UBL BASED BUSINESS DOCUMENT MANAGEMENT FOR ACHIEVING BUSINESS INNOVATION IN VIRTUAL ENTERPRISE ENVIRONMENTS

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ABSTRACT

UBL BASED BUSINESS DOCUMENT MANAGEMENT FOR ACHIEVING BUSINESS INNOVATION IN VIRTUAL ENTERPRISE ENVIRONMENTS

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E-business came into play when computers have started to be an important part of the businesses over the past decades. Businesses moved traditional aspects of their businesses into the software world to be able to compete with other businesses and make use of the emerging facilities.

Business document management is one of these aspects. The information, knowledge exchange among or within businesses are realized through documents. The semantically rich, conceptually shaped documents constitute a playground for computer scientists. Semantic based document management standards have been created by trade centres to increase interoperability, define common semantics, prevent conflicts among businesses and help in other dimensions to the businesses.

One of the standardization efforts is realized by United Nations Centre for Trade

Facilitation and Electronic Business(UN-CEFACT) in the form of a specification i.e. Core Components Technical Specification(CCTS). CCTS defines a methodology to be used for managing documents and creates a basis common vocabulary for businesses. The well-known implementation of CCTS is Universal Business Language(UBL). UBL is an XML based standard. UBL not only presents a wide collection of XML business data components but also details customization methods for specific needs of businesses.

In this study, UBL is applied to business documents for the goal of innovation in virtual enterprise environments. To achieve this goal, innovation activities and related business documents of two companies are studied. This leads us to document schemas and information, knowledge required for enabling innovation. Then, CCTS approach and UBL is utilized to model and use documents as a source of knowledge.

The research leading to these results has received funding from the European Commission Seventh Framework Programme under grant agreement no ICT-285746, as a part of the BIVEE Project (Business Innovation and Virtual Enterprise Environment)

Keywords: e-Business, Document Modelling, Document Management, Innovation, Virtual Enterprise, UBL, UN/CEFACT CCTS

ÖZ

SANAL İŞLETME ORTAMLARİNDA İŞ YENİLİĞİ İÇİN UBL TABANLİ DÖKÜMAN YÖNETİMİ

BAŞAR, RAHMİ VOLKAN
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Son yıllarda bilgisayarların iş dünyasında önemli bir yer kazanmasıyla e-iş etkisini arttırmaya başlamıştır. İşletmeler işlerinin geleneksel bölümlerini, diğer işletmelerle rekabet edebilmek ve ortaya çıkan kolaylıklardan faydalanabilmek için yazılım dünyasına taşımaya başlamışlardır.

İş dökümanı yönetimi bu bölümlerden biridir. İşletmeler, kendi içinde veya birbirleri arasında bilgi akışını, transferini dökümanlarla gerçekleştirmektedir. Dökümanların anlamsallığı, kavramsal bakımdan şekilselliği, bilgisayar bilimi için bu alanı önemli kılmıştır. Anlamsal döküman yönetim standartları birlikte işlerliği arttırmak, ortak anlamsallığı sağlamak, işletmeler arasında oluşabilecek anlaşmazlıkların önüne geçebilmek ve diğer boyutlarda yardım sağlayabilmek için ticaret merkezleri tarafından yaratılmıştır.

Bu standartlaşma çabalarından bir tanesi Birleşmiş Milletler İdari, Ticari ve Ulaşımla İlgili Uygulama ve Usulleri Kolaylaştırma Merkezi(UN-CEFACT) tarafından bir spesifikasyon olarak yaratılan Esas Parçalar Teknik Spesifikasyonudur(CCTS). CCTS döküman yönetimi için kapsamlı bir yöntem anlatırken, ortak kullanılan parçaları da tanımlar. Evrensel İş Dili(UBL), bu spesifikasyonun çokça bilinen gerçekleştirimlerinden biridir. UBL XML tabanlıdır ve kapsamlı bir XML iş veri bileşenleri derlemesi sunmanın yanında, döküman kişiselleştirmesi yöntemlerini de detaylandırır.

Bu çalışmada, UBL sanal işletme ortamlarında yenilik yaratmak amacıyla iş dökümanlarına uygulanmaktadır.İki şirketin yenilik faaliyetleri ve kullanılmakta olan ilgili dökümanlar incelenmektedir. Bu inceleme sayesinde, döküman şemaları ve yeniliği tetikleyebilecek bilgiler anlaşılmaktadır. CCTS yaklaşımından ve UBLden, dökümanların modellenmesi ve bilgi kaynağı olarak kullanılabilmesi için yararlanılmaktadır.

Yapılan araştırma Avrupa Birliği 7. Çerçeve Programı kapsamında ICT-285746 hibe anlaşmasıyla desteklenen BIVEE Projesinin (İş Yeniliği ve Sanal İşletme Ortamları) bir parçası olarak fonlanmaktadır.

Anahtar Kelimeler: e-İş, Döküman Modelleme, Döküman Yönetimi, Yenilik, Sanal İşletme Ortamları, UBL, UN/CEFACT CCTS

In memory of my beloved brother, Tunay...

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I would also like to thank BIVEE project partners, especially the whole CNR IASI team for coordinating the development on Production and Innovation Knowledge Repository and the whole AIDIMA and LOCCIONI team for providing the end-user requirements.

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LIST OF ABBREVIATIONS

ABIE	Aggregate Business Information Entity
ACC	Aggregate Core Component
API	Application Programming Interface
ASBIE	Association Business Information Entity
ASCC	Association Core Component
BBIE	Basic Business Information Entity
BCC	Basic Core Component
BIE	Business Information Entities
BIS	Business Innovation Space
BIVEE	Business Innovation and Virtual Enterprise Environments
ECOLEAD	The European Collaborative Networked Organisations Leadership Initiative
CC	Core Component
CCL	Core Components Library
CCR	Commercial Components Requirements
CCTS	Core Component Technical Specification
DC	Dublin Core
DCMI	Dublin Core Metadata Initative
DocOnto	Document Ontology
GUI	Graphical User Interface
HTTP	Hyper-Text Transfer Protocol
ICT	Information and Communications Technology
iSURF	An Interoperability Service Utility for Collaborative Supply Chain Planning across Multiple Domains Supported by RFID Devices
MCR	Mission Control Room
OASIS	Organization for the Advancement of Structured Information Standards
OWL	Web Ontology Language
PIKR	The Production and Innovation Knowledge Repository

RDF	Resource Description Framework
RFID	Radio-Frequency Identification
RForI	Research for Innovation
SDO	Salt Document Ontology
SemSim	Semantic Similarity
SMW+	Semantic MediaWiki Plus
SWOT	Strengths, Weaknesses, Opportunities, Threats
SPARQL	SPARQL Protocol and RDF Query Language
UBL	Universal Business Language
UN/CEFACT	The United Nations Centre for Trade Facilitation and Electronic Business
URI	Uniform Resource Identifier
VE	Virtual Enterprise
VEMF	Virtual Enterprise Modeling Framework
VIF	Virtual Innovation Factory
VPS	Value Production Space
W3C	World Wide Web Consortium
WWW	World Wide Web
XML	Extensible Markup Language

CHAPTER 1

INTRODUCTION

Business Innovation is an important and a key issue for today's enterprises. In addition to frequently studied innovation activities in a single enterprise, it is equally important to deal with the business innovation in virtual enterprise environments. In virtual enterprises, several different enterprises regardless of their sizes collaborate to respond new business opportunities. The degree of importance has been declared by European Commission through Europe 2020 strategy [9] and the Innovation Union [11].

Business Innovation and Virtual Enterprise Environment (BIVEE) [4] is a research & development project co-financed by European Commission Framework Programme 7. "BIVEE aims at building a distributed, collaborative, knowledge-intensive framework, where innovative business models, novel management methods, and emerging ICT solutions will be integrated to the benefit of interoperable virtual enterprises." [4] The goal is to improve the competitiveness of small and medium enterprises of Europe by increasing their innovation capabilities as parties in virtual enterprise environments. This work is rooted in the activities and results of the ongoing BIVEE project.

Innovation is a continuous activity which runs in parallel with existing core business activities of an enterprise. While some enterprises have independent research and development departments, most of the SMEs adopt ad-hoc methods for improvement and innovation purposes as discussed in [47]. Considering the fuzzy "Innovation" term and the complexity involved, the BIVEE project intends to divide this complexity by making a distinction between an "improvement"

and "innovation". These are highly interconnected parts of today's enterprises. The BIVEE project names these parts as "spaces" and discusses "improvement" and "business innovation" activities in separate spaces in a detailed way [32]. This convention will also be utilized in this work with the core focus in Business Innovation Space.

An improvement can be defined as a small set of activities which can directly be applied to the production processes. Improvement activities are modeled within the Value Production Space (VPS) which can be perceived as a digital virtual realization aimed at modeling and representing a complex, distributed reality of a virtual enterprise, with its operations, in a way that is easy and intuitive to be presented to and managed by a large variety of stakeholders, and in particular business people. For VPS, BIVEE intends to explore and propose innovative management methods, new business models and practices for the "improvement" concept. On the other hand, innovation processes are inherently different than the production related processes and BIVEE tries to model and formalize the business innovation processes within the Business Innovation Space (BIS). Instead of processing raw materials into products or elementary services into complex services as VPS does, the BIS targets to create new processes and alliances based on the previous experiences.

In this work, a document centric approach is presented to manage business documents in a virtual enterprise environment to create business innovation and improvement. Today, business documents are heavily-used and knowledge-intensive ways of information sharing. This fact makes documents an important knowledge source. BIVEE Project needs to utilize this source in realizing its aim: building a knowledge-intensive framework. The knowledge at hand will allow BIVEE Framework to enable collaboration among employees over real documented information and even assist them in their daily tasks.

In concrete terms, the scope of this thesis work is to examine documental resources of end-user partners in BIVEE Project and investigate whether Universal Business Language (UBL) is capable of modelling the structures of these resources. The goal is to utilize the documental resources to create business

innovation in virtual enterprise environments as a part of the document centric approach. The work ends with the technical realization of this formalization which enables BIVEE Framework to integrate with a third party UBL editor for user experience.

As a start, the background on business document management and the business innovation domain is given. The foundation of this work is based on available document standards, specifications and technologies. The background chapter, in this respect, gives introductory information to ensure a good understanding of the main areas in this research. The application of the given concepts in a relatively new domain creates the novelty of this work.

This study starts from scratch and follows the software engineering methodologies to the end. The core aspects of the study will be detailed in "Document Management" chapter. Working with two end-user companies to realize the goal requires a great deal of effort to learn the internals of these companies as a requirement. The start for requirements elicitation process is the descriptions and as-is structures of these two end-user enterprises in the BIVEE project. Their innovation and improvement activities are analyzed. The key actors and steps are identified. Each of these steps is formalized. And finally, "documents" are extracted.

Having analyzed the AS-IS status, the next step is the identification of the internal processes which can be mapped to VPS and BIS separately. Afterwards, with the document centric approach, the key documents exchanged between the actors of virtual enterprises during their improvement and innovation processes are identified. Indeed, this is the data requirements for the BIVEE platform and presented in Requirement Elicitation chapter of this thesis. For the detailed requirements to be used in BIVEE, the starting point is the data and then elicitation of the functional, interface and nonfunctional requirements accordingly. The analysis of the structure and content of the identified documents and their formalizations is a first step to come up with a unified and standardized approach in Business Innovation activities. The goal is to make BIVEE Platform provide a set of software tools in-line with our methodology and objectives for

the semantic management of the documents exchanged within the VPS and BIS.

Technical details on the realization of the aforementioned document centric approach have also been presented within the thesis. The start is a discussion on the flow of data technically from the user perspective. Then, a development design to realize our goals and objectives is presented together with interacted tools and services. The role and benefit of this work as a part of of BIVEE Framework have been detailed to clarify the utilization of outputs. Lastly, the related work has been given before the appendices chapter which includes additional useful details about the research.

Figure 1.1 presents the high level overview of the architectural flow. The first part to note, in this overview, is the need of modelling a set of documents on an UBL editing and maintenance tool. The second step is where the technical implementation of this thesis work resides: Mediator web service receives a UBL zip package from the UBL modelling tool and makes the necessary calls on the semantic repository API of the BIVEE platform. This enables BIVEE Platform to use these documents as a part of its semantic repository. The details and motivation of the architectural flow are presented throughout this thesis.

This thesis starts by presenting a detailed background overview on the work realized. This chapter starts with a summary of the technologies and standards, gives general information about the domain 'Business Innovation'. It gives a brief analysis of what is already studied in the document management and business innovation research areas. Requirements elicitation process is vitally important for this work and this has been included in the background chapter as a whole. The thesis then discusses document management as a separate chapter describing the objective, methodology, the formalization process and details about technical realization. Discussion is the last part where the results of the work is discussed from different perspectives. Finally, conclusion gives a summary of the results.

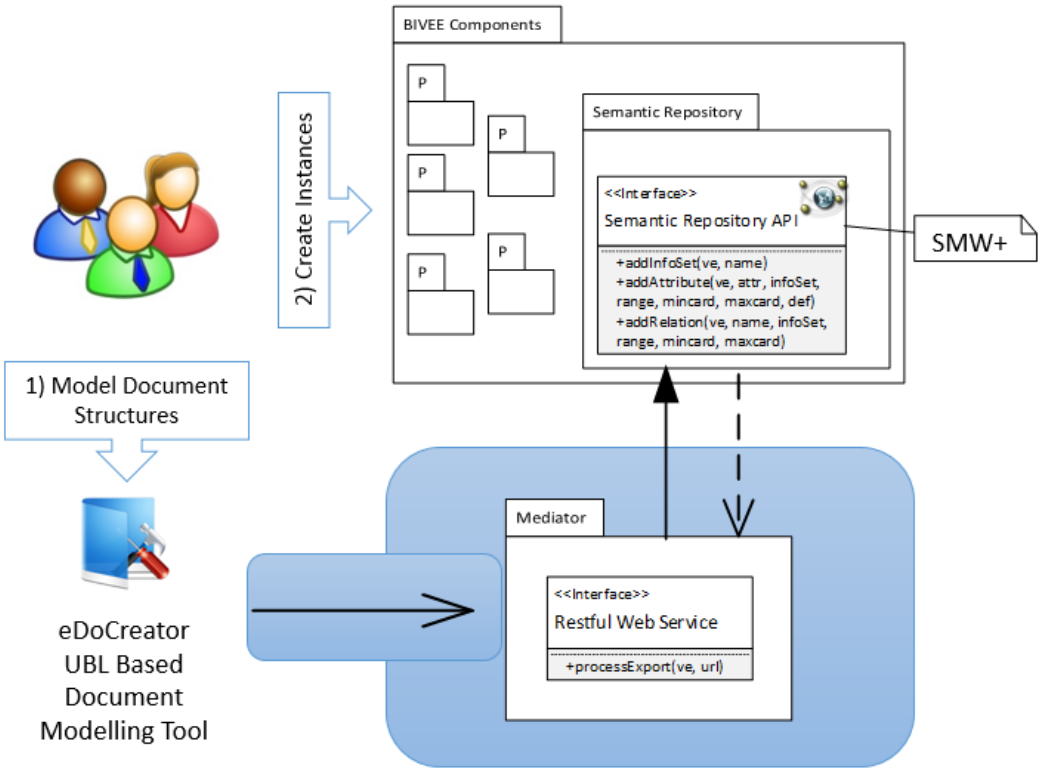

Figure 1.1: High Level Overview of the Architectural Flow

CHAPTER 2

BACKGROUND

2.1 Technologies and Standards

The studies in the past resulted in many standards for representing the data in documents and assigning semantics i.e. meanings to documents and their contents within the business context. to increase the document interoperability, a document standard needs important characteristics: adaptability (to different contexts), extensibility and customization. These characteristics are important metrics to evaluate a document standard. Core Component Technical Specification (CCTS) [20] is an important step in this direction created by UN/CEFACT (The United Nations Centre for Trade Facilitation and Electronic Business) [38]. CCTS is a well-suited specification for defining data models and creating data exchange standards to better represent information flows among enterprises [20]. In CCTS, as its name suggests, there exists semantic building blocks which are called "Core Components". Document models can be built by using these core components. Hence, this leads to documents themselves. If the same building blocks are commonly used to build document models following the well-defined methodology, documents interoperability among independent parties can be achieved. For this purpose, UN/CEFACT has created a library of Core Components [5] to be used by the industries, government organizations and companies. This library is a an important base for CCTS in its quest for "deriving all electronic documents from common building blocks with well-defined rules" [51]. In this work, CCTS methodology is followed in the construction and management of the documents for innovation activities in a virtual enterprise.

OASIS UBL (Organization for the Advancement of Structured Information Standards - Universal Business Language) [18] is among the first CCTS implementations. The Core Components are adapted as they are and they are restricted to a business context. The Core Components are called "Business Information Entities (BIE)" in UBL. OASIS defines an Extensible Markup Language (XML) library of common business documents as well as reusable data components (BIEs, Data Types), from which any document can be constructed [16] within business contexts. In order to meet differences in business requirements, customizations and extensions to already available BIEs and documents are enabled in UBL.

The customizations in these entities and documents can be difficult when the complexity increases. In addition, this makes the maintenance of the customized entities and documents tedious. In this respect, making use of the iSurf eDoCreator [2] [8] as a catalyzer for the users of the BIVEE Platform not only increases the user experience but also enables a standard interface for BIVEE Framework for its purpose. eDoCreator maximizes the re-use and minimizes the time spent on document customization and design. A web-accessible graphical user interface that allows users to collaboratively explore available entities and documents, define new ones, customize available ones, drag entities to create new documents easily and export what has been modelled as XML Schema [17] files greatly eases the task of document modelling. In essence, eDoCreator is a UBL document modelling tool. It will only be used to produce document schemas as a starting point for the DocOnto by using small building blocks.

The tool basically tries to enable the discovery of already defined blocks to match the enterprise requirements. Users can create new building blocks from scratch. For the document creation, user is requested to add building blocks to the document. For the customization mechanism, users can make use of two features: using a selected block without any modifications or creating a customization of the building block for reuse. UBL 2.0 artifacts such as the documents, common aggregate components, common basic components, qualified and unqualified data types are loaded to the common repository of eDoCreator, initially. The main aim of the modeling environment is to maximize re-use

of these available building blocks and minimize duplicate efforts of document designers using discovery mechanisms and sharing of document artifacts.

New document models are created in a visual interface by assembling available document building blocks by dragging and dropping BIEs at the basic level. The tool automatically locates the dragged component. The modeling environment supports UBL Conformant Customization and Compatible Customization. It allows

1. subsetting source document model
2. extending source document model
3. constraining document artifacts
4. creation of new document artifacts from scratch

Currently, eDoCreator is officially being used by OASIS for the creation of v2.1 of UBL standard.

CCTS and UBL provide with the required semantic base and content for the documents that are modelled as a result of this work. However, there is a need for separate knowledge regarding each document that can not be simply added as a content. This concept, in general, is known as "metadata": data about data. There are different initiatives which have already proposed solutions for the management of metadata. These initiatives are commonly forced by world wide web with the increase of internet usage. The need has started with different ways of describing resources e.g. describing the content of a web page through meta tags. The goal is to enable different locator services (i.e. search engines) and readers to get the very same information about the page before actually processing the body of the page. One of these initatives which is now called "Dublin Core Metadata Initiative (DCMI)" has resulted in a standard in the form of 15 metadata elements [46]. These elements are known as "Dublin Core" metadata elements and are utilized within this work to formalize document metadata.

Linked data [12] is a term used by Tim Berners-Lee. It is introduced to note

the importance of a linked open data throughout the web in order to identify, look up things, get useful information about them and discover more things with links from them. These four expectations are the main motivations why linked open data is important and why it has been created in the first place [24]. The goal of Linked Data has been realized with the use of Web Ontology Language - Resource Description Framework (OWL-RDF) [21] and SPARQL Protocol and RDF Query Language (SPARQL) standard [19].

However, there is a clear lack of a link between the modelled documents and the greater world wide web (WWW). Dublin Core metadata elements, in this respect, also provide solution to the problem of the missing linked open data principles. Dublin Core is composed of elements with a well-defined semantic tied to each. These well-known elements are commonly used descriptors in WWW. Their use enable third party software systems and readers to understand important information about documents and their contents.

SMW+ (Semantic MediaWiki Plus) is a semantic software package designed to introduce structured data into the context of small business and enterprise operations [15]. One of the important feature it provides is to enable collaboration. SMW+ is known to be a mature semantic media wiki bundle with GUI-based ontology with a number of ontological gardening extensions. It has also various import, export options in addition to an API which can be consumed by developers. SMW+ is also good for teams who collaboratively build ontologies. The role of SMW+ in BIVEE is being a base for Production and Innovation Knowledge Repository. That's why, the document ontology should be importable and improvable on SMW+.

2.2 Business Innovation

"Genius is one percent inspiration and ninety-nine percent perspiration". This quotation from Thomas. A. Edison intends to say what is behind innovation. In a simplistic way, many times innovation is identified as the result of creativity or artistic flair only, that are in turn conceived as spontaneous attitudes. Creativ-

ity is important, but reaching innovation, in the sense of introducing ideas (new products and services) to the market, also needs the adoption of defined procedures to generate the ultimate value. [36] defines the capacity for innovation of an organization as creativity multiplied by execution power. While creativity is about introducing a clever idea, execution is the process of transforming this idea to a successful business. If innovation starts from creative energy, this energy needs to be supported by rigorous procedures to come up with valuable results. And knowledge at large plays a relevant role in this scenario.

[44] identifies one of the required material for the process of innovation: existing knowledge. Knowledge and its possession enables creativity by making associations and linkages float in unusual and surprising ways [28]. According to [35], innovation captures, acquires, manages and diffuses knowledge to surface brand new knowledge by being a practice and process. [42] delineates innovation as a new knowledge creation, with the purpose of making internal business process and structure of organizations more sophisticated.

In its simplest form, project partners at BIVEE Project works hard to build a platform that improves the innovation capabilities of virtual enterprises by presenting them an advanced playground for ideas and the knowledge. The focus, in this thesis, is on issues concerning knowledge access and sharing as relevant aspects in supporting business innovation activities. In this work, Virtual Enterprise (VE) scenarios are referred since the issues are even more critical due to the heterogeneities, the geographical dispersion, and the cultural and background peculiarities of the VE members.

2.3 Related Work

A Virtual Enterprise can be defined as the alliance, collaboration between different enterprises. A lot of research has been performed on the management of these alliances through ICT. There are several standards (e.g. OASIS UBL [14]) and mature software tools [51] in terms of supply chain management which can be perceived as a document management reality for virtual enterprises.

On the other hand, innovation management within the enterprises is a relatively new concept and there are few widely accepted models, approaches and tools for this purpose [32].

Recent research activities address the models and methods for managing innovation processes in enterprise alliances i.e. virtual enterprises [32]. Such a research line has produced little results so far. Considering the formalization of the methods and models, there is no concrete definitions for the exchanged documents during the innovation activities within virtual enterprises. For this purpose, the BIVEE project works for the creation of the best models and methods, and our work exposes the novelty in this respect. And, in this thesis, a document centric approach is presented. This approach is believed to have succeeded for supply chain management in virtual enterprises (UBL is a CCTS implementation).

The European Collaborative Networked Organisations Leadership Initiative [10] project (ECOLEAD) produced valuable results for the collaborative networks of enterprises, called Virtual Organizations. It mostly focuses on the reference models for collaborative networks rather than the innovation management within these networks [25] [26] [27]. Furthermore, it does not address any document centric activities regarding the innovation and improvement processes within the virtual organizations.

A book written by Paul Trott [50] mostly discusses the models for innovation management within a single enterprise. A virtual enterprise exposes way different characteristics for the innovation management than the internals of a single enterprise.

Christoph Riedl [45] addresses the importance of Open Innovation and mainly focuses on the semantic management of the ideas. In this work, several different processes are addressed within the VPS and BIS. Idea management can be seen as a small part within VPS.

The DocOnto Framework can be called a base where this work stems from and contributes to. One of the main objectives of the project is to support and facilitate innovation activities in a VE environment. To this end, the Virtual

Enterprise Modeling Framework (VEMF) has been developed. According to the VEMF innovation-related activities happen within the business innovation waves [39].

SALT Document Ontology [37] can be counted as an in-line effort to our DocOnto framework. It describes document structures through text chunks, sentences, paragraphs, and sections. Hence, SALT deals with the structural knowledge of documents, publications in particular. In DocOnto, our aim is to manage semantics of documents which have been identified and being formalized through meaningful building blocks within a well-established methodology (CCTS, UBL) and framework (eDoCreator).

Among related initiatives, Dublin Core [7], a vocabulary of fifteen properties for description of documental resources, and SALT [37], which is for describing the organization of a document in terms of sections and paragraphs should be counted. While there was an intention to re-use part of the terms from Dublin Core, looking at documents differently from SALT is wise, since the focus is more on the semantics instead of the organization of the structure of a document.

The biggest assumption made in this work is about the knowledge creation process. It is assumed that the documented resources are the results of conversion for tacit to explicit knowledge or vice versa. Nonaka et. al. [41] discusses the process through a model called SECI: the socialization, the externalization, the combination, and the internalization. Experience sharing via feedbacks, comments, brainstorming etc. are ways of socialisation within a virtual enterprise. Externalization phase starts with facilitation of experience exchange and continues to combination phase via dissemination over the team with the help of reports. In the internalization phase, the explicit knowledge becomes tacit through training, reading materials or experimentation. BIVEE Project covers the SECI model with other techniques and the documented resources play a supportive role when it comes to innovation related social topics such as chaos management.

2.4 Requirements Elicitation

The BIVEE project has two end-user partners, namely Aidima [1] and Loccioni [13].

Users of the BIVEE project work in different domains. "Innovation" is addressed in different levels in each enterprise. Aidima is interested in Value Production Space and Loccioni tries to utilize Business Innovation Space. As mentioned above, considering "business innovation" as an inseparable whole, BIVEE addresses two tightly interconnected and different spaces: Value Production Space and Business Innovation Space. In this work, the key documents for each space are identified separately. The requirement analysis for the BIVEE Platform [22] details the need for such an approach.

The BIVEE project introduces the “waves” concept for the Business Innovation Space. According to this formalization, the BIS activities of a virtual enterprise are divided into four waves, namely Creativity, Feasibility, Prototyping and Engineering. Figure 2.1 presents this waves approach, applied to innovation activities of the Research for Innovation department of Loccioni group. In this work, after analyzing the processes of the enterprises, identification of the key documents proceed with a classification according to these four waves.

Creativity is the wave where the creation of new ideas take place. **Feasibility** is where the scope and the intended impact of proposed ideas are defined, including a first account of technical and financial feasibility. **Prototyping** wave is where the first implementation of selected ideas is developed, and its performance and characteristics are verified to give also the opportunity to rethink some design. **Engineering** is where activities aimed at producing the specification of the final version of the new product (essentially the Bill of Materials and manufacturing procedures), ready for the market, and the corresponding production process are conducted

Understanding the current business activities and current application landscape of the end-users within the defined concept of waves and phases is the first step to identify the needs of the systems. To start with this first step, a questionnaire for

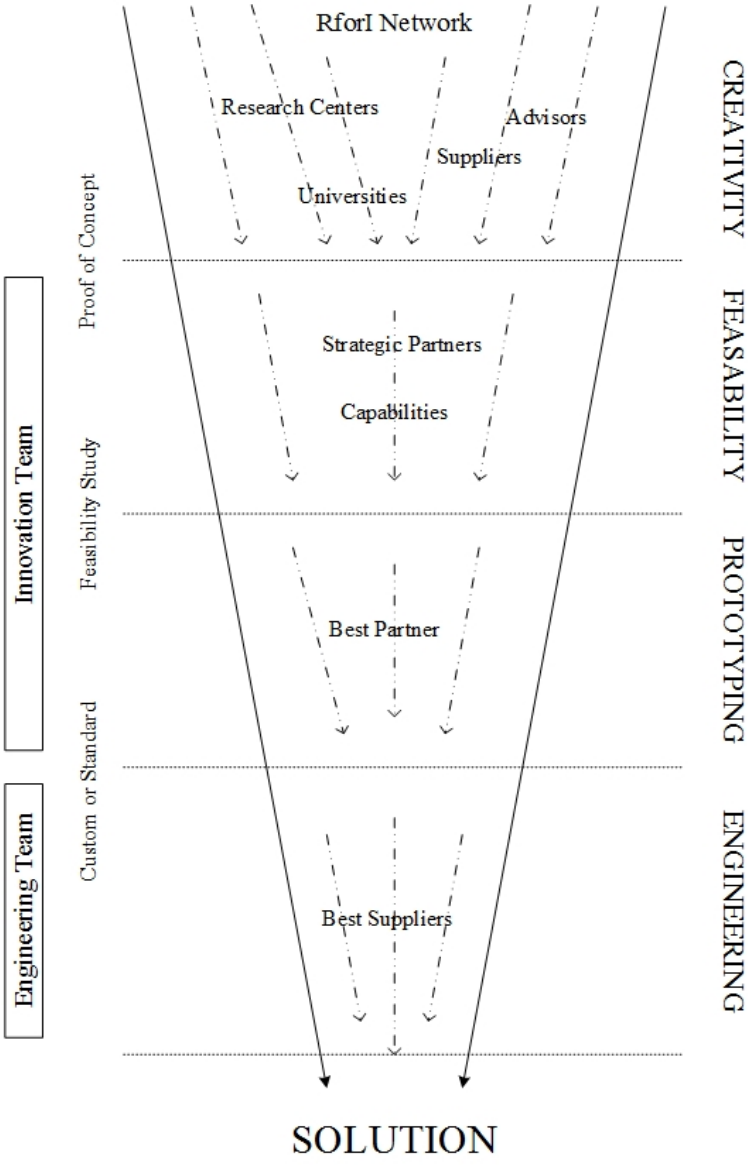

Figure 2.1: Overview of the Innovation Line inside Loccioni

the end-user enterprises is prepared. 29 hierarchically designed questions have mostly requested information about the innovation activities. These questions are presented in Appendix A.

We have come up with a detailed analysis of these two enterprises. The main objective is to understand the current business domain, business models, production activities, and the way the end-users look to innovation and innovation activities. Like most of the European enterprises, Aidima and Loccioni have

their own processes for innovation management. Different kinds of information are transferred among different kinds of actors inside the enterprises. Formalizing the structure and content of the information exchanged among the actors is an important issue regarding the BIVEE objectives.

Having detailed descriptions about the end-user organizations, the AS-IS status of them is extracted in a formalized and document centric way. AS-IS status of the end-user enterprises is analyzed through two main topics:

1. *Information Flow Analysis* intends to give detailed information about the improvement and innovation related processes of the enterprise. In this part, process flowcharts and their descriptions are analyzed in a conceptual level.

2. *User Specification provides* information about the main actors of the activities, their responsibilities and roles within the processes. Conceptual users and their associated roles are analyzed inside a User Specification Table.

Apart from such a detailed analysis, a thorough user requirement analysis has been realized for BIVEE Platform. Within the scope of this process, all the use cases are determined based on the feedbacks of all the stakeholders including the end-user companies, their business partners and other enterprises from all over europe [22].

Information flow analysis and the user specification table are available in Appendix B. These tables together with the requirement analysis lead to pilot application and validation cases for BIVEE Platform [30] [29]. The numerical detailed analysis of the AS-IS status shows a number of improvement points where BIVEE Platform could make a difference.

2.4.1 Document Centric Approach

The document centric approach starts with the formalization of the improvement and innovation related processes and tries to identify the important documents

which are exchanged between the employees of different enterprises regarding the virtual enterprise environment. These are not restricted to the cross enterprise processes or documents going from one enterprise to another. Inside the same enterprise, the information may follow an important path which should also be formalized in terms of innovation management. This can also be derived from the fact that different departments of the same enterprise can be in an independent role in a virtual enterprise. Figure 2.2 presents a schematic representation of our starting point for the document centric approach. The information flow is intercepted between the important actors of the improvement and innovation related processes.

Exchange of the documents can be through e-mails, hardcopy reports, phone calls or the enterprise may be using a document portal or a content management system for these kinds of documents. The analysis covers all possible communication lines and identifies the exchanged information by employing Dublin Core Metadata Element Set [7] which is a vocabulary of fifteen properties for use in resource description. These DC metadata elements (actually a subset of the fifteen elements) and extensions (applying the BIVEE context) have leaded to a schema for the metadata definition of the documents. Details of the schema can be found in [43] and are summarized as follows:

- **title**: The formal name of the document, an exact match to dc:title. Title of a document can expose the content e.g. "An electronic chair system for the disabled".
- **description**: A free-text account of the document, an exact match to dc:description.
- **creator**: The actor responsible for the document, an exact match to dc:creator with the use of a controlled vocabulary for the values from the list of actors.
- **contributor**: An entity responsible for contributions, an exact match to dc:contributor with the use of a controlled vocabulary for the values from the list of actors.

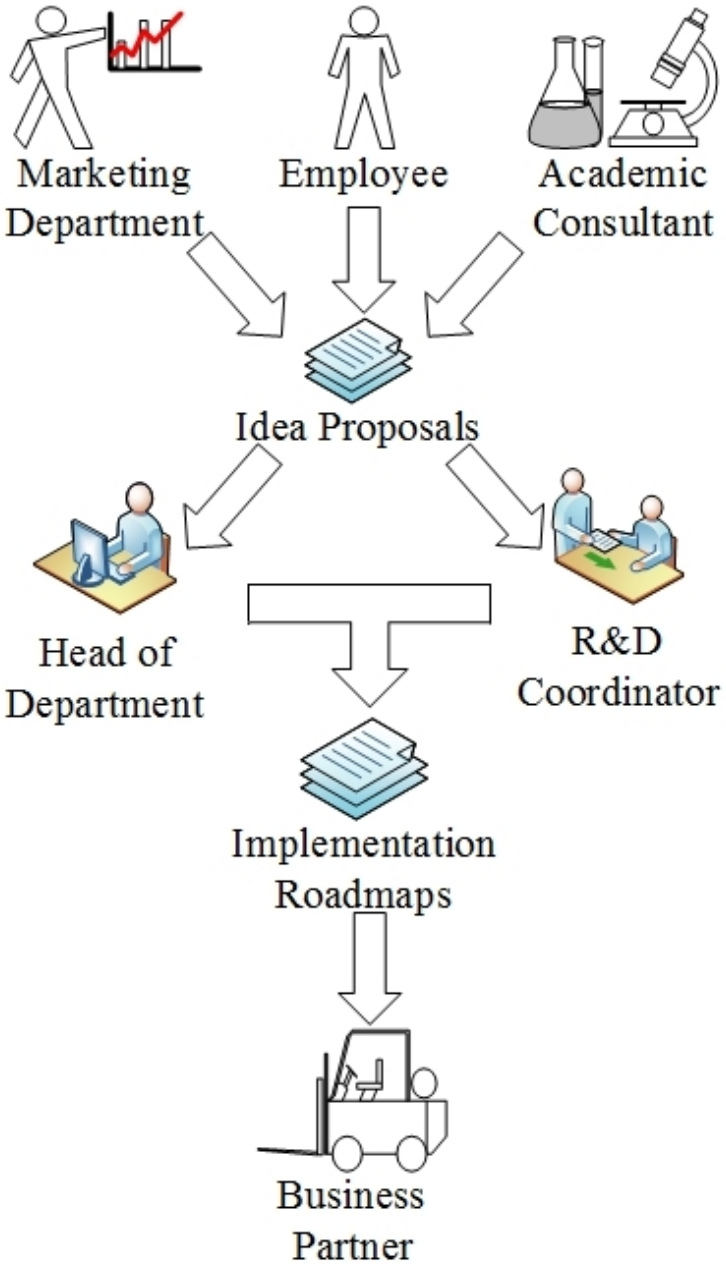

Figure 2.2: Overview of the Document Centric Approach

- **date**: The delivery date of the document, an exact match to dc:date. According to Dublin Core, this shows a point of time in the resource lifecycle.
- **format**: The mime-type of the document. Whether it is a plain text, pdf, ms-word, ms-excel or any other type. An exact match to dc:format.
- **identifier**: A reference to the document, an exact match to dc:identifier.

- **language**: The language of the document, an exact match to dc:language.

- **sender**: The sender of the document from a controlled vocabulary. It does not exist in Dublin Core, however dc:publisher exposes a similar meaning.

- **receiver**: The receiver actor of the document from a controlled vocabulary.

- **transfer-type**: The transfer type of the document among actors from a controlled vocabulary e.g. printed, electronically etc.

The Core Components Technical Specification (CCTS) [20] methodology is adopted (which is produced by UN/CEFACT). The objective of CCTS approach is to identify, capture and maximize the re-use of business information to support and enhance information interoperability. The foundational concept of CCTS is the core component (as its name implies). Core components are semantic building blocks, those can be used to build document models (hence documents) through aggregations and associations. CCTS approach says that core components act as conceptual models that are used to define Business Information Entities (BIEs) through the application of context and qualification. The document centric approach addresses the information entities (the building blocks) and tries to find the common parts of the identified documents by analyzing the structure and content. This means, each document will be constructed by aggregation and association of small information entities ("Business Information Entity" in CCTS terminology).

[47] presents the document centric approach towards the identification and formalization of the documents exchanged during the innovation processes in virtual enterprises among the main actors. As a result, a number of documents have been identified and the building blocks for those documents have been formalized.

2.4.2 Business Innovation Space Documents

While in the value production space we typically transform raw material into finished products (or elementary services into complex services), here existing production processes and organizations is taken and producing new processes and organizations is the aim. But new business models and practices have a risk of becoming obsolete rapidly, therefore it is necessary to enter in the innovation space where it is necessary to put in place the strategies, methodologies, practices, supported by ICT tools which can promote and foster continuous open enterprise innovation.

Table 2.1 lists all identified documents whose descriptions can be found in Appendix C.

Table2.1: Identified Documents for BIS

Creativity	**Feasibility**	**Prototyping**	**Engineering**
Business Ecosystem	Market Analysis	Prototype Requirements	Budget
Partner Profile	Gantt Chart	Implementation Roadmap	Bill of Materials
Research Line	Solution	Monitoring Sheet	Cost Report
Proposed Idea	Project Validation	Gantt Diagram	Resources
Validated Idea	Feasibility Study	Final Technical Report	Protocols
Customer Issue	Go/No Go	Results Report	Commercial Components Requirements (CCR)
Technical Solution	Project Proposal		Prototype Modification
RforI (Research for Innovation) Report	Candidacy Report		Product Data Sheet
Marketing Report	SWOT(Strengths, Weaknesses, Opportunities, Threats) Analysis		New Product Acceptance
Innovation Report			Working Report
Estimated Budget			
Internal Order			
Resources			

All the internal structures of these documents in the respective businesses are given in the appendices of BIVEE Project Deliverable [48]. An example doc-

ument and its content will be given in the next chapters to demonstrate the technical realization part of this thesis.

2.4.3 Value Production Space Documents

In this space, an enterprise is expected to visualize and follow the production related activities within the virtual enterprise. This corresponds to exchange of information or goods among different enterprises or departments of the enterprises [34]. According to our document centric approach, the goal is to formally identify each document transfer within a virtual enterprise considering the Value Production Space. Before going into the structural details and content of the documents, analysis of the document to understand whether it is related with an "improvement" activity or not based on the definition is realized in [32].

Table 2.2 lists all identified documents whose descriptions can be found in Appendix D.

Table2.2: Identified Documents for VPS

Planning	**Sourcing**	**Building**	**Delivery**
Strategy Report	List of Production	Protocols	Packing Instructions
Production Batch	Acquired Material	Non-conformities Report	Delivery Order
Estimated Cost & Time	Supplier Budget & Claim	Manufacturing Order	Invoice
Go/NoGo Decision	Packing Slip	Work Order	
Order	Invoice	Outsourcing Order	
Product Data Sheet		Quality Control Specs	
Cost Breakdown			

All the internal structures of these documents in the respective businesses are given in the appendices of BIVEE Project Deliverable [48]. An example document and its content will be given in the next chapters to demonstrate the technical realization part of this thesis.

CHAPTER 3

DOCUMENT MANAGEMENT

Regarding innovation as an outcome of unplanned and spontaneous brainstorming is a primitive and straightforward thought. Without an awareness and contextual knowledge about a domain, the attached expectations and problems, it is not an easy task to produce inspiring ideas and innovation. In an enterprise context, knowledge has a number of sub-areas like actors, roles, documents, domain etc. BIVEE Project builds a repository to enable a ground for different types of knowledge to be used together for its ultimate goal: increasing innovation and improvement capabilities of European SMEs.

It is important to propose a solution to each sub-area and have links in between these areas to present the reality correctly in a software environment. This work comes into play in BIVEE Project to propose a solution to knowledge representation for documented resources. In Virtual Enterprises, the knowledge becomes more valuable when it is shared and used by different parties. Hence, document transfer is one of the commonly used ways to transfer this represented business knowledge from one party to another. As an example, a formal partner profile document can be transferred from one enterprise to another to describe all the necessary information as a starting point of collaboration.

During the flow throughout these four innovation waves, end users produce, use, access and evaluate many documents. In the Creativity wave, as an example, many idea proposals can be produced by employees to fix problems regarding the processes. While a subset of these ideas will be elaborated more and will pass to the next stage, others will be eliminated for business reasons. The current

consumer profile, the lack of technology or the decreased amount of return based on the investment can be among these reasons.

The ability to keep track of such information (i.e. the ideas in detail and the reasons for rejections) is one of the most appealing feature for end-user partners. This will allow them to store guided decisions, re-use them later in different conditions to gain time/money in the future. Without such a feature, they currently lose valuable ideas in a couple of months. For this reason, documented resources for previous projects, last year's proposals or old reports in specific topics can be counted among the relevant important knowledge resources. An ontology-based semantic approach, in a VE context, can be an effective way to present, share, access and reason over documents. These abilities become more and more important when the size of the virtual enterprise gets larger and larger.

3.1 Objective

During innovation related activities, a number of documental resources such as idea proposals, feasibility reports etc. are created and used. Designing these innovation-related semantics-based documents together with their structures requires a framework (Document Ontology (DocOnto)). Such a framework should be capable of applying semantic enrichment and Linked Data approach [24]. The designed document models will, then, be used by the BIVEE [4] project to develop an ICT platform to support innovation.

A document ontology provides the means for the semantic categorization and annotation of the "documents". The objective of the ontology covers the definition of document schemas with their structure, organization and dependencies. During the requirements analysis with end-user partners, data requirements covering a list of daily work documents are identified. They are available in Appendix C and D.

The main objective of the ontology is simply to be a base for the document schemas. The additional objectives of the ontology are:

- **Structure**: Structure in this context means the data fields of the document in a structural manner with the usage of building blocks. In the structure of the documents, the meanings of these building block exist as free-text descriptions and their cardinalities are given. As an example, a partner profile document (used by both end-users) is used to describe a partner in the business ecosystem and contains the required fields, name and description, together with optional list of past interaction records with the partner.

- **Organization**: This represents the usage of the ontology in conjunction with other types of knowledge like actors and domain. A document ontology should reflect the overall organization of the documents within the virtual enterprise in terms of interactions with other ontologies. For example, an idea proposal document can be created by one or more employees from one or more enterprises and include references to the actors residing in a different ontology (i.e. Actor ontology).

- **Relation**: Relation between resources within a document ontology should be formalised. These relations can be listed as dependencies (prerequisite of, feedback to, update to), decomposition (includes, part of) and generic (related to) relation. For example, Validated Idea Document is an update to Idea Proposal Document and is related to a Research Line Document.

There are also a number of important principles to consider in the creation of the ontology. In general, these are Functionality, Generality, Interoperability, Easy-Creation, Maintenance and a number of additional principles.

- **Functionality**: The ontology should have the functionality to realize the features described above. These functionalities should be used by the target software flawlessly. This software in this case is BIVEE Platform.

- **Generality**: The ontology should be generic so that virtual enterprises or researchers trying to exploit the results of BIVEE Project can easily adapt the approach and methodology for their needs. The document ontology should be a generic schema that defines the structure of the documents in

BIVEE Platform. In essence, there can be a variety of documents that can be used in different virtual enterprise environments. The Document Ontology should contain generic documents and a generic document structure for each of our end-users. The very first step in the creation of a document ontology should be agreeing on a document structure for a VE

- **Interoperability**: The ontology will be used in a virtual enterprise environment and this requires that the document ontology is capable of operating among enterprises. All the tools, standards and specifications are explained in the "Background" section of this thesis. While building a document ontology, one or more data formats and tools will be used. Having more than one tools and data-format rises interoperability problems. The tools should be able to send and get the required data in required format to prevent automatization problems.

- **Setup Overhead**: The document ontology should be created and used by the software without a tedious effort and detailed technical descriptions. This is helpful specifically for the exploitation of the project results and the minimal development time for other uses and users. BIVEE Platform is being developed in collaboration with the BIVEE end-user organizations, but should not be restricted for their use only. It should support any virtual enterprise outside of the consortium after the release. This requires BIVEE Platform to be easily configured for the needs of other virtual enterprises. In this respect, DocOnto should be updated easily within a scenario.

- **Maintenance**: The maintenance of the ontology is an important requirement because of the path followed by the mind of the developer to the ontology is hard to intervene. Specifically during the development and in a possible change, DocOnto should be easily updated to reflect the changes to the BIVEE Platform. This update should take place before the setup of the BIVEE Platform.

- **Additional Principles**: It is required to pay a specific attention to change management. In any period of the development and exploitation, additional principles or changes are very likely to arise. Compatibility to

standards is one of the major solutions to this problem. Having backed up with a standard lets developers and users spend less time on maintenance efforts and leave the additional less-priority principles to the standard. Standards are safe since they require quite tedious and comprehensive research landings to be completed and published.

One of the most important objectives for this work is to utilize standards to realize these principles as pointed out above. Document standards and specifications are considered in the methodology definition process. The use of a standard results in interoperable, safe, high quality and consistent outputs. Furthermore, it allows other partners to exploit already available solutions without reinventing the wheel. That's why, a number of document standards, several exploitable projects and their results are investigated.

3.2 Methodology

UBL is a well-established OASIS standard which has been widely adopted in eBusiness arena. It is always a good approach to follow such well-stablished methodologies and specifications. Furthermore, as BIVEE, we like to contribute to UBL by introducing new processes and set of documents for innovation and improvement management within virtual enterprises. That's why, we start with creating document schemas through eDoCreator (which use the UBL artifacts to build the documents) and then come up with the corresponding ontology, the DocOnto. Our plan is to develop a software which performs an automatic conversion from the UBL documents schemas of BIVEE to DocOnto.

UBL supports extensions and refinements. eDoc is founded on the notion of refinements. As long as there is an integration between eDoc and BIVEE, refinements are possible. An example use case could be: Whenever there is a change in the structure of a document, the schema is updated through the GUI of eDoCreator, then this change is applied to the BIVEE platform automatically through web services or semi automatically by export and import facilities. If user wishes, s he can improve the ontology through the editor of SMW+. This,

of course, requires a communication between the two environments (SMW+ and eDoCreator).

eDoCreator will be used to adjust the structure of the documents. Once we create initial versions of the documents, the created XML Schema will be fed into a service to be translated to an OWL ontology. Then, we expect that SMW+ provides services accepting OWL ontologies. Furthermore, all this process can be automatized. A button can automatically perform all internal transformations through the web service calls and feed the SMW+.

The proposed framework follows a customizable approach inspired by the Core Component Technical Specification, which allows enterprises in VE to refine the Document Ontology (DocOnto) for its exclusive needs. The customization facilities are being implemented via the integration of a UBL documents editor (eDoCreator) and the semantic knowledge base that is being implemented in the BIVEE project known as PIKR (Production and Innovation Knowledge Repository) [31], .

An end to end scenario has been planned and the aim is to realize the scenario for virtual enterprises:

- A new virtual enterprise wishes to use BIVEE Platform. To create domain specific document ontology, a member of the virtual enterprise forms the schemas of the documents or customizes already available document set through eDoCreator GUI based on UBL artefacts. After creating the documents on eDoCreator, the member follows an automatized process by supplying needed details in a user-friendly way. Finally, he has the new ontology on the SMW+.

3.3 Formalization

At first glance, innovation is usually attributed to the result of creativity and artistic flair which are conceived as spontaneous activities. However, this can be considered as a simplistic vision, because, in most of the cases, in order to

get inspiration and reach up to innovation, full awareness and rich knowledge about the addressed problem are need. And this is more correct if there is no limit on the focus to the first stage of an innovation activity, but the whole picture is considered together with the process of developing and implementing the innovative ideas. In this work, the problem of knowledge access and sharing in a Virtual Enterprise (VE) context is addressed, where the scenario is highly fragmented and heterogeneous. In particular, an ontology-based framework (DocOnto) is proposed for the semantic description of documents involved in innovation-related activities. The framework, which is grounded on the Linked Data approach, is described in terms of *InfoItems* and *InfoSets*. *InfoItems* are building blocks which correspond to small, meaningful and semantically annotated elements while *InfoSets* correspond to recursive aggregation and association of these *InfoItems*. Within the DocOnto framework, document management for the innovation activities in VEs finds a semantics-based solution [49].

3.3.1 InfoSet categories

With the contribution of the two end-users organizations, we have defined innovation related activities through the four waves and indicated what information actually is produced, used and accessed. This activity brought to the identification of two sets of documents, one for each end-user [47]. These results have been taken as specifications and, starting from them (listed in Appendices B, C and D), a conceptualization of these documents has been performed for identifying valuable *InfoSets*, *InfoItems* and associations between them.

For instance, the two organizations use very similar documents for reporting the initial description of an innovation project, namely *Internal Order* and *Project Proposal*. On the basis of that only the *ProjectProposalInfoSet*, has been introduced in the DocOnto. The same happened for the, *FeasibilityReportInfoSet*, which represents the description of *SWOTAnalysis* and *FeasibilityStudy* documents.

The result of this conceptualization is synthesized in the table 3.1, where we have divided the documents with respect to the waves they are characteristic of

and in terms of *Proposal* and *Assessment* (devoted to describe the evaluation of proposals) *InfoSets*.

Table3.1: InfoSet Categories

Innovation Wave	**Proposal InfoSet**	**Assessment InfoSet**
Creativity	Proposed Idea Innovation Report Issue/Problem/Need Market Report Customer Issue Budget Report Company Issue Technical Solution Report	Assessment Report
Feasibility	Project Proposal Project Partner Request Gantt Candidacy Proposal	Feasibility Report
Prototyping	Prototype Requirements Implementation Roadmap Prototype Technical Report	Monitoring Sheet Results Report
Engineering	Budget Bill Of Material Human Resources Protocols Product Data-Sheet Commercial Components Requirements	Prototype Modification Costs Analysis

3.3.2 InfoSet structure

InfoSets are organized into three main sections which group different kinds of *InfoItems* and relationships between *InfoSets*:

Header groups *InfoItems* like the title of the document (or part of it), an abstract, the authors and contributors, indicators for evaluating the quality of the document, and the URI of the concrete document to be used for retrieving it.

Content groups *InfoItems* describing what the concrete document (or part of it) talks about. We are not interested in the structure of the document (e.g., the fact that a document is composed into an introduction, main body and

conclusions), but in the essence of the document, its semantics (e.g., in the case of a *ProposedIdea*, what are the addressed *ResearchLines*, what are the *Objectives*). *InfoItems* in the Content section mainly carry information related to application domains, which use specific terminologies. The adoption of domain-focused dictionaries, thesauri or ontologies is encouraged for incrementing the level of interoperability and enabling reasoning mechanisms.

Related Knowledge Resources allows *InfoSets* to be related to other *InfoSets* (e.g., an *AssessmentReport*, should be linked to the *InfoSet* where evaluated contents are described, e.g., a *ProposedIdea*). Associations pertaining to this section are in turn classified in terms of:

- **PrerequisiteOf**: given an *InfoSet*, it links *InfoSets* that were required for its production. For instance, the elaborates association links an *InnovationReport* to a *ProposedIdea*, or the addresses association links a *ProposedIdea* to an Issue.
- **FeedbackTo**: it links an *Assessment InfoSet* to the *InfoSet* where evaluated contents are described.
- **UpdateTo**: it links an *InfoSet*, which is an update for another *InfoSet*. As an example one *ProposedIdea* document updates another *ProposedIdea* document with a new consideration.
- **Includes**: It allows saying that the information described in an *InfoSet* contains the information described in another *InfoSet* (e.g., a given *InnovationReport* contains a *MarketingReport*).
- **PartOf**: it allows saying that the information described in an *InfoSet* is contained in the information described in another *InfoSet* (e.g., a given *MarketingReport* is contained in an *InnovationReport*).
- **RelatedTo**: represents a generic semantic association between two documents.

Figure 3.1 depicts the relationships that can occur between *InfoSets* from the Creativity wave. *Assessment InfoSet* is highlighted in a different colour.

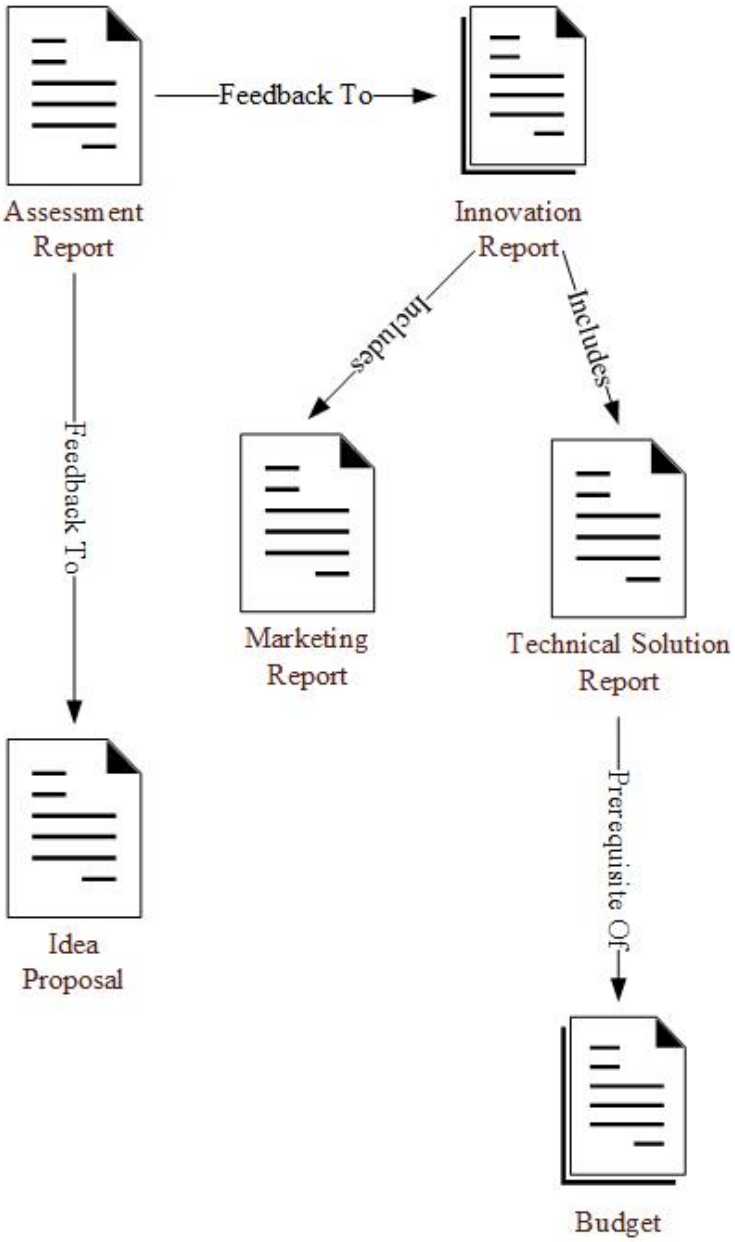

Figure 3.1: InfoSets Relationships in the Creativity Wave

A concrete document can be semantically described by more than one *InfoSet*, since a document can carry different types of information. For instance, a concrete document representing a project proposal can contain information about the technical solution (how to technically address the project issues), as well as the GANTT (timing of the project), which are intended to be semantically represented by using two different *InfoSets* (namely, *TechnicalSolutionReport* and *Gantt*).

In Table 3.2 an example of instantiated *InfoSet*, about the description of a technical solution document is reported.

Table3.2: An example of InfoSet instance

Technical Solution Report	
Header	
Title	Advanced HMI
Identifier	TS_AdvancedHMI
Description	System for the robot programming based on the 3d reconstruction of the inspected components
Responsible	John Smith
Contributor	Mattew Broderick
Creation Date	13/06/2012
Format	ms-word
Language	Italian
Document Indicators	Readability=4; Technical Quality=4
Resource Link	http://bivee.eng/bis/loccioni/doc/proposedIdea21.doc
Content	
Research Line	3D vision, cloud point, artificial intelligence algorithm, athropomorphous manipulator
Beneficiary	Loccioni group
Technology	HMI
Novel Features	simple, intuitive
Advantages	3d reconstruction, optimal path, collision avoidance
Related Resources	
Part of	doc:IP_AdvancedHMI
Has budget	doc:BS_AdvancedHMI

Structures of all the documents in the respective businesses are given in the appendices of BIVEE Project Deliverable [48]. An example document and its content is given above to demonstrate the technical realization part of this thesis.

3.3.3 UBL Based Customization Approach

The earlier electronic document standards focused on static document definitions, which were inflexible for adapting different requirements. The leading effort for this problem came from the UN/CEFACT Core Component Technology Specification (CCTS) [20] in the early 2000s. The idea behind UN/CEFACT CCTS is to provide re-usable building blocks for business documents, which are available from a common repository. This increases the possibility of discovering and re-using similar document artifacts consumed in different collaborations for

sustaining data interoperability. Furthermore, it constitutes an agreement base for documents through a syntax independent conceptual model.

CCTS has the notion of building blocks called Core Components (CC). Core components can be used to model and exchange the information which can constitute the whole data. Core components are context-neutral having a generic semantic and purpose, and can be re-used in different contexts [51]. Business Information Entities (BIE) are contextualized CCs. There are three types of core components [20]:

1. A **Basic Core Component (BCC)** constitutes a singular characteristic and has a semantic definition unique to the business. Represents a property of an ACC. Example: "Contract" contains a BCC named "ContractId" and the type of this BCC is "Identifier". Its meaning in a business is "Contract has a ContractId.

2. An **Aggregate Core Component (ACC)** is a collection of core components which together convey a distinct business meaning. It is a collection of related pieces of information that together convey a distinct meaning, independent of any business context. Ex: Address Line, Address, Contact, Contract, Location, Period etc.

3. An **Association Core Component (ASCC)** defines an association between two core components: defines a role between ACCs. Example: "Contract" contains an ASCC named "Effective" and the type of this ASCC is "Period". Its meaning in a business is: "Contract is effective in a period"

Using these 3 types of CC and core data types, documents compliant with CCTS can be constructed. In a business environment, trading partners agree on document structures to be exchanged. UBL provides a set of documents to be used by the business partners. The documents provided by UBL include lots of information fields based on the requirements of very different parties. For example, an Invoice document includes lots of details which may be useless for two trading parties. This time, these organizations agree on the fields they

will use in an Invoice document. UBL provides these documents with very few "required" fields and lots of "optional" fields. That is, this is a starting point for organizations who want to be conformant or compliant with UBL.

We want to follow the very same strategy in BIVEE. For example, we want to come up with a schema (and a corresponding ontology) for an Idea Proposal document. This will cover the needs of both Loccioni and Aidima. We can regard this as a union of two specific documents. Of course, some documents are mutually exclusive, and we must also consider them as different documents coming from each enterprise. With this approach, Loccioni (or Aidima) has two options:

- The organization can directly use the document schema proposed by BIVEE by only using the information fields required by that organization.
- The organization can customize the document (UBL has customization guidelines, i.e. one party can exclude the optional fields and create its own version, hence still be conformant to the document schema of BIVEE) for its VE and then use that new version during document exchange.

CCTS uses a number of terms to restrict associations and aggregations. Some of these terms are Cardinality, Definition, Context, Property Term, Version etc... In parallel, BIEs have also three types: Basic Business Information Entity (BBIE), Association Business Information Entity (ASBIE) and Aggregate Business Information Entity (ABIE). Business Data Types (BDTs) are the contextualized Core Data Types. Core components of CCTS act as conceptual models defining Business Information Entities (BIEs). BIEs may specify a restricted form of its underlying CC and have the same types as expected. Aggregated BIE (ABIE), Association BIE (ASBIE) and Basic BIE (BBIE) are the BIE types used in UBL. They are the implementations of of ACC, ASCC and BCC, respectively. The extendability of UBL stems from these reusable data components. When a new document is required, UBL allows developers to use available BBIEs, ASBIEs and ABIEs or creating new ones based on the available data types.

UBL [18] implements CCTS and publishes a number of XML based Business Document Definitions, Common BIEs and Data Types such as an Invoice document or an Address BIE. UBL also presents the Core Data Types of the CCTS with the name "Unqualified Data Types". These data types are used to create a number of common building blocks (ABIEs). These building blocks are then used to create a number of defined documents. The same building blocks are used in different documents frequently. These data types, ABIEs and documents are what UBL presents to the community through xml, xsd, xsdrt, xls formats. The already available documents are in these groups: General Business, Sourcing, Ordering, Billing, Payment, Transport Services etc.

Data requirements change for different virtual enterprises in order to address the needs of innovation activities. Hence, it is required to customize the DocOnto for each virtual enterprise once the requirements have been set up. UBL provides a methodological way for the customization of already available documents and BIEs. Since this methodology has already been implemented by eDoCreator, our solution inherently supports customization of existing documents and BIEs identified for innovation activities. According to the UBL standard, new information entities can be added to meet the requirements of a specific business context, optional information entities can be omitted, the meaning of information entities can be refined, new constraints can be specified, new aggregations or documents can be combined or assembled or new business rules can be added during a customization. These changes can be applied with the help of eDoCreator with conforming to the customization guide-lines of UBL. When a new set of innovation documents is required by a new enterprise, users can model their documents through customizations on eDoCreator. In DocOnto framework, since we model the documents through *InfoItems* and *InfoSets*, and since we follow the UBL approach, our modelling directly maps to UBL terms when we leave out the semantic technologies of our framework. This mapping can be depicted as follows: BBIE - *InfoItem*, ABIE - *InfoSet* and ASBIE - *Associations*

Finally, as a part of the approach, it is important to point out what eDoCreator is capable of. Figure 3.2 shows the output (OWL file) of UBL zip package content (XSD files) after the semantic lifting process through the Ontmalizer tool created

by Yuksel [53]. Figure 3.3 is the visual that is taken from Protege, an OWL visualization tool. The figures show the capabilities of UBL and eDoCreator.

```
  xmlns:xsd="http://www.w3.org/2001/XMLSchema#"
  xmlns:j.3="urn:un:unece:uncefact:codelist:specification:IANAMIMEMediaType:2003#"
  xmlns="urn:oasis:names:specification:ubl:schema:xsd:ApplicationResponse-2#"
  xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#" >
<rdf:Description rdf:about=
"urn:oasis:names:specification:ubl:schema:xsd:ProposedIdea-2#ProposedIdea">
  <rdfs:subClassOf rdf:resource=
  "urn:oasis:names:specification:ubl:schema:xsd:ProposedIdea-2#ProposedIdeaType"/>
  <rdf:type rdf:resource="http://www.w3.org/2002/07/owl#Class"/>
</rdf:Description>
</rdf:Description>
<rdf:Description rdf:about=
"urn:oasis:names:specification:ubl:schema:xsd:NoIDCommonAggregateComponents-2#Idea">
  <rdf:type rdf:resource="http://www.w3.org/2002/07/owl#ObjectProperty"/>
  <rdfs:subClassOf rdf:resource=
  "urn:oasis:names:specification:ubl:schema:xsd:NoIDCommonAggregateComponents-2#IdeaType"/>
  <rdf:type rdf:resource="http://www.w3.org/2002/07/owl#Class"/>
</rdf:Description>
<rdf:Description rdf:nodeID="A5322">
  <owl:maxCardinality rdf:datatype="http://www.w3.org/2001/XMLSchema#int">1
  </owl:maxCardinality>
  <owl:onProperty rdf:resource=
  "urn:oasis:names:specification:ubl:schema:xsd:NoIDCommonAggregateComponents-2#Idea"/>
  <rdf:type rdf:resource="http://www.w3.org/2002/07/owl#Restriction"/>
</rdf:Description>
<rdf:Description rdf:nodeID="A5348">
  <owl:allValuesFrom rdf:resource=
  "urn:oasis:names:specification:ubl:schema:xsd:NoIDCommonAggregateComponents-2#IdeaType"/>
  <owl:onProperty rdf:resource=
  "urn:oasis:names:specification:ubl:schema:xsd:NoIDCommonAggregateComponents-2#Idea"/>
  <rdf:type rdf:resource="http://www.w3.org/2002/07/owl#Restriction"/>
</rdf:Description>
<rdf:Description rdf:about=
"urn:oasis:names:specification:ubl:schema:xsd:ProposedIdea-2#ProposedIdeaType">
  <rdfs:subClassOf rdf:nodeID="A5322"/>
  <rdfs:subClassOf rdf:nodeID="A5348"/>
  <rdfs:subClassOf rdf:nodeID="A5258"/>
  <rdfs:subClassOf rdf:nodeID="A5270"/>
  <rdfs:subClassOf rdf:nodeID="A5263"/>
  <rdfs:subClassOf rdf:nodeID="A5273"/>
```

Figure 3.2: Semantically lifted UBL document - OWL output

3.4 Technical Realization

In this section there is an overview of the technical aspects related to the current implementation of DocOnto within the semantics-based knowledge management infrastructure, namely Production and Innovation Knowledge Repository (PIKR) [31], developed as part of the BIVEE project.

PIKR, the knowledge base of the BIVEE platform, and eDoCreator are required to share the information on the syntax and semantics of the documents. For this technical interoperability problem, a number of requirements can be listed

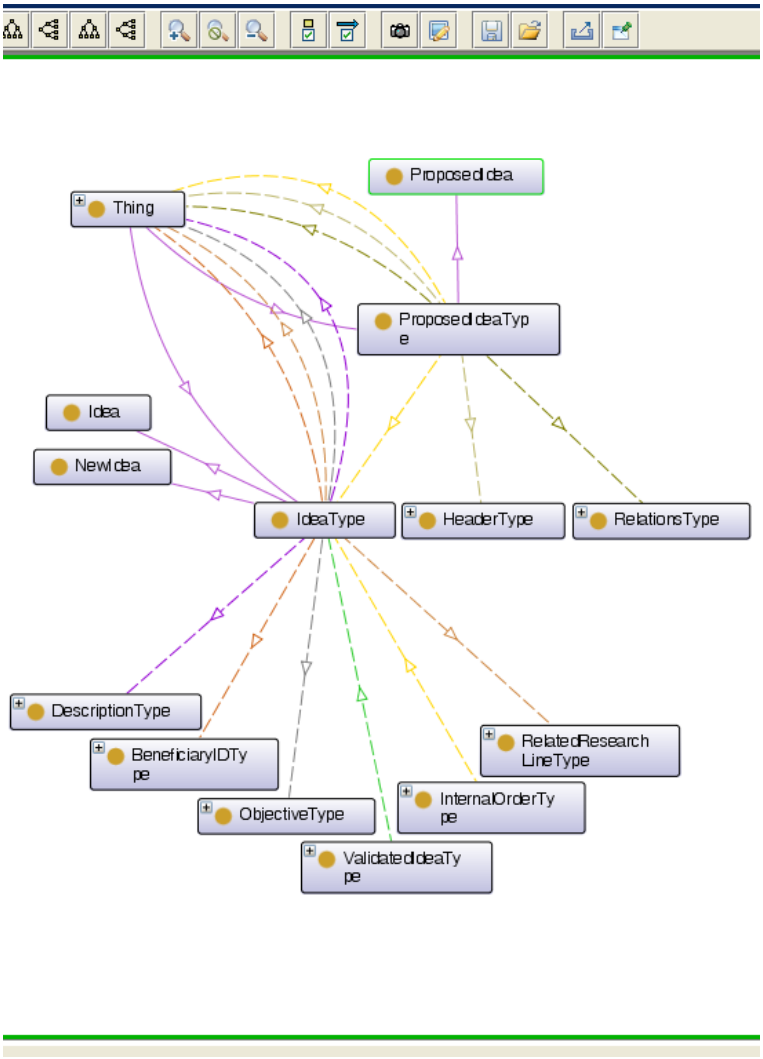

Figure 3.3: Semantically lifted UBL document - Visual

as follows:

- eDoCreator can export XML Schema [17] of modelled documents (aka document schemas). PIKR needs a middleware to process this knowledge into a semantic representation.
- To import the knowledge from the document schemas, they need to be processed and the structural and semantic knowledge should be extracted.
- During the extraction or once all knowledge has been extracted, appropriate interaction mechanisms should exists to reflect that knowledge to PIKR.

- The whole process should be automated in order to ease the task of the end-user as much as possible.

In order to meet these requirements, a middle layer, called Mediator, has been designed to operate between eDoCreator and PIKR. eDoCreator has been updated to invoke third party web services during the export operation with the XML Schema files. The Mediator processes the XML Schema files and calls the PIKR Application Programming Interface (API) accordingly to reflect the extracted knowledge. From the user perspective, there are two steps to follow in order to make use of BIVEE Environment with a specific set of innovation documents: Model and Invoke.

1. Modelling documents on iSurf eDoCreator through customizations

2. Invoking the mediator through the GUI.

3.4.1 Development Design

Table 3.3 summarizes the starting point for the development work. It shows the flow of the information and the needed format. The most important requirement for this flow is automatization of the process.

Table3.3: Technical Information Flow

Step	Input	Tool (Description)	Output
1	Document Schemas	eDoCreator (Document schemas created through GUI and exported)	XSD Files
2	XSD Files	Mediator (Transformation of XSD and API Consumption)	PIKR API Calls
3	PIKR API Calls	PIKR API (SMW+ Internal processing)	SMW+ Ontology

The flow given has been realized and the figure 3.4 presents an overview of the design between eDoCreator and PIKR through in-the-middle Mediator component. The details for each part of this figure are given in the following sections in three parts: iSurf eDoCreator, Mediator and PIKR API.

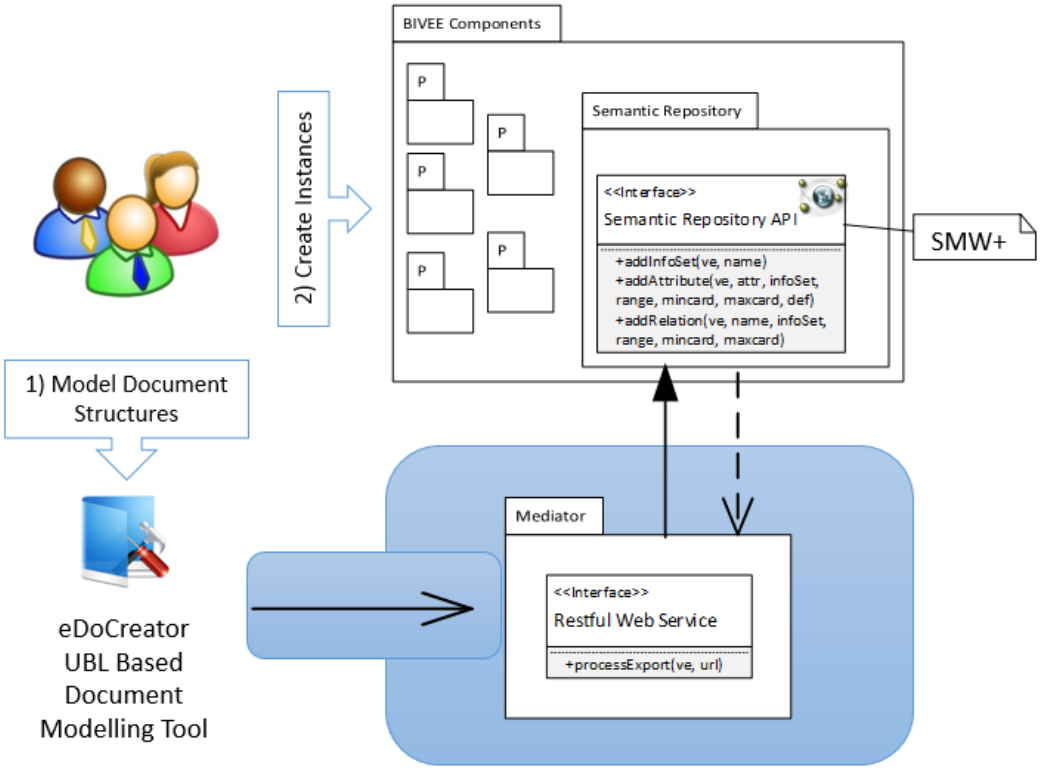

Figure 3.4: Technical Solution for editing and maintenance of the DocOnto

3.4.1.1 PIKR API

PIKR API is a component developed by BIVEE Project partners. Hence, the only information that will be given about this API will be restricted to the interface it provides. This API is a Java Archive file communicating with the PIKR. It simply forms the required base for Mediator to make the necessary calls to the remote SMW+ server. It allows Mediator component to consume its methods:

- **int addInfoSet(veIdentifier, infoSetName)**: insert a type of document (e.g., IdeaDocument) in the PIKR. It responds with an integer:
  - **1** the operation was successful
  - **0** the document was already created before
  - **-1** something went wrong

- **int addAttribute(veIdentifier, attributeName, infoSetName, attributeRange, minCardinality, maxCardinality, defaultValue)**: associate a kind of attribute (a property with a basic type, e.g., issueDate) to a specified kind of infoSet (e.g. IdeaDocument). Attribute should mainly cover the Header section and has a range: Date, String. With respect to the UBL types, this method should support the insertion of BBIEs. It responds with an integer:
  - **1** a property (attribute or relation) with the same name is not already associated to the specified docType (i.e., the docType is not the domain of any property with the name equal to attributeName). The effect on the PIKR is that the attribute is created and associated to the docType.
  - **0** an attribute with the name equal to attributeName is already associated to docType. The new attribute definition replaces the old one.
  - **-1** something went wrong on the PIKR.
  - **-2** a relation with the name equal to attributeName already exists. No changes are applied in the PIKR.
  - **-3** the docType does not exists. No changes are applied in the PIKR.
- **int addRelation(veIdentifier, relationName, infoSetName, relationRange, minCardinality, maxCardinality)**: associate a kind of relation (a property with e.g., Objectives) to a specified kind of infoSet (e.g. IdeaDocument). For example, relation should cover the Content (where relations' range could be just a set of ontology concepts) and RelatedKnowledgeResources (where relations' range is expected to be a documentType) sections. In addition, a relation could enable to link two infoSets (e.g., the infoSet corresponding to the IdeaDocument and a structured sub-component). With respect to the UBL types, this method should support the insertion of ABIEs and ASBIEs. It responds with an integer:
  - **1**: a property (attribute or relation) with the same name is not already associated to the specified docType (i.e., the docType is not

the domain of any property with the name equal to relationName). The effect on the PIKR is that the attribute is created and associated to the docType.

  - **0**: an attribute with the name equal to relationName is already associated to docType. The new relation definition replaces the old one.
  - **-1**: something went wrong on the PIKR.
  - **-2**: a relation with the name equal to relationName already exists. No changes are applied in the PIKR.
  - **-3**: the docType does not exists. No changes are applied in the PIKR.

- **removal methods**: Removal methods will be used for relations, documents and attributes for update purposes.
  - removeDocumentType(veIdentifier, documentTypeName)
  - removeAttribute(veIdentifier, attributeName)
  - removeRelation(veIdentifier, relationName)

3.4.1.2 iSurf eDoCreator

The start of the development for eDoCreator has started with the modelling of all the documents identified. For this purpose, UBL BBIEs are created on the tool and they are used for creation of documents. Figure 3.5 displays an example document modelled on eDoCreator.

The only modification on eDoCreator has been in the already available export window of the product. An input has been added for the name of the virtual enterprise for export and a button to start the processing. It simply issues a call to the mediator service with a URL for the exported zip package.

3.4.1.3 Mediator

Mediator is a RESTFul web service which implements two methods: **processExport** and **removeExport**. These methods can be called by any software

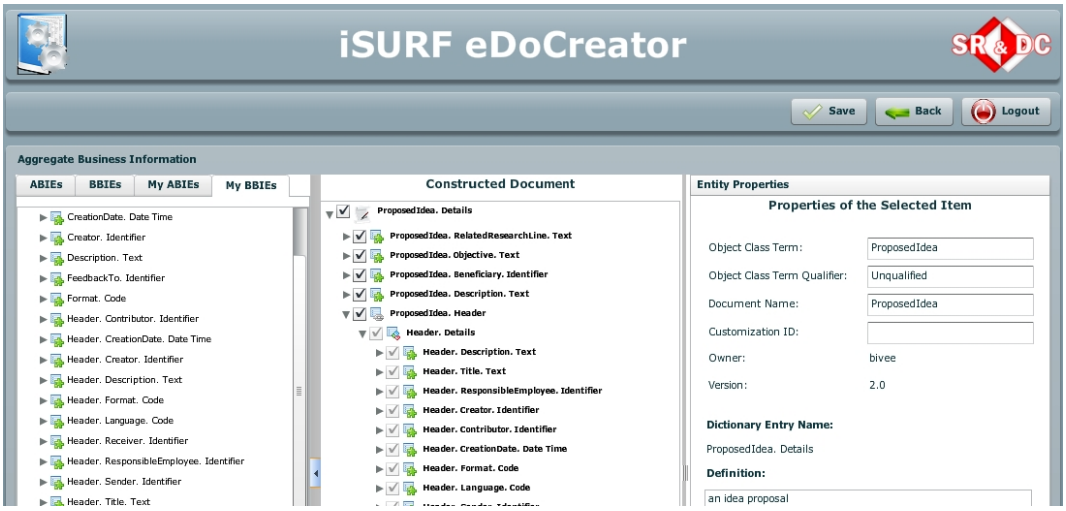

Figure 3.5: Proposed Idea document model on eDoCreator

with a url to the UBL zip package and a virtual enterprise name.

Here is the workflow for Mediator service:

- Download the zip file from the url
- Create a *Processor* thread with the downloaded file and the virtual enterprise name
- *Processor* thread unzips the file
- *Processor* parses the xsd structure which is special for UBL and is the same for any UBL zip package
- *Processor* invokes PIKR API locally to create attributes, documents and relations.
- PIKR API redirects these calls to SMW+ server and creates the ontology.

The processor class has been added to Appendix E.

3.4.2 Production and Innovation Knowledge Repository

PIKR is a BIVEE component created by other project partners as a knowledge hub of the BIVEE Platform. The spaces VPS and BIS communicates through

PIKR and all the data is linked to each other within this repository. This section is only an external information not directly achieved by this thesis, yet it is important to give the idea on how the outcomes of the this thesis work will affect the BIVEE Platform and how the documented resources will be used by user facing components of the BIVEE platform.

3.4.2.1 Representation and Storing

To make the semantic information exchange and the reuse easier, the DocOnto is encoded according to Web Ontology Language - Resource Description Framework (OWL-RDF) [21], a meta-data sharing and ontology standard. This allows us to adopt standard solutions to manage the DocOnto and the semantic descriptions of documents defined according to it, e.g., through a Triple Store (the Apache Jena [3] toolkit is currently adopted in the PIKR) which provides scalable retrieval and storage for data in RDF.

In the context of the PIKR, the DocOnto is intended to be used within an infrastructure defined according to the Linked Data principles, to share, expose, and connect pieces of knowledge in a seamless and open way. In particular, following the Linked Data approach, the PIKR supports the description of documents in terms of a set of reference structures (defined in the DocOnto) enriched with domain knowledge (through domain specific ontologies), and provides entry-points for accessing and processing the maintained knowledge. To enforce the openness of the platform from a technical perspective, every knowledge fragment is identified by a Uniform Resource Identifier (URI), accessible via Hyper-Text Transfer Protocol (HTTP), described by RDF/OWL, and processable by semantics-enabled reasoning facilities exposed as Web Services.

3.4.2.2 Reasoning Services

The knowledge representation framework discussed in the previous sections, called PIKR, enables the enactment of a number of reasoning facilities to support the management of documental knowledge in innovation projects, in terms

of the following services. These services have been detailed in [23] and [43].

These services are designed to be also consumed by visual components of BIVEE. Hence, users will make use of these facilities through those visual components i.e. Mission Control Room (MCR) for value production space [52] and Virtual Innovation Factory (VIF) for business innovation space [40].

Search

This service provides keyword-based search functionalities. The user request is expressed as an ontology-based feature vector describing the criteria for the selection of the resources of interest. By applying semantic similarity techniques (the Semantic Similarity (SemSim) metric [33]) the degree of matching between the terms used to formulate the request and the ones used to describe the available resources is computed, and a list of ranked results is returned. For instance, suppose that the user is interested in finding all the documents that have been authored in the last two years and concerning the initial stages of the design of a piece of furniture equipped with an electronic device. The corresponding request should be formulated as follows:

$$\{content{:}[Furniture,\ Electronic\_Device];\ type{=}Proposal,\ creationWave{=}Creativity,\ issueYear{>}2010\}$$

The engine will retrieve semantically related resources, such as Proposed Idea or Project Proposal documents about a Contour Chair with an embedded Media Player (which are assumed to be defined in the domain ontology as kinds of piece of furniture and electronic device, respectively).

Query

This service enables to retrieve pieces of knowledge which exhibit some given properties. Queries are posed in terms of the vocabulary and semantic relations provided by the PIKR ontologies, and the underlying reasoning engine returns a list of answers that satisfy all the specified properties. These answers may consist of factual knowledge (DocOnto instances), conceptual knowledge (ontological terms), or references to concrete resources. We are currently developing a query language, based on SELECT-WHERE paradigm along the line of the SPARQL

Protocol and RDF Query Language (SPARQL) standard [19]. For instance, to identify reusable best practices or technical solutions in a given domain, we may want to retrieve all the protocols related to documents addressing the research line 3D_Vision. This can be expressed as follows:

$$Q(?p) : protocol(?p)\ AND\ related(?p,?doc)\ AND\ research\_line(?doc,3D\_Vision)$$

Compliance Checking

This service allows for checking the compliance of the factual knowledge, captured at a given time in the semantic description of the documents, with respect to business policies and internal regulations. Compliance requirements can be represented in the DocOnto as business rules, i.e., statements that define or constrain the structure of the documents or the dependencies among them on the basis of the sequencing of business operations. The compliance check verifies the consistency between the assertions contained in the F-PIKR and the axioms defined in the Knowledge Resource Ontologies formalizing the business rules. Examples of constraints are “Each Innovation Report needs to be composed by a Project Proposal and a Market Analysis", or "A Monitoring Sheet cannot be produced unless a Gantt Chart has been finalized before". The former rule can be formalized by the following axiom:

$$\text{if } innovation\_report(x) \text{ then } \exists\ y,z.\ project\_proposal(y) \text{ and } market\_analysis(z) \text{ and } partOf(x,y) \text{ and } partOf(x,z)$$

3.5 Discussion

A number of items are worth a discussion about this thesis work. These items summarize the contribution of this work, open points it has and the usability issues it can be related.

- This work shows that Universal Business Language, which is a standard generically used in procurement domain, can be applied to business innovation domain successfully. Although this is an open point to depict this

for other domain types, this work does not differentiate or cares about the domain. The requirement is that the documental resources needs to utilize UBL Information Entities to base their semantics.

- This work is applicable for environments where documents are modelled and placed in a UBL zip package and the semantic backend is SMW+. An able document customization tool, eDoCreator and a SMW+ backed platform have enabled this work to be applicable to BIVEE Project. Although it has not been studied in detail, the use of interfaces i.e. APIs guarantees that environments which conform to these requirement can utilize this work fully.

- By nature of the work, the virtual enterprise environment is constructed by the other BIVEE Components. These components allow links between actors, documents, KPIs within the virtual enterprise. The addition of different enterprises i.e. the virtual enterprise context requires a cross product use case where the functionality resides horizontally. This work is rather vertical in the sense that it creates a base for documental resources and does not concentrate solely on virtual enterprise context.

- Since semantic web applications have a tendency to experience performance degradation issues when faced with large data, it is a wise decision to discuss this aspect. The basic responsibility of the Mediator web service is to transform from a zip package i.e. an xsd file, folder hierarchy to a set of calls required to construct the same knowledge within the semantic repository of the BIVEE Platform. This means that Mediator is not dealing with the semantics directly, it rather transforms it from one form to another. The possible performance degradation for this work stems from the number, complexity of the documents the UBL zip package contains.

- There is a cost and an advantage when an enterprise moves from an internal document management system to BIVEE semantic repository. BIVEE semantic repository is not a replacement for internal document management systems so the cost, mainly, is to model the document templates used in the enterprise into a UBL customization tool. The advantage is to

collect documented resources to the innovation hub of an enterprise where actors, domain already reside. With such a collection, BIVEE Platform will be much more capable.

CHAPTER 4

CONCLUSION

In this thesis, a document centric approach for the user requirements of the BIVEE project is presented. This work focusses on UBL and tries to utilize it in an uncommon domain in a semantic level. To this end, the identification of the improvement and innovation related processes of end-user enterprises is realized. Then, together with the end user partners, we have tried to identify the key documents and classify according to the "waves" approach in BIS. We continued with the detailed analysis of each document. Selected documents are decomposed and common parts of the documents are identified. Formal semantic structure for the selected document will be implemented through ontological annotations and the approach follows a bottom-up approach: tiny information units will come together to form the improvement and innovation documents. Future work might include a standardization proposal of these documents as BIVEE approaches to a level of maturity.

Within the technical accomplishments of this thesis, an ontology-based framework for semantic description of innovation-related activities is outlined. A bunch of *InfoSets* corresponding to categories of information that are produced, consumed and evaluated during innovation projects. Furthermore, relationships that can occur among *InfoSets* is shown and elementary components of the *InfoSets* are introduced.

The identification of a basic set of *InfoItems* for each *InfoSet* is an important step at this point. Doing that, the intention is to re-use available vocabularies as much as possible following the Linked Data approach. Another important issue

is to enable knowledge extraction from documents in order to provide support to automatically suggest *InfoSets* instantiation, and this is being implemented within the Mediator module as introduced in Chapter 4.1.

In this work, along with the documents management facilities for virtual enterprise innovation activities, Semantic Web technologies through Linked Data approach [24] [12] are utilized. The DocOnto framework introduces a customizable ontology set for the management of the identified documents within innovation activities. During the set-up of the documents through eDoCreator with UBL (and hence CCTS), Dublin Core [6] metadata terms have been adopted in order to structure the meta-data for each information entity.

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APPENDIX A

END USER QUESTIONNAIRE

TableA.1: End User Questionnaire

No	Question
General Information	
1	How do you define a product in the light of the discussions made in the first plenary meeting?
1.1	Based on your definition, does your company have any products? What are they?
Innovation in context	
2	How do you define innovation?
2.1	Could you give some specific (imaginary, maybe impossible to achieve) examples?
2.2	How do you define innovation in the context of your company? Any examples?
Innovation management process	
3	What is the innovation management process of your company?
3.1	Do you have a separate R&D department to manage innovation within your company? If yes, details please.
3.2	Do your managers push ideas to the employees? If yes, details please.
3.3	Do you organise brainstorming sessions to create innovative ideas? If yes, details please.

Table A.1 (continued)

No	Question
3.4	Do you apply any performance evaluation for the production of innovation within your company?
3.5	Do you expect innovative ideas from your employees? If yes, details please.
3.5.1	What happens if an employee of your company comes up with an innovative idea?
3.5.1.1	How does he/she share the idea with the managers?
3.5.1.2	How does he/she share the idea with the rest of the company?
3.6	Do you share innovative ideas with your business partners (other companies such as providers, retailers, customers etc...)?
3.6.1	If you share how do you do it? Do you use any specific platform? Or phone calls? Or reports etc...?
3.7	What actions are taken based on this idea within the company?
3.7.1	Which departments are involved in the discussion of the idea?
3.7.2	What is the methodology in this discussion? Do you have any formal processes for this purpose?
3.7.3	What happens based on the results of the discussion?
3.7.4	Do you apply any planning activities, if the idea is accepted as valuable? If yes, what are the details?
3.7.5	Do you apply any forecast or monitoring activities, if the idea is accepted as valuable?
3.7.6	Any awards to the employee who came up with the idea?
3.7.7	What are the equivalent actions if the idea is not accepted as valuable?
Software in use	

Table A.1 (continued)

No	Question
4	Do you have specific programmes/activities to increase the innovation capabilities of your employees? If yes, what are these activities?
4.1	Who can attend these activities? Any selection criteria?
4.2	What is the frequency of these activities?
4.3	Are there any specific tools to organise and manage these type of activities?
4.4	Do you have any specific action/process to lead from these activities to innovative ideas? If yes, what are the details?

APPENDIX B

USER SPECIFICATION AND INFORMATION FLOW ANALYSIS

B.1 User Specification

TableB.1: User Specification Table for Innovation Space of Loccioni

Activity Actor	**Desc.**	**Info Needs**	**Source Actor**	**Info Produced**	**Dest. Actor**
Creativity					
Universities / Research Centres	Propose idea			Proposed idea / issue	Research for Innovation (RforI) Team
Advisors	Propose idea			Proposed idea / issue	RforI Team
Customers	Propose idea			Proposed idea / issue	RforI Team

Table B.1 (continued)

Activity Actor	**Desc.**	**Info Needs**	**Source Actor**	**Info Produced**	**Dest. Actor**
RforI Team	Analyse solutions for the proposed idea	Proposed idea / issue	Universities, Research Centres, Advisors, Customers	Technical Solution	RforI Manager
Marketing Department	Analyse the market scenarios	Technical Solution	RforI Manager	Marketing Report	RforI Manager
RforI Manager	Summarise the market and technical reports	Technical Solution, Marketing Report	RforI Team, Marketing Department	Innovation report	Loccioni Management
Loccioni Management	Decision making	Innovation Report	RforI Manager	Decision, Internal order	RforI Manager, Project Manager
Feasibility					
Marketing Department	Analyse the market opportunities	Innovation Report	RforI Manager	Market Analysis	Project Manager, RforI Manager

Table B.1 (continued)

Activity Actor	**Desc.**	**Info Needs**	**Source Actor**	**Info Produced**	**Dest. Actor**
Project Manager	Coordinate project	Innovation Report, Budget, Internal order, Resources	Loccioni Management	Gantt charts, Sub-projects, specific budgets, List of necessary resources	Innovation Team
Innovation Team	Developments of sub-projects	Sub-projects Gantt charts, objectives and budget	Project Manager	Sub-project Technical Solutions	Project Manager
Project Manager	Feasibility study	Sub-project Technical Solutions	Innovation Team	Feasibility Study Report	RforI Manager
RforI Manager	Evaluation and validation of the results	Feasibility Study, Market Analysis	Innovation Team, Marketing Department	Decision	Loccioni Management, Project Manager, Innovation Team
Prototyping					

Table B.1 (continued)

Activity Actor	**Desc.**	**Info Needs**	**Source Actor**	**Info Produced**	**Dest. Actor**
Best Partner	Prototype requirements			Prototype requirements	Project Manager, Innovation Team
Project Manager	Mechanical, Electrical and assembly plan definition	Feasibility study	Project Manager	Gantt charts	Mechanical Department, Electrical and Production Departments
Project Manager	Technical analysis of the solution	Prototype development results	Innovation Team	Prototype Technical Report	RforI Manager, Loccioni Management
Project Manager	Summarize the achievements and check the requirements	Prototype development results and prototype requirements	Innovation Team	Results Report	Best Partner, RforI Manager, Loccioni Management
Engineering					

Table B.1 (continued)

Activity Actor	**Desc.**	**Info Needs**	**Source Actor**	**Info Produced**	**Dest. Actor**
Marketing Department	Analyse cost	Budget, Prototype Technical Report, Results Report	Project Manager	Cost Report	Project Manager
Innovation Team	Optimisation and standardisation of the product	Prototype Technical Report, Budget, Cost report	Project Manager	Prototype Modification	Project Manager
Project Manager	Evaluation and Validation	"Pre-series" results	Innovation Team	Decision	RforI Manager, Loccioni Management
Production Manager	Solution Release	"Pre-series" results, prototype modification	Innovation Team	BoM, Executive design, Protocols, Commercial Components Requirements (CCR)	RforI Manager, Production Manager

TableB.2: User Specification Table for Innovation Space of Aidima

Activity Actor	**Desc.**	**Info Needs**	**Source Actor**	**Info Produced**	**Dest. Actor**
Creativity					
AIDIMA Employee	Innovation Idea	–	–	Idea proposal	Head of Department
Associated Company	Innovation Idea	–	–	Idea proposal	Management board
Another Tech. Institute or Organisation [Ask for collaboration]	Innovation Idea	–	–	Idea proposal	Management board
Business segment (AIDIMA)	Detection of possible needs from associated companies	Research lines / –	R&D coordination unit / –	Idea proposal	Head of Department
Head of Department (HoD)	Initial revision of the proposal	Idea proposal	AIDIMA Employee	Report of the defined idea / Dismiss idea	Management board
Full Department	Periodical Brainstorming	Current Research lines / –	–	Report of the new Innovation Idea	Innovation committee / R&D coordination unit

Table B.2 (continued)

Activity Actor	**Desc.**	**Info Needs**	**Source Actor**	**Info Produced**	**Dest. Actor**
Innovation committee / R&D coordination unit	Periodical Brainstorming	Defined idea Report / Current Research lines	Head of Department / Company	Research line	Companies / All
Grupo FASE AIDIMA + Companies	Set of meetings / Detection of needs	–	–	Idea proposal / Research line	Companies / All
Feasibility					
Management board (ADIMA + Companies)	Proposal definition	Research line	Head of Department / Company	New project proposal based on this line / Dismiss	R&D coordination unit
R&D coordination unit	Innovation management	New project proposal based on this line	AIDIMA Department / Company	Registration of the Idea Information into the AIDIMA ERP	–

Table B.2 (continued)

Activity Actor	**Desc.**	**Info Needs**	**Source Actor**	**Info Produced**	**Dest. Actor**
Associated Company (Of not member from MB)	Project evaluation	Project proposal	R&D coordination unit	PARTIPATE / OR NOT	Head of Department
Department / R&D Coordination Unit / Partner company	Redefinition of project requirements	Project proposal	R&D coordination unit	Prototype requirements / Terms of contract	Head of Department
Prototyping					
R&D coordination unit	Project monitoring	Project proposal	Management board	Implementation roadmap	AIDIMA / Partner Company
Head of Department	Project monitoring	Project proposal	Management board	Gantt diagrams / Monitoring sheets	R&D / Partner Company / All
AIDIMA Department Technician	Prototype Development	Project Requirements / Imp. Roadmap	R&D coordination unit	Development Reports	R&D coordination unit / Partner Company

Table B.2 (continued)

Activity Actor	**Desc.**	**Info Needs**	**Source Actor**	**Info Produced**	**Dest. Actor**
Project partner Company or Companies	Prototype Development	Project Requirements / Imp. Roadmap	R&D coordination unit	Development Reports	R&D coordination unit / Partner Company
AIDIMA / Partner Companies	Prototype Development	Project Requirements / Imp. Roadmap	R&D coordination unit	Final report / Prototype specifications	R&D coordination unit / Partner Company
Engineering					
Target Company	Manufacturer, Producer, Retailer	Final prototype report / Prototype	AIDIMA / Partner Companies	Results validation / PRODUCTION / DISMISS	AIDIMA / All
Company (Technical office)	Evaluate prototype modifications	Prototype specifications	AIDIMA / Partner Companies	New product data sheet	Company (Clients & Marketing)
Company (Clients & Marketing)	New product evaluation	New product data sheet	Company (Technical office)	New product acceptance	Company

B.2 Information Flow Analysis

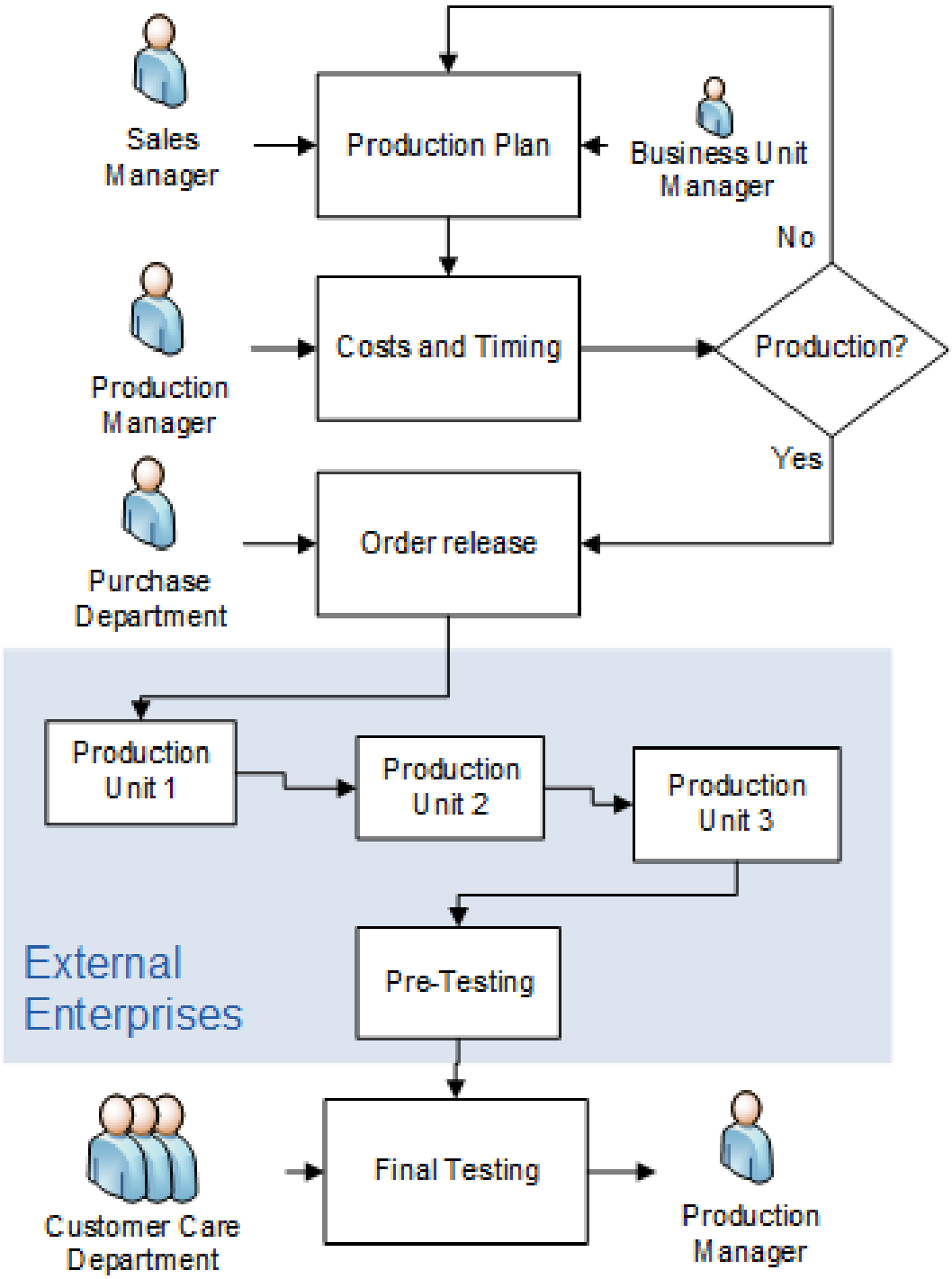

Figure B.1: Information Flow Analysis for Business Innovation Space of Loccioni

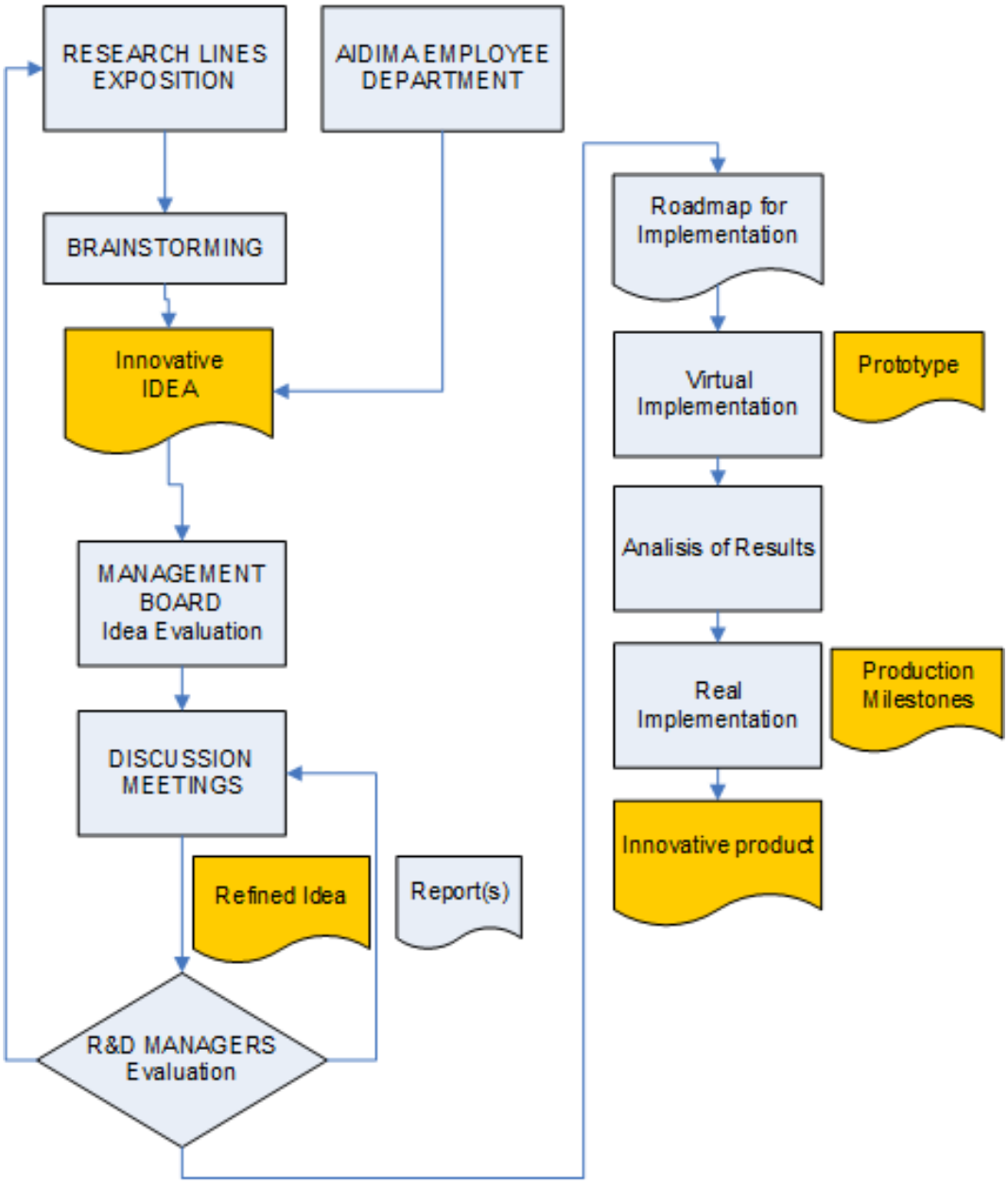

Figure B.2: Information Flow Analysis for Business Innovation Space of Aidima

APPENDIX C

BUSINESS INNOVATION SPACE DOCUMENTS

TableC.1: Business Innovation Space Documents

Document	**Defined?**		**Description**	
	A?	**L?**	**AIDIMA**	**LOC**
A. Creativity				
1. Partner Profile	Yes	Yes	From the POV of AIDIMA some different profiles can be considered: Manufacturers / Retailers / Technological Partners / Suppliers / Retailers / Technological Institutes / and Organizations. Each profile has their own valuable atributtes in order to be modelled.	Detailed information about the organization living in the Business Ecosystem. We extend "Party" definition of UBL. Partner profiles may change according to the context. For example there can be a "Business Ecosystem Profile", "VIF Profile" and "VE Profile" for a single organization. These can be defined hierarchically.

Table C.1 (continued)

Document	Defined?		Description	
	A?	L?	AIDIMA	LOC
2. Business Ecosystem	Yes	Yes	This ecosystem is set of heterogeneous enterprises which perform several kind of activities. Grupo FASE or Management Board are two examples of enterprise ecosystems in the context of AIDIMA. This ecosystem allows its member to share information, documents, discuss about the ideas and conclusions of their meetings and take final decissions according to all the information shared between its members. The ecosystem must provide collaboration facilities for all its members.	Defines the ecosystem in which profiles of all organizations are persisted. These can be enterprises, SMEs, universities, research centers etc... which have the chance to collaborate for specific objectives. Enterance/Exit mechanisms, cooperation methods and agreements between the organizations might need additional document definitions.

Table C.1 (continued)

Document	Defined?		Description	
	A?	L?	AIDIMA	LOC
3. Research Line	Yes	Yes	The research line is the description of the idea conceived by any AIDIMA member or associated company. It is evaluated and validated inside AIDIMA and companies (Innovation Commitee). Ex: Health & safety systems in woodworking machinery. The title is usually abstract and oriented to solve any need of the wood and furniture industries. It contains no reference to a concrete solution which is defined during the project development. In its most formal mode it is represented by slides containing the name of departments involved, the description of the task, objectives to achieve and the application scope	A Research Line defines the business sectors, directions about which LOC should make research. LOC has a number of "current research lines", which is determined through strategic view of the group and of the business lines. Research lines are discussed and evaluated every year.

Table C.1 (continued)

Document	Defined?		Description	
	A?	L?	AIDIMA	LOC
4. Proposed Idea	Yes	Yes	This document only contains a brief description of any innovative idea proposal. Can be considered as an unformal document. Depending on the kind of idea this first proposal may include diagrams, technical descriptions and drawings. Its content is very similar to the research line very often, but the idea is described in a more abstract way. This document is usually written by any AIDIMA researcher or the Innovation Committee. This document is refined through the different mettings.	An idea suggesting a "kind of solution" to a problem. Could arrive from an email or through a meeting with a partner of our network and formalized in a report.
5. Validated Idea	Yes	No	This is New idea proposal or redefinition of current research line in order to satisfy an specific company need.	

Table C.1 (continued)

Document	Defined?		Description	
	A?	L?	AIDIMA	LOC
6. Customer Issue	Yes	Yes	The customer issues are short attachments included on the final version of the proposed idea (validated idea) showing the special requirements and conditions contributed by the customer project participants in order to carry out with any project related to that proposal.	Included in the point "4. Proposed idea"
7. Solution (Technical Solution)	No	Yes		Describes the solution to an issue/problem or a pathway to the implementation of an idea.
8. Research For Innovation Report	No	Yes		We use the Technical Solution like a draft of the solution. Then the RforI Manager validates. the idea and creates the RforI report to sharing this document with the LOCCIONI management.

Table C.1 (continued)

Document	**Defined?**		**Description**	
	A?	**L?**	**AIDIMA**	**LOC**
9. Marketing Report	No	Yes		Is only an analysis of the market sensibility about the solution, because we don't have a product yet.
10. Innovation Report	No	Yes		Combination of "Research For Innovation" and "Marketing" reports.
11. Budget	No	Yes		Prospective budget to apply the idea. This can be a new product or a new service etc...
12. Internal Order	No	Yes		Generate a code to identify the project in each departments.
13. Resources	No	Yes		List of people to be involved in the project with the percentage of their time.
B. Feasibility				

Table C.1 (continued)

Document	Defined?		Description	
	A?	L?	AIDIMA	LOC
1. Market Analysis	No	Yes		This is different by the Marketing report because this Market analysis is made in continuum with this wave. It is more detailed because the solution take shape, so the marketing has more information to analyse the market. There isn't a document but there is a collecting of information.
2. Gantt	Yes	Yes	Tasks sequence and estimated time.	Gantt chart of the project.
3. Solution	No	Yes		This is the solution for each sub-project proposed by external actors if they are contacted from the Innovation Team.
4. Project Validation For Participation	Yes	No	The company accepts fot the participation in a new project under the conditions.	

Table C.1 (continued)

Document	**Defined?**		**Description**	
	A?	**L?**	**AIDIMA**	**LOC**
5. Feasibility Study	Yes	No	The feasibility study report that describes the solution adopted,the technology in use and some data that validate the solution (e.g. a photo with the defect inspected, a graph with the signal monitored)	
6. Go/No Go Decision	No	No		To date we don't have a formal document for this.
7. Project Proposal	Yes	No	This document must contain the most relevant project information, for example, the project title. author(s), short description, objectives, justification, benefits, risks, timing, important dates and some estimation of costs	

Table C.1 (continued)

Document	**Defined?**		**Description**	
	A?	**L?**	**AIDIMA**	**LOC**
8. Project partner request	Yes	No	This is a reduced version of the previous project proposal. Only contains the project name and abstract, the company description, the target partner expertise sought and some contact details.	
9. Candidacy proposal	Yes	No	This proposal must contain the name of the company, a short description of the specialized staff and the acquired knowledge, the previous experience in similar projects and any kind of information that can be considered as interesting for the specific project candidacy.	

Table C.1 (continued)

Document	Defined?		Description	
	A?	L?	AIDIMA	LOC
10. SWOT Analysis	Yes	No	This is the most important document for the project / idea feasibility evaluation. This is prepared by the AIDIMA PMO with the Research team support and released to the AIDIMA management for take the decision of carry out with the project or not. Contains the 4 important key features: strengths or staff experience, weakness or strange project areas, opportunities or project profits and threats or possible problems that may arise during the project development	
C. Prototyping				

Table C.1 (continued)

Document	**Defined?**		**Description**	
	A?	**L?**	**AIDIMA**	**LOC**
1. Prototype requirements	Yes	Yes	List of the prototype key requirements. It depends on the kind of product to deliver but usually contains only a sub-group of the final product requirements.	Written by the customer (best partner). Could arrive from emails or meeting.
2. Implementation Roadmap	Yes	Yes	List of milestones and timing for the project development. This document usually includes the project general description, the implementation draft schedule, the tasks to perform sorted by its importance with the reference of its responsible and in some cases a brief explanation about the results validation methodology and the project tracking system used for this project.	Set of milestones to accomplish during the project development. Makes easier the tracking of the project and the goals achievement.

Table C.1 (continued)

Document	**Defined?**		**Description**	
	A?	**L?**	**AIDIMA**	**LOC**
3. Monitoring sheet	Yes	Yes	The heads of the involved departments elaborates and checks often this monitoring document where the most relevant tasks and expected hours of dedication are introduced. Before the creation of the first monitoring sheet version version, each partner fills the suitable information (definition of sub-tasks and time estimation for each task) This document varies depending on unexpected situations.	Simple excel sheet indicating the tasks to perform, resposibilities and estimated finishing dates. Only for internal use for development issues.

Table C.1 (continued)

Document	**Defined?**		**Description**	
	A?	**L?**	**AIDIMA**	**LOC**
4. Gantt diagram	Yes	Yes	This document can be considered like the static version of the monitoring sheet so represents the expected project planning in an inflexible way. Its structure is the same like any Gantt diagram but some subtasks definitions shown on the monitoring sheet are not included in the Gantt diagram so these are considered like too specific development tasks.	New gantt diagram with the new departments involved.

Table C.1 (continued)

Document	Defined?		Description	
	A?	L?	AIDIMA	LOC
5. Specific Documents	Yes	Yes	Drawings, design files, diagrams, development reports, meeting minutes. These can be internal for AIDIMA / Involved company or be transferred between both during the prototype development.	Business specific documents such as Mechanical Drawings, Electrical Drawings etc... I think LOC also has these kind of documents. In my opinion, BIVEE should provide a "generic" support for the exchange of these documents. However, there is no need to provide an integration with these specific documents.
6. Technical Report	Yes	Yes	Includes the possible troubles during the development and the technical issues related to the project implementation stages.	Project final Report (Technical oriented). Includes the results of the prototyping with the validation of the solution.
7. Results Report	Yes	Yes	This is the not technical project report for a general audience. This document includes the final conclusions of the developed project, the benefits, general issues and future planning.	Project final Report (Not technical oriented). Like a final project deliverable.

Table C.1 (continued)

Document	**Defined?**		**Description**	
	A?	**L?**	**AIDIMA**	**LOC**
D. Engineering				
1. Budget	No	Yes		Budget review of the project.
2. Bill/List of Materials	No	Yes		The list of all materials to build up the product.
3. Cost Report	No	Yes		The cost of everything to produce the new product/service. Detailed cost analysis of each step.
4. Resources	No	Yes		A new team could be involved in this phase. Like in the creativity wave.
5. Protocols	No	Yes		The document defines the specification of each action to be made in the production: to assembly the product, to control the output of the assembly, to control the function of each component, to control the global functioning of the product.

Table C.1 (continued)

Document	**Defined?**		**Description**	
	A?	**L?**	**AIDIMA**	**LOC**
6. Commercial Components Requirements (CCR)	No	Yes		The features of the components with the reference of the supplier with the objective to pass these information to the purchase department.

Table C.1 (continued)

Document	Defined?		Description	
	A?	L?	AIDIMA	LOC
7. Prototype modification	Yes	Yes	This document can be considered as a short attachment to the prototype requirements document. Includes annotations to previous requirements, delete or even add new requirement to the designed prototype. Usually these modifications are conceived by the final manufacturer beneficiary and according to market analysis and customer specific needs. An example of these can be the adjustment of some product piece. In this case the relevant information would be the piece identification and the date and description of this adjustment task.	In order to industrialize the production of the prototyped product, some modifications to the first prototype can be applied in order to adjust it to the production line features. Like "pre-series".

Table C.1 (continued)

Document	**Defined?**		**Description**	
	A?	**L?**	**AIDIMA**	**LOC**
8. Product data-sheet	Yes	Yes	The product data-sheet is a short briefing of the product also for technical audience and final customer. Includes the name of the new product, instructions of assembly just in case, parts materials, measures and maintenance and cleaning instructions. To explain this points usually some drawings are attached into the document.	User manual

Table C.1 (continued)

Document	**Defined?**		**Description**	
	A?	**L?**	**AIDIMA**	**LOC**
9. New product acceptance	Yes	Yes	is is an internal document describing how to proceed in order to include the final product / service into the manufacturer catalogue if this is a physical product or into the organization business processes if this is a service. Usually is arranged by the market department and is represented as a short market analysis and product impact from a strategic scope.	Custom clients and Marketing study the selling of the product. This is the pursuance of results validation.

Table C.1 (continued)

Document	**Defined?**		**Description**	
	A?	**L?**	**AIDIMA**	**LOC**
10. Working report	Yes	No	This reports are organized by dates according to the project length. This report is generated by each person who participates in the project development. This includes every date, the time dedicated to the project and the specific project stage in which the employee has been working. This reports are collected and merged by the AIDIMA PMO in order to evaluate the profitability of the project.	

APPENDIX D

VIRTUAL PRODUCTION SPACE DOCUMENTS

TableD.1: Virtual Production Space Documents

Document	**Defined?**		**Description**	
	A?	**L?**	**AIDIMA**	**LOC**
A1. Strategy				
1. Strategy Report	No	Yes		Meeting report between Business Unit manager and the sales department
2. Production Batch	No	Yes		It is included in the strategy report
3. Estimated Cost & Time	No	Yes		Report with the cost and the expected time to production
4. Go/No Go Decision	No	Yes		To date we don't have a formal document for this
A2. Order Evaluation				

Table D.1 (continued)

Document	**Defined?**		**Description**	
	A?	**L?**	**AIDIMA**	**LOC**
1. Order	Yes	No	Defines the details of an order of a required material for the production. This can be extended from UBL Order document	
2. Order Validation	Yes	No		
3. Order Redefinition	Yes	No	In the case the company receives an special order. The order can be redefining according to the company capabilities and a new modified order is sent to the customer.	
4. Order Dismiss	Yes	No	Negative response from manufacturer in step A2.2	
5. Product Data Sheet	Yes	No	Brief description of the product. It is very different for each furniture typology and manufacturer although they may have common fields.	

Table D.1 (continued)

Document	**Defined?**		**Description**	
	A?	**L?**	**AIDIMA**	**LOC**
6. Reviewed Product Data Sheet	Yes	No	Product Data Sheet v2 (modifications & updates)	
7. Cost Breakdown	Yes	No	List of the pieces of the product and the processes to apply to them. Also shows cost for any material & process.	
B. Supplying				
1. List of Production	No	Yes		This is different than the Bill/List of Materials document. In the BOM we have a code for each single part of the product. While in the List of Product there are code usefull for the purchase department that group more components

Table D.1 (continued)

Document	Defined?		Description	
	A?	L?	AIDIMA	LOC
2. Acquired Material	No	Yes		In our software tool we have two phase that describe the purchase of the components. The product manager introduces the List of Production in this tool and the state is OR (Order Request). When the purchase department makes the order the state is OP (Order Purchase)
3. Supplier budget	Yes	No		
4. Order to supplier	Yes	No	The same as LOC's Bill of Materials	
5. Supplier Claim	Yes	No	Contains the client code / name, claim reason and the detail of the involved furniture items. Very different from one manufacturer to another.	
6. Invoice from supplier	Yes	No		
C. Production				

Table D.1 (continued)

Document	Defined?		Description	
	A?	L?	AIDIMA	LOC
1. Protocols	No	Yes		The enterprises that assembles the product must validate the protocols and send it to the Product Manager.
2. Non-conformities Report	No	Yes		At the end of each batch series the product manager creates a report with statistics on each components and on each suppliers.
3. Manufacturing order	Yes	No	General manufacturing instructions. Generated from the Cost Breakdown.	
4. Work order	Yes	No	Process-oriented order. Generated from the Cost Breakdown	
5. Outsourcing order	Yes	No	Order to outsourced company for production or services.	
6. Quality control specifications	Yes	No	Internal document. Protocol of quality control	
D. Delivery				

Table D.1 (continued)

Document	**Defined?**		**Description**	
	A?	**L?**	**AIDIMA**	**LOC**
1. Packaging Instructions	Yes	No		
2. Delivery Order	Yes	No		
3. Invoice from retailer	Yes	No		

APPENDIX E

PROCESSOR THREAD

```
package eu.bivee.doconto.process;

import java.io.File;
import java.util.HashMap;
import java.util.Iterator;
import java.util.Map;

import org.apache.log4j.xml.SAXErrorHandler;
import org.w3c.dom.Element;
import org.w3c.dom.NodeList;

import com.sun.xml.xsom.XSAnnotation;
import com.sun.xml.xsom.XSComplexType;
import com.sun.xml.xsom.XSElementDecl;
import com.sun.xml.xsom.XSModelGroup;
import com.sun.xml.xsom.XSParticle;
import com.sun.xml.xsom.XSSchema;
import com.sun.xml.xsom.XSSchemaSet;
import com.sun.xml.xsom.XSSimpleType;
import com.sun.xml.xsom.XSTerm;
import com.sun.xml.xsom.parser.XSOMParser;
import com.sun.xml.xsom.util.DomAnnotationParserFactory;
```

```
import eu.bivee.doconto.utils.Utils;
import eu.bivee.pikr.documents.dataapi.DatatypeCategory;
import eu.bivee.pikr.documents.dataapi.InfoItemAttribute;
import eu.bivee.pikr.documents.dataapi.InfoItemRelation;
import eu.bivee.pikr.documents.dataapi.InfoSet;
import eu.bivee.pikr.documents.dataapi.impl.
                            IncompatiblePropertyException;
import eu.bivee.pikr.documents.dataapi.impl.
                            IncompatibleValueException;
import eu.bivee.pikr.documents.dataapi.impl.
                            PIKR_documents_DataFacadeImpl;
import eu.bivee.smw.sparql.Constants;

public class Processor implements Runnable {
private String filePath;
private String veId = "Bivee";
private boolean isCreate = true;
private XSSchemaSet schemaSet;

private boolean output = true;
private boolean call = true;

private final static String isPrefix = "";
private final static String docPrefix = "";
private final static String relPrefix = "";
private final static String attrPrefix = "";

private Map<String, InfoItemAttribute> createdAttributes;
private Map<String, InfoItemRelation> createdRelations;
private Map<String, InfoSet> createdInfoSets;

private final static String cctsNS = "urn:un:unece:uncefact"
                           + ":documentation:2";
```

```
private final static String cacNS = "urn:oasis:names:specification"
        + ":ubl:schema:xsd:NoIDCommonAggregateComponents-2";

public Processor(String filePath, String veId, boolean isCreate) {
this.filePath = filePath;
this.veId = veId;
this.isCreate = isCreate;
}

private String removeSpaces(String in) {
return in.replace(' ', '_');
}

public void run() {
createdAttributes = new HashMap<String, InfoItemAttribute>();
createdRelations = new HashMap<String, InfoItemRelation>();
createdInfoSets = new HashMap<String, InfoSet>();

// unzip the zip file
File folder = Utils.unzip(filePath);
if (folder == null) {
System.err.println("Error during unzip...");
return;
}

// delete the zip file
File zipFile = new File(filePath);
zipFile.delete();
System.out.println("zip file is deleted.");

// get the folder containing relevant XSDs
File documentFolder = new File(
            filePath.substring(0, filePath.length() - 4) +
```

```
            File.separator + "xsd" +
            File.separator + "maindoc" +
            File.separator + "userDefined" +
            File.separator + "NoID"  + File.separator);
System.out.println(documentFolder.getAbsolutePath());

// process each xsd file
for (File f : documentFolder.listFiles()) {
schemaSet = null;
try {
// parse xsd
XSOMParser parser = new XSOMParser();
parser.setErrorHandler(new SAXErrorHandler());
parser.setAnnotationParser(
                           new DomAnnotationParserFactory());
parser.parse(f);

// get the schema set
schemaSet = parser.getResult();
} catch (Exception e) {
System.err.println("Error during xsd parse...");
e.printStackTrace();
return;
}

// process the schema set
process(schemaSet);
}
System.out.println("Success");
}

private void process(XSSchemaSet schemaSet) {
if (schemaSet == null) {
```

```
System.err.println("ProcessError: Null Schemaset");
return;
}

// Each file is processed. Get schema for current xsd file
XSSchema docSchema = schemaSet.getSchema(1);
XSElementDecl docElement = getDocumentElement(docSchema);

// get the complexType for a document
String docTypeName = docElement.getType().getName();
XSComplexType docType = docSchema.getComplexType(docTypeName);

createABIE(docSchema, docType, true);
}

private void populateContent(String isName, XSSchema docSchema,
XSComplexType complex) {
// Get the content as particle
XSParticle particle = complex.getContentType().asParticle();
if (particle != null) {
XSTerm term = particle.getTerm();

// Is term a model group?
if (term.isModelGroup()) {
XSModelGroup group = term.asModelGroup();
for (XSParticle child : group.getChildren()) {
// process and make the necessary API calls
processChild(isName, docSchema, child);
}
}

// Is term an element declaration?
if (term.isElementDecl()) {
```

```
System.err.println("==>ElementDecl is not supported!");
}

// Is term a model group declaration?
if (term.isModelGroupDecl()) {
System.err.println("==>ModelGroupD is not supported!");
}

// Is term a model group declaration?
if (term.isWildcard()) {
System.err.println("==>Wildcard not supported!");
}
}

// Get the content as a simple type
XSSimpleType simple = complex.getContentType().asSimpleType();
if (simple != null) {
System.err.println("==>SIMPLE:" + simple.getName());
}
}

private void processChild(String isName, XSSchema docSchema,
XSParticle child) {
XSTerm term = child.getTerm();
// Is child term an element declaration?
if (term.isElementDecl()) {
// get the details from annotation element
Element annot = (Element) child.getAnnotation()
                                          .getAnnotation();

// get the type of the component: ABIE/BBIE/ASBIE
NodeList nl = annot.getElementsByTagNameNS(cctsNS,
                                         "ComponentType");
```

```
String compType = nl.item(0).getTextContent();

if (compType.equals("BBIE")) {
                // BBIE: Create properties
createBBIE(isName, child);
} else if (compType.equals("ASBIE")) {
                // ASBIE: Create relations
createASBIE(docSchema, isName, child);
} else if (compType.equals("ABIE")) {
                // ABIE: Create infoSets
System.err.println("ABIE");
}
}

// Is child term an element declaration?
if (term.isModelGroup()) {
System.err.println("====>ModelGroup is not supported!");
}

// Is child term a model group declaration?
if (term.isModelGroupDecl()) {
System.err.println("====>ModelGroupDecl is not supported!");
}

// Is child term a model group declaration?
if (term.isWildcard()) {
System.err.println("====>Wildcard not supported!");
}
}

private void createABIE(XSSchema docSchema,
      XSComplexType docType, boolean isDocument) {
// get the annotation from the complex type for details
```

```
XSAnnotation docAnnot = docType.getAnnotation();
Element annotObj = (Element) docAnnot.getAnnotation();

// get the name of the document from annotation
NodeList nl = annotObj.getElementsByTagNameNS(cctsNS,
                                              "ObjectClass");
String docName = nl.item(0).getTextContent();

// get the definition
nl = annotObj.getElementsByTagNameNS(cctsNS, "Definition");
String docDefn = nl.item(0).getTextContent();

// create and add the infoset

InfoSet infoSet;
if (isDocument) {
String isName = removeSpaces(docPrefix + docName);
infoSet = new InfoSet(isName, docDefn, true,
Utils.getDocCategory(isName));
} else {
String isName = removeSpaces(isPrefix + docName);
infoSet = new InfoSet(isName, docDefn, false,
Utils.getDocCategory(isName));
}

if (!createdInfoSets.containsKey(infoSet.getName())) {
PIKR_documents_DataFacadeImpl pikr =
                PIKR_documents_DataFacadeImpl.getInstance();
// MyImpl pikr = MyImpl.getInstance();
if (isCreate) {
if (output) {
System.out.println("AddInfoSet:"
                        + infoSet.getName() + "="
```

```
+ infoSet.getCharacteristicOf() + "="
+ infoSet.getDescription() + "#");
}

if (call) {
String is = pikr.addInfoSet(this.veId, infoSet);
System.out.println("InfoSet added: " + is);
}
} else {
try {
if (output) {
System.out.println("RemoveInfoSet:"
                            + infoSet.getName() + "#");
}
if (call) {
String is = pikr.removeInfoSet(this.veId,
infoSet.getName());
System.out.println("InfoSet removed:" + is);
}
} catch (IncompatibleValueException e) {
e.printStackTrace();
}
}
createdInfoSets.put(infoSet.getName(), infoSet);
}

// handle the content
populateContent(infoSet.getName(), docSchema, docType);
}

private void createASBIE(XSSchema docSchema, String isName,
                                      XSParticle child) {
// get the details from annotation element
```

```
Element annot = (Element) child.getAnnotation()
                                          .getAnnotation();

// get the name of the information entity
NodeList nl = annot.getElementsByTagNameNS(cctsNS,
                                             "PropertyTerm");
String name = nl.item(0).getTextContent();

// get the definition of the information entity
nl = annot.getElementsByTagNameNS(cctsNS, "Definition");
String defn = nl.item(0).getTextContent();

// get the cardinalities
String minCard = child.getMinOccurs().toString();
String maxCard = child.getMaxOccurs().toString();

nl = annot.getElementsByTagNameNS(cctsNS,
                                       "AssociatedObjectClass");
String relRange = nl.item(0).getTextContent();

// get the complexType for the range
XSComplexType docType = schemaSet.getComplexType(cacNS,
                relRange + "Type");
if (docType != null) {
createABIE(docSchema, docType, false);
}

InfoItemRelation rel = null;
try {
if (maxCard.equals("-1")) {
maxCard = Constants.UNBOUNDED;
}
String relName = removeSpaces(relPrefix + name);
```

```
String ns = Utils.lookupNS(relName);
String term = Utils.lookupTerm(relName);

rel = new InfoItemRelation(term, defn,
                     isPrefix + relRange, minCard, maxCard, ns);
} catch (IncompatibleValueException e) {
e.printStackTrace();
return;
}

if (!createdRelations.containsKey(isName + rel.getName())) {
try {
PIKR_documents_DataFacadeImpl pikr =
                    PIKR_documents_DataFacadeImpl.getInstance();
// MyImpl pikr = MyImpl.getInstance();
if (isCreate) {
if (output) {
System.out.println("AddRelation:" + isName + "-"
    + rel.getNamespace() + "=" + rel.getName()
+ "=" + rel.getDescription() + "="
+ rel.getRange() + "=" + rel.getMinCard()
                            + "=" + rel.getMaxCard() + "#");
}
if (call) {
String r = pikr.addRelation(this.veId,isName,rel);
System.out.println("InfoItemRelation added: " + r);
}
} else {
if (output) {
System.out.println("RemoveInfoItemOutGoingIS:"
+ isName + "-" + rel.getName() + "#");
}
```

```
if (call) {
String r = pikr.removeInfoItemOutGoingInfoSet(
this.veId, rel.getName(), isName);
System.out.println("InfoItemRelation removed: "
                                    + r);
}
}
} catch (IncompatiblePropertyException e) {
e.printStackTrace();
return;
}
createdRelations.put(isName + rel.getName(), rel);
}
}

private void createBBIE(String isName, XSParticle child) {
// get the details from annotation element
Element annot = (Element) child.getAnnotation()
                                        .getAnnotation();

// get the name of the information entity
NodeList nl = annot.getElementsByTagNameNS(cctsNS,
                                          "PropertyTerm");
String name = nl.item(0).getTextContent();

// get the definition of the information entity
nl = annot.getElementsByTagNameNS(cctsNS, "Definition");
String defn = nl.item(0).getTextContent();

// get the cardinalities
String minCard = child.getMinOccurs().toString();
String maxCard = child.getMaxOccurs().toString();
```

```
nl = annot.getElementsByTagNameNS(cctsNS, "DataType");
String dataType = nl.item(0).getTextContent();
DatatypeCategory cat = Utils.lookupCategory(dataType);

InfoItemAttribute attr = null;
try {
if (maxCard.equals("-1")) {
maxCard = Constants.UNBOUNDED;
}

String attrName = removeSpaces(attrPrefix + name);
String ns = Utils.lookupNS(attrName);
String term = Utils.lookupTerm(attrName);

attr = new InfoItemAttribute(term, defn, cat, minCard,
                                              maxCard, ns);
} catch (IncompatibleValueException e) {
e.printStackTrace();
return;
}
if (!createdAttributes.containsKey(isName + attr.getName())) {
try {
PIKR_documents_DataFacadeImpl pikr =
                    PIKR_documents_DataFacadeImpl.getInstance();
// MyImpl pikr = MyImpl.getInstance();
if (isCreate) {
if (output) {
  System.out.println("AddAttribute:" + isName + "-"
    + attr.getNamespace() + "=" + attr.getName()
+ "=" + attr.getDescription() + "="
+ attr.getRange() + "=" + attr.getMinCard()
+ "=" + attr.getMaxCard() + "#");
}
```

```
if (call) {
  String att = pikr.addAttribute(veId, isName, attr);
  System.out.println("InfoItem added: " + att);
}
} else {
if (output) {
  System.out.println("RemoveInfoItem:" + veId + "-"
+ isName + "-" + attr.getName() + "#");
}
if (call) {
String att = pikr.removeInfoItem(veId, attr.getName());
System.out.println("InfoItem removed: " + att);
}
}
} catch (IncompatiblePropertyException e) {
e.printStackTrace();
return;
}
createdAttributes.put(isName + attr.getName(), attr);
}
}

private XSElementDecl getDocumentElement(XSSchema documentSchema) {
Iterator<XSElementDecl> elements =
                        documentSchema.iterateElementDecls();
while (elements.hasNext()) {
return ((XSElementDecl) elements.next());
}
return null;
}
}
```