
{
Set instance nProblem$_i$ as new instance cebe$_v$in the CEBE set, where $0\leq v\leq j$; Set v++;
}
END

According to the algorithm, SWRL rules are developed in order to automate the extraction of the CEBEs. SWRL rules are depicted in Table 1.

Table 1. SWRL Rules driving the Identification of Candidate EBEs.

No.	Name	Description
1	sRule_generate_CEBE_ BusinessBehavior Unit(?u) ∧ performsBusinessBehavior(?u,?BB) → CEBE(?BB)	Business behaviours that have a function or service type in the unit are the CEBEs. The unit represents the department of a case study. U=Unit, BB= Business Behavior.
2	sRule_generate_CEBE_UnitPosition Unit(?U) ∧ hasPosition (?U,?P) → CEBE(?P)	Positions in the unit are CEBEs. The unit represents the department of a case study. U=Unit, P=Position.
3	sRule_generate_CEBE_Integrative Technology Tool(?T) ∧ hasUser(?T, ?A) ∧ IsIntegrativeTechnology(?T, true) → CEBE(?T)	Integrative technologies that are used by agents of Leadership KME in a case study are found to be CEBEs. T= Tool, A=Agent
4	sRule_generate_CEBE_ExternalCustomers Customer(?C) ∧ IsExternalCustomer(?C,true) → CEBE(?C)	External customers of the case study are considered CEBEs. C= customer
5	sRule_generate_CEBE_ExternalRestrictions Restriction(?R) ∧ IsExternalRestriction(?R, true) → CEBE(?R)	Restrictions from outside the case study can be candidate EBEs. R= Restriction.
6	sRule_generate_CEBE_ExternalProblemWith Assumption Assumption(?A) ∧ solvesProblem(?A,?P) ∧ IsExternalProblem(?P, True) → CEBE(?P)	External problems that have assumptions to be solved can be CEBEs. A= Assumption, P = problem
7	sRule_generate_CEBE_ExternalCustomer Contract E-Document(?D) ∧ Customer(?C) ∧ IsExternalCustomer(?C,true) ∧ signsDocument(?C, ?D) ∧ hasType(?D,"Contract") → CEBE(?D)	Contracts that are signed by external customers can be CEBEs. D= Document, C= Customer

5. Demonstration of Semantic Linkages

After the design and development of the new linkages between the aKMEOnt and the srBPA ontologies, a typical example of a deposits department in a bank has been applied in order to demonstrate these linkages and check the CEBEs that can be extracted from its semantic KMEs.

The first and second semantic rules extract CEBEs from the Organisation Structure KME (see Table 2).

'sRule_generate_CEBE_BusinessBehavior'
Unit(?u) ∧ performsBusinessBehavior(?u,?BB) → CEBE(?BB)
'sRule_generate_CEBE_UnitPosition'
Unit(?U) ∧ hasPosition (?U,?P) → CEBE(?P)

The third semantic rule extracts CEBEs from the IT KME (see Table 3).

'sRule_generate_CEBE_IntegrativeTechnology'
Tool(?T) ∧ hasUser(?T, ?A) ∧IsIntegrativeTechnology(?T, true) → CEBE(?T)

Table 2. Identified CEBEs from the Organisation Structure KME.

CEBEs	Description
Customer Service Management	Deposits business functions
Incoming, local and International Transfers	
Customer Identification and Verification	
Cheque Book Management	
CIF Management	
Card Management	
Management of Deposits	
Blacklist Management	
Cash and Teller Management	
Accounts Executive	
Safe Box Deposits	Deposits business services
Current Account	
Fixed Account	
Savings Account	
Joint Account	
Cheque Book Issuing	
E-Cards Issuing	
Cash Withdrawing	
Cheque Depositing	
Cash Depositing	
Cheque Cashing	
Cheque Clearing	
Currency Exchanging	
Money Transferring	
Salary Transferring	
Bank Statement Issuing	
Bills Paying	
Customer Relationship Officer	Bank front office position
Senior Customer Relationship Officer	
Customer Relationship Supervisor	
Teller/Customer Service Representative	
Bank Manager	Bank Position and the highest rank in branch location
Accounts Executive Officer	Deposits executive position
Accounts Executive Supervisor	
Senior Accounts Executive Officer	
Head of Accounts Executive Department	

Table 3. Identified CEBEs from the IT KME.

CEBEs	Description
Core Banking System	The bank system technology
Bank Intranet	The internal internet tool for sharing information inside the bank
Internet Banking / Web Access	Allowing user to conduct financial transactions via the internet
ATM	Automated teller machine
ATMBroker	Supports all transactions processed through ATM machines and enables interfacing between the bank ATM switch or national switch and core banking system
Exchange Rate Board	System that provides the capability to link the display rate board to the core banking system
Companies Control System	Retrieving data related to the corporate customers

The fourth and fifth semantic rules extract CEBEs from the Knowledge Context KME (see Table 4).

'sRule_generate_CEBE_ExternalCustomers'
Customer(?C) ∧ IsExternalCustomer(?C,true) → CEBE(?C)

'sRule_generate_CEBE_ExternalRestrictions'
Restriction(?R) ∧ IsExternalRestriction(?R, true) → CEBE(?R)

Table 4. Identified CEBEs from the Knowledge Context KME.

CEBEs	Description
Central Bank Instructions	Instructions issued by the central bank to all local banks
Central Bank Law	Rules imposed by the central bank on all local banks
Deposits Guarantee Act	Laws in relation to deposits business and department
Law Regulating the Exchange	
Public Debt Law	
Banking Law	
Income Tax Act	
Electronic Transactions Act	
Instructions Unit Bounced Cheques No. 22-2005	Instructions related to cheques that cannot be processed
Bank Policy	Principles that rule the bank procedures
Bank Customer	Any individual or party that benefits from bank services
Corporate	Large organisations or companies
Local Bank	Other banks locally operated
Foreign Bank	External bank
Central Bank	National bank that provides financial services for the country and it is considered also as a customer for the local banks
Retail	Individual customers
SMEs	Small and medium-sized enterprises

The sixth semantic rule extracts CEBEs from the Culture KME which suggests external problems that can be CEBEs (see Table 5).

'sRule_generate_CEBE_ExternalProblem_WithAssumption'
Assumption(?A) ∧ solvesProblem(?A,?P) ∧ IsExternalProblem(?P, True) → CEBE(?P)

Table 5. Identified CEBEs from the Culture KME.

CEBEs	Description
Customer Identification and Verification Problems	Bank employee finds problems with identifying and verifying customers who need certain values rooted in bank such as customer satisfaction and trust
Customers Special Cases	There are certain special customers' cases in cash and deposits transactions such as customers' disabilities. These cases require handling through a set of values or assumptions
Wrong Money Transfers	Problems in transferring money to other banks or individuals might occur and need certain values such as trust and collaboration to handle

The seventh semantic rule extracts CEBEs from the Business Repository KME (see Table 6).

'sRule_generate_CEBE_ExternalCustomer Contract'
E-Document(?D) ∧ Customer(?C) ∧ IsExternalCustomer(?C,true) ∧ signsDocument(?C, ?D) ∧ hasType(?D,"Contract") → CEBE(?D)

Table 6. Identified CEBEs from the Business Repository KME.

CEBEs	Description
Account Opening Form	A contract signed by customer to open any account
Safe Deposit Form	A contract that gives the customer the service of keeping his/her belongings in a safe place

Finally, these CEBEs which have been extracted from different KMEs are checked by business analysts in order to decide whether each of them is an EBE that characterises the deposits business in a bank or not. Accordingly, the third step of the Riva method will be completed and remaining steps can be resumed in order to develop the business process architecture of the bank deposits.

6. Conclusions

In this paper semantic ontologies and SWRL rules have been applied in order to link the KMEs and BPA disciplines. Semantic representation of different KMEs which include Organisation Structure, IT, Leadership, Culture, Knowledge Context and Business Repository have been utilised using SWRL rules in order to automate the identification of the CEBEs of the deposits department in a bank. This automatic identification of CEBEs can be substituted for the second step of the Riva method. Moreover, it introduces a flexible BPA that can identify and adopt new EBEs which achieves a continuous and real-time generation of BPA elements and thus a dynamic BPA. The CEBEs of the deposits department in different banks are noticed as being in common with some differences in their naming as well as positions and restrictions CEBEs due to differences in bank hierarchies and the country in which the bank is located. This observation is aligned with Ould [29] who claims that the Riva BPA is an invariant for an organisation in the same business

In conclusion, linking KMEs to a BPA using a semantic-driven approach can support the dynamic capabilities of a BPA. It allows for the tracing and adoption of regular changes and enables a continuous generation and re-configuration of its elements. Moreover, it can involve knowledge accumulation and innovation, which adds a competitive advantage to the enterprise and thus develops an effective BPA. Therefore, it is recommended that aKMEOnt is applied in order to lead the development of different business process modelling approaches such as the role-based, function-based and goal-based ones.

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