Ontology-Driven Financial Regulatory Change Management: An Iterative Development Process.

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***Abstract*—Semantic technologies are claimed as a feasible solution to support many of the Financial Industry challenges, such as facing the constant regulatory changes across the countries. A first approach is to create international agreed ontologies for the financial business domain, and specifically in regulatory change management (RCM). In this scenario, to consider the financial business goals during the ontology development is key to define helpful ontologies, as well as to provide the methodologies and processes to develop the target ontologies. This paper describes the Financial Industry Regulatory Ontology (FIRO), and also the iterative process model used to develop it. This process stems in considering a complete life cycle, from the ontology design to the validation by the financial business side. At this step, this process is focused in supporting RCM.**

I. Introduction

There are fundamental challenges in terms of Governance, Risk and Compliance that the Financial Industry is facing nowadays. Challenges such as the task automation for the compliance levels verification in terms of regulatory legislation. This is the case, for instance, for Anti-Money Laundering (AML) legislation compliance, which nowadays is mainly manually pursued by the compliance officer in companies. In a global context, this concern becomes more important due to the increasing legislation volume from the regulators bodies that need to be considered for a company. For instance, regulations from The US Dodd-Frank Wall Street Reform and Consumer Protection Act, and the EU Single Supervisory Mechanism are some of them.

The research presented in this paper is in the framework of the Governance Risk and Compliance Technology Centre (GRCTC)[1]. The GRCTC's overriding objective is to build a portfolio of innovative, applied research projects, driven by semantic technologies, which collectively address the significant challenges facing the Financial Industry in terms of Governance, Risk and Compliance.

In this scenario, there is a growing realization in the financial industry that semantic technologies offer the most feasible solution to many of these challenges. Semantic knowledge bases along with process models will provide the technological foundation for facing the financial services issues. The focus of the research presented in this paper stems in defining an ambitious ontology set for financial regulatory legislation that is named FIRO (Financial Industry Regulatory Ontology). FIRO is developed following the protocols adopted by the Enterprise Data Management Council (EDMC)[2] for the FIBO (Financial Industry Business Ontology) ontology. FIRO is conceived as a ontology model composed by modules which are ontologies for a specific purpose in the regulatory domain. For this purpose, an iterative process has been adopted for developing FIRO. This process is considered in iterations, which comprises steps from the ontology design to the validation by the business side. This iterative process model is aligned with the JEOE process model in [3]. We have also conducted a proof of concept in the Regulatory Change Management (RCM), in order to test the validity of our semantic solution for supporting typical tasks during the compliance revision against official legislations. The first results show the feasibility for automating these tasks that now a days are manually performed by lawyers.

This paper is organized as follows: Section II describes the FIRO model, Section III describes the iterative development process for FIRO. A first proof of concept is presented in Section IV. Section V states the conclusions and the future work.

II. FIRO Model

The Financial Industry Regulatory Ontology (FIRO) is an ontology model composed of relevant and interlinked ontologies in the financial industry regulation domain. These interlinked ontologies are also called *modules*. FIRO captures regulatory imperatives and rules based on standards and official regulatory legislation into formal semantics, which is specified using the Description Logic-based ontology language: OWL-DL[4]. The main FIRO objective is to enable an efficient access to, and smarter consumption of, the wide and complex spectrum of financial services industry regulations. The FIRO ontologies are being defined according to main business goals and priority concerns in the financial industry. To this aim, the GRCTC Steering Board is taking a major role attracting key collaborators into the institute research.

FIRO is an evolving model mainly influenced by the constant financial regulation evolution, due to new laws or amendments are constantly appearing in this industrial sector. Thereafter, FIRO needs to also constantly incorporate the regulation legislation changes, by including new concepts or updating the existing ones, and then FIRO must be flexible enough to properly manage the changes. In this matter, we have decided to follow an iterative and incremental process for developing FIRO. Then, the FIRO ontologies are developed in

iterations, prioritizing the ontologies design according to the GRCTC Steering Board's goals in terms of supporting specific tasks in the Regulatory Change Management Process.

The FIRO model, at this development step, is composed by the following ontologies:

FIRO Module	Description
FIRO-H	This ontology describes the high-level concepts and their relationships, based on the financial industry regulatory initiatives. This includes concepts, such as Obligation, Prohibition, Exemption or Sanction.
FIRO-S	This ontology models the general structure of a parliamentary, legislative and judiciary document. For this purpose, the Akoma Ntoso Standard [5] is being used as the main source for defining this ontology. [1]
FIRO-[Domain]	This ontology describes the concepts and their relationships for domain-dependent regulations. Currently, FIRO-AML for the Anti-Money Laundering regulation is under development.
FIRO-Op[Purpose]	This ontology merges all the three previous ones, in order to support a particular purpose and task in the regulatory change management process.

TABLE I. FIRO MODULES

The FIRO ontologies are conceived (through an automated tool support): 1) to enable a compliance officer to identify regulations relevant to the company business; 2) to construct policies and controls based on those regulations; and 3) to assess internal compliance, all in a transparent and traceable manner. FIRO are conceived to constitute the backbone of the software systems capable of assisting the compliance officer in the aforementioned tasks.

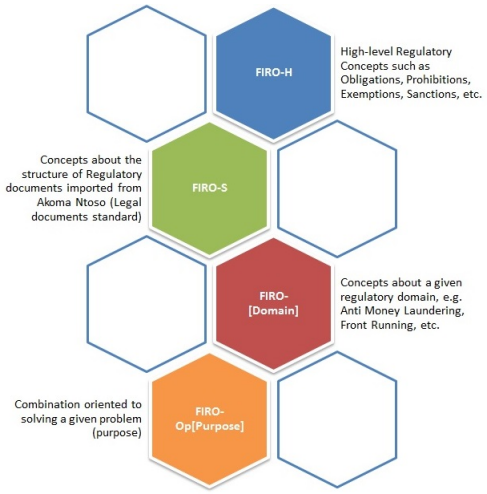

Fig. 1. Financial Industry Ontology (FIRO) Model

III. MODELING FIRO: AN ITERATIVE DEVELOPMENT PROCESS

The process for developing the FIRO ontologies follows an iterative and incremental approach. This process is aligned with the JEOE process model [3], in two main points: 1) by developing the ontology in iterations, and 2) by following the initiative of "*Just Enough*" in terms to consider for each iteration, the minimal knowledge, concepts and axioms for the ontology, according to the business requirements. For each iteration a FIRO ontology is selected to be designed, developed and tested. For these selected ontologies new axioms are defined and some existed ones are updated (incremental approach). The FIRO development tasks are performed working very closely with the Subject Matter Experts (SMEs), who provides the detailed requirements, regarding the financial legislations and legal terms.

The FIRO development process consists in three main activities: 1) To design and develop a semantic model for financial regulation, 2) To classify incoming legislation, and 3) To validate the purpose of the knowledge base. These activities encompasses an entire cycle for iteratively designing, developing and testing the FIRO's ontologies. In this process it is required that these three main activities must be completely done in the scope for each iteration, in order to close the FIRO development cycles.

The FIRO development process is detailed as follows:

1) **Design and Develop a Semantic Model for Financial Regulation (II)**:

Activity	Description
Candidate Terms and Relationships Extraction	a) The relevant high-level legal concepts identification by the SMEs are defined in the language SBVR (Semantics Of Business Vocabulary And Rules[2])[6], and kept in the FIRO requirements document. The process for identifying legal terms and to transform them into SBVR statements are described in [7]. b) The domain-dependent legislation is analyzed, and then determined the relevant terms by the SME. A secondary but also important objective in this task is to complete a detailed vocabulary for each of the domain regulations under study. Now a days a detailed vocabulary for Anti-Money Laundering is under development. c) The legal documents structure, based on Akoma Ntoso Standard [5] is also analyzed in this step, and the results are kept in the FIRO requirements document.
Ontology Development	a) In this task the ontology design decisions are made, based on the concepts and legislation rules that were identified in the previous step. Design decisions such as the corresponding axioms derived from the SBVR statements are then specified and introduced into the corresponding FIRO's ontology. At this moment, FIRO-H, FIRO-S and a FIRO-[Domain] (actually FIRO-AML: FIRO Anti-Money Laundering) are under development. The design decisions are kept in ontology design documents. b) The FIRO-Op[Purpose] ontology for supporting a specific Regulatory Change Management is developed at this step. The business GRCTC's goals drive the selected purpose for supporting the Regulatory Change Management. The approach is to merge the required FIRO ontologies to produce a new purpose-specific ontology that we called FIRO-Op[Purpose].

TABLE II. DESIGN AND DEVELOP A SEMANTIC MODEL FOR FINANCIAL REGULATION

2) **Classify Incoming Legislation (III)**:

3) **Validate the Purpose of the Knowledge Base (IV)**:

IV. PROOF OF CONCEPT

This proof of concept is focused on the Regulatory Change Management (RCM) in the Financial setting. Two specific legislations are analyzed for this proof of concept: UK Money

Activity	Description
Relevant Instance Data Extraction	a) The FIRO-H instances are then created based on the high-level concepts in the FIRO-H ontology. b) The FIRO-[Domain] instances are also created. For this purpose, specific legislation is analyzed in contrast to the FIRO modules in order to extract the current and proper information to populate FIRO-[Domain]. c) Current document structure is also identified and the proper FIRO-S instances are created. d) The FIRO-Op[Purpose] is then populated by adding the proper relationships between the FIRO-H, FIRO-S and FIRO-[Domain] instances, according to the task purpose at hand in the Regulatory Change Management process.

TABLE III. CLASSIFY INCOMING LEGISLATION

Activity	Description
Validation	a) Firstly, the consistency checking of the FIRO's ontologies is performed in this step. b) The data testing is also a fundamental task in order to properly validate the FIRO model, for effectively supporting the financial regulatory change management activities. In this matter, relevant and targeted queries are designed and run into FIRO-Op[Purpose]'s KB. c) Some software applications prototypes are also built in this activity, in order to test the FIRO feasibility for supporting information systems in an industrial setting.

TABLE IV. VALIDATE THE PURPOSE OF THE KNOWLEDGE BASE

Laundering Regulations 2007 and 2012 [8], [9] (Figure 2). The aim is to automate the compliance verification process from the recent UK Money Laundering Regulations 2012[9] regulation against the previous one. This revision is nowadays manually pursued by the compliance officer in companies, by literally reading the legislation to identify the law modifications in interest to the company. For this proof of concept four ontologies are selected to be developed: FIRO-H, FIRO-S, FIRO-AML (a FIRO-[Domain] ontology for Anti-Money Laundering) and FIRO-RCM (the specific FIRO-Op[Purpose] for *Regulatory Change Management*).

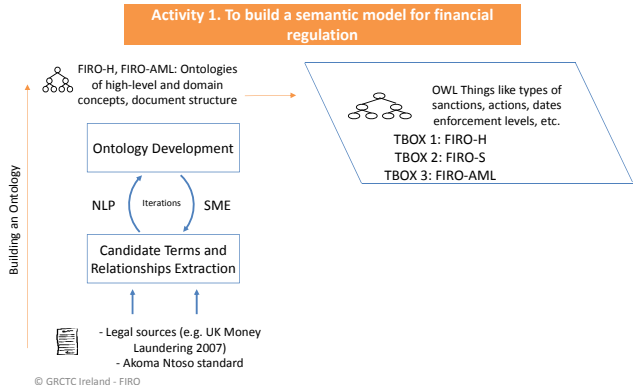

Fig. 2. The FIRO ontology concepts are based on: the FIRO-H's come from several legal sources, the FIRO-S's from the Akoman Ntoso standard[5], and the FIRO-AML's from the UK Money Laundering Regulations 2007 and 2013 [8], [9].

The iterative ontology development process described in

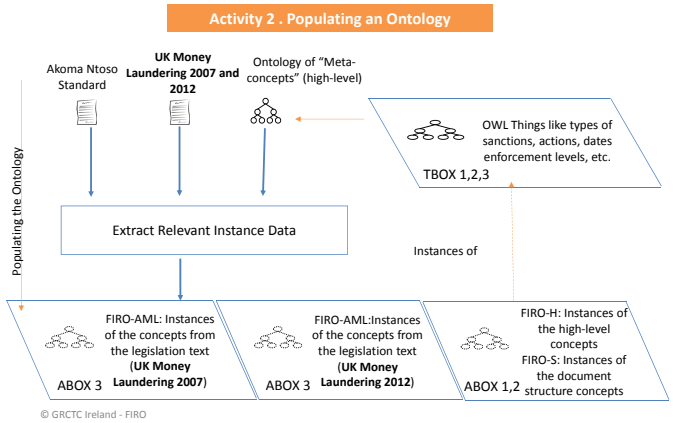

Fig. 3. Instances in FIRO-RCM: FIRO-AML's and FIRO-S's are based on the laws and structure of UK Money Laundering Regulations 2007 and 2012 [8], [9], and the FIRO-H's are defined according to the SME requirements.

Sect. III is then applied in this proof of concept, by following the same execution structure as follows:

1) **Designing and Developing a semantic model for financial regulation**: The SMEs have investigated reliable and agreed legal sources for specifying the terms (TBox), corresponding to the FIRO-H high-level concepts and for FIRO-AML. The FIRO-S terms (TBox) are defined by directly analyzing the Akoma Ntoso standard. Currently, there is an advanced version of the FIRO-H's, FIRO-S's and FIRO-AML's TBoxes. Figure 2 shows the FIRO development process' Activity 1, for this proof of concept.
2) **Classifying incoming legislation**: The SMEs have also analyzed the specific legislation in order to extract the proper data to populate the FIRO ontologies. At this moment, UK Money Laundering Regulations 2007 and 2012 [8], [9] have been analyzed and the corresponding instances (ABoxes) for FIRO-H, FIRO-AML, FIRO-S are then created in FIRO-RCM. Figure 3 shows the FIRO development process' Activity 2, for this proof of concept.
3) **Validating the Purpose of the Knowledge Base (KB)**: We have developed several SPARQL queries to test the KB for asking relevant questions in interest for the SMEs. The intention is to reveal an effective support for the changes revision process in the regulatory change management tasks. In this matter, the queries ask FIRO-RCM for key data that give information about the type of changes in the legislation at hand. Figure 4 shows some excerpts of these queries, as follows:
   a) List of Obligations or other Provision types in the UK Money Laundering Regulations 2007[8]. The aim is to identify if the legislation is bias to obligations, or prohibitions or possibilities (exemptions).
   b) Identify the Obligations in the corresponding physical sections in the UK Money Laundering Regulations 2007 document; as well as to identify the document structure (sections,

subsections, etc) to match the Provision type that each section contains. The aim is to physically locate where are provisions or obligations.

c) Identify particular Obligations types related to Provision types. The goal is to locate if the Obligations or Prohibitions belong to a Provision type such as laws for *Enhanced Due Diligence*, *Monitoring* or *Supervision*.

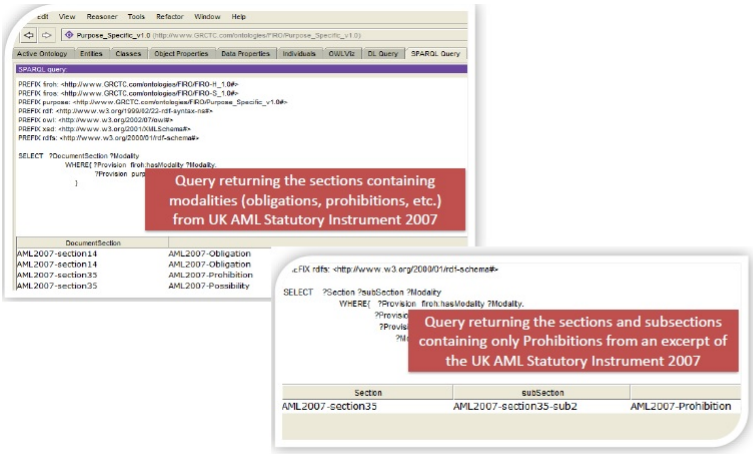

Fig. 4. FIRO-Op(AML): Queries showing the Provisions and Modalities located in the UK Money Laundering Regulations 2007 [8], as well as the sections and subsections.

V. Related Work

Some other approaches for ontology development process are present in literature. METHONTOLOGY enables the construction of ontologies at the knowledge level, and includes activities for the identification of the ontology development process, a life cycle based on evolving prototypes [10]. The On-To-Knowledge methodology proposes an incremental and cyclic ontology life cycle, based on evolving prototypes [11]. The DILIGENT methodology proposes an ontology life cycle model based on evolving prototypes [12]. All these methodologies proposes a prototype-driven ontology development in iteration, which is completely in line with our iterative process model proposes in this paper. NeOn (Networked Ontology Model) [13] proposes a life cycle model along with an extensive Glossary of Activities, the core of these are performed in our iterative process model, with different focus according to the iteration at hand (for space reasons are not detailed in this paper).

VI. Conclusions and Future Work

Semantic technologies are still emergent to support the financial business, however this is a powerful approach to provide intelligence to the information systems. Ontologies in OWL-DL[4] are being used around the world to define not only a semantic vocabulary but also to obtain implicit knowledge, by performing reasoning. In this paper, we have shown our approach to base on semantic technologies, the compliance verification for the regulatory change management process. For this purpose, we have presented the FIRO ontology model and the iterative development process to create it. In the proof of concept, we have shown the potential for using an expressed ontology in a formalization as the OWL-DL language, to get key information for those questions that nowadays the compliance officer manually responds, during the RCM process.

As future work, we are working on several research lines: 1) To improve the iterative development process for creating FIRO; 2) to investigate Natural Language Processing (NLP) methods for extracting the instances terms from the legal sources, during the FIRO population; 3) to complete a financial vocabulary and the corresponding FIRO modules; and 4) to develop the strategies to mine the FIRO information during the RCM automation process.

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