INFORMATION SYSTEM ENGINEERING FOR AN ELECTRICITY DISTRIBUTION COMPANY

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Abstract: Information Systems (IS) of electricity distribution companies are often composed of various and heterogeneous applications or systems that need to exchange information. Distribution activities evolve in different contexts and environments, and the interoperability is a particular difficult task to realize for electricity distribution companies. A laws-based IS engineering approach is proposed in our research laboratory. Given the distribution activities are regulated by a legal framework, we propose to apply this approach to the electricity distribution domain.

1 INTRODUCTION

The main business activities of electricity utilities are production, transport, distribution and consumption. Distribution activity consists of deliverying electricity to end users. The major business functions of electricity distribution contain activities that are responsible for the network, which are acting in a real-time environment that must interact with external activities of network operations like financial systems, maintenance systems, resource planning etc. Distribution networks generally include high-voltage, medium-voltage and low-voltage power lines. The distribution management domain covers business functions, software systems, physical equipment and staff concerned with the distribution of electrical power to consumers. Distribution management can be divided in two distinct sub-activities: on the one hand the electricity supply that is concerned with the purchase of electrical energy from bulk producers for sale to individual consumers, and on the other hand the electricity distribution that covers the management of the physical distribution network that connects the producers or consumers. Distribution activities are governed by a legal framework represented by a set of laws that regulate their execution.

Recently an innovative approach (Khadraoui, 2007) for Information System (IS) engineering based on laws ontology has been developed that allows extracting knowledge from laws, which is described by laws-based ontology, since the initial stage of IS development to discover informational concepts, rules and roles in the related IS. This approach helps systematic compliance of an IS to be developed with the laws as well as to align the IS with the laws evolution.

The objective of this paper is to present the work accomplished in a Genevan electricity company at SIG[1] (Industrials Services of Geneva) that aimed to apply the proposed approach for IS engineering in the context of an electricity distribution company. SIG is a public independent utility that ensures services distribution of proximity for all Geneva's population and is responsible for water, gas, electricity and heat-energy supply for the entire Geneva territory. This work focuses on the electricity distribution part.

An IS of an electricity distribution company is often composed of various, distributed software application systems which support the management of electrical distribution network. Therefore, the IS must be able to exchange information between these heterogeneous systems, generally provided by different vendors. The questions about IS integration

[1] http://www.sig-ge.ch

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are independent from the legal framework, but are more questions of IS efficiency. Furthermore IS helping distribution management at SIG must be compliant with the new law regulating the future open Swiss market of electricity called LApEl ("*Act about Electricity Supply*[2]") that will come into force on the 1st January 2008. An organism called AES ("*Association of Electricity Swiss companies*[3]") responsible for the good process of the liberalization of electricity market in Switzerland edited standards named "*Recommendations for the branch*" that aim at fulfilling the conditions of the future law; they describe concepts, roles, and rules related to various activities of an electricity distribution company and therefore contain main source of knowledge on which we can build the informational kernel of IS to support the electricity distribution activity. In other words, these recommendations are considered to be the semantic universe on which some parts of the IS kernel can be built.

The objective of this paper is to report the work done in SIG that consisted to apply the following proposed approach to the context of the electricity distribution domain. This paper is structured as follows. In the section 2 we introduce the framework of our approach for IS engineering. In the section 3 we briefly describe the legal sources we use to apply the proposed approach to the electricity distribution domain and we illustrate our work with a simple example. We end the paper with some conclusions.

2 LAWS-BASED ONTOLOGY FOR IS ENGINEERING

The proposed approach for IS engineering based on laws ontology aims to extract knowledge from legal sources in order to help compliance of the IS with the legislation in which is acting. The proposed approach for IS engineering is carried out according to a framework including four levels: the ontological level, the informational level, the activities domain level, the technical level. As we can see in figure 1, these four levels are independent but strongly linked to one another; none of these levels must be isolated and some conceptual interrelations must be taken into account.

The ontological level in which all the fundamental and stable concepts are listed, defined and positioned in function of the relations between them, corresponds to the starting point of the approach. Ontological models built with these concepts describe a specific domain; in our work the electricity distribution domain. Besides invariant concepts, some ontological roles and rules are identified in this level. An ontological role is defined as a particular organizational role[4] that is fundamental for the IS development. Business rules are used to help the organization to better achieve goals, communicate between principals and agents, between the organization and interested third parties, demonstrate fulfilment of legal obligations, operate more efficiently, perform analysis and current practices. Laws contain business rules. A part of these business rules will be expressed as integrity constraints[5] in the IS. Their role is to preserve the coherence, correctness and consistency of an IS during its exploitation.

The informational level is composed of the IS kernel that represents the base of the IS and of organizational layers that complete the IS kernel. The kernel is built directly from the ontology, translating the different concepts and relations between them in informational elements according to some directives. The informational level is specified with static, dynamic and regular aspects that will be expressed with integrity constraints. Specifying the IS kernel from the IS ontology is not sufficient to make the IS operational; the kernel that derived from the IS ontology still needs to be completed with organizational layers that are representing the specific aspects of a particular organization not described in the laws. The organizational aspects relate to the business rules, the business processes, the business activities and the organizational roles inside an organization. Applied to the electricity distribution domain organizational layers will describe the organizational aspects of the distribution activity.

The activities domain level allows describing how actors of an institution can work together and how they coordinate their activities. This level clarifies decisions and internal responsibilities of the institution. Elements describing the activities domain level are mainly business activities, business processes, and organizational roles.

[2] *« Loi sur l'Approvisionnement en Electricité »* means the law that will operate the Swiss electricity market.
[3] *« Association des entreprises Electriques Suisses »*

[4] WfMC defines an *organizational role* as list of attributes, of competencies, and know-how that an actor possesses and put into practice; and so it defines the position of an actor in an institution (Khadraoui, 2007).
[5] *Integrity constraints* are logical conditions defined over classes, verified by transactions or methods.

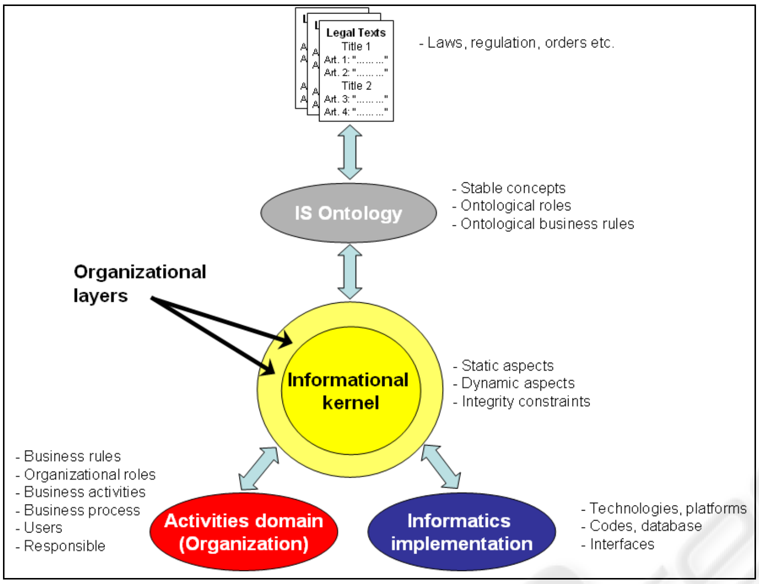


Figure 1: Framework for laws-based IS engineering (Khadraoui, 2007).

Finally the technical level aims to study the implementation of the concepts specified in the informational level. It is about choice of the technology, of informatics architecture and environment adequate for the deployment of the IS.

The next section describes how we apply the approach at the domain of electricity distribution and we demonstrate how the recommendations proposed by the AES can be considered as main source of knowledge for electricity distribution. We illustrate our words with a simple example that handles of the process to execute when a consumer chooses to change of energy provider.

3 STANDARDS “AES” AS MAIN SOURCE OF KNOWLEDGE

3.1 Documents Description

The Association of Electricity Swiss companies (AES) published a series of standards that provide means for all actors of the market to keep the right balance of electricity supply during and after the market opening of the electricity Swiss market and may constitute the legal framework on which the ontological level of IS engineering can be built. The recommendations of AES were edited in view of the electricity market opening in Switzerland and they represent the content of the future governing law. We can extract from these recommendations some stable and fundamental concepts. In addition, some ontological roles and business rules can also be identified and extracted from this document.

3.2 Illustration

3.2.1 Construction of a Part of the IS Ontology

We illustrate our approach with an example based on a simple process that handles the case of a change of energy provider. This process describes interactions produced between the different market actors when a consumer wants to change his energy provider. According to the description of this process given in the Standardized Exchange of Data document, when a consumer wants to change his electricity provider, he first has to conclude a contract with a new provider in agreement with the old one. As soon as all contractual conditions are fulfilled, the change demand can be sent to the Distribution Network Manager (DNM). The DNM receives the change demand and analyses it. Two kinds of decision can be taken by the DNM: either the demand is refused or the demand is accepted. The first decision stops the process here: the motive of the refusal is sent and the old contract remains active. In the other case, when the demand is accepted by the DNM, a notification of change is sent and the old contract (with the old provider) should be cancelled (inactive). The old provider can send the closing bill to the consumer, and the new supply can begin.

The example handles a small part of an IS of an electricity distribution company: it focuses only on the provider change demand for a consumer. Even in this process of provider change, we do not give an entire and exhaustive representation, because it is obvious that others concepts have to be taken into account in view to be a real and full example.

The ontology model is represented by an oriented graph where nodes are concepts and edges are links between concepts. A concept can be the generalization or specialization of another concept; this relationship is useful to classify concepts according to their common properties or specificities. A concept C_1 depends existentially on a concept C_2 if the existence of C_1 is related to the existence of C_2; if the concept C_2 disappears then the concept C_1 disappears too. In our model, a concept can be an instance of another concept. The instance, itself is considered as a concept.

In the ontology model, there is no distinction of static or dynamic concepts (e.g. static concepts correspond to objects whereas dynamic concepts correspond to object behaviours, processes in the real world). Ontology model has three types of links: (i) instantiations, (ii) existential dependencies and (iii) generalization/specialization links (Khadraoui, 2007).

Table 1: Provider change demand sending.

Recommendation fragment: *"The new provider sends to the DNM a change demand, immediately or maximum 10 business days before the beginning of supply. Consumer must have concluded a new supply contract with the new provider and agreed with the new and the old provider about contractual conditions of electricity supply."*
Concepts extracted: *Consumer, Provider, Supply contract, Beginning date of supply.*
Ontological roles: *Consumer, Provider, DNM*
Ontological business rules: *The provider change demand can only occur if a contract has previously been agreed with the new and the old provider.*

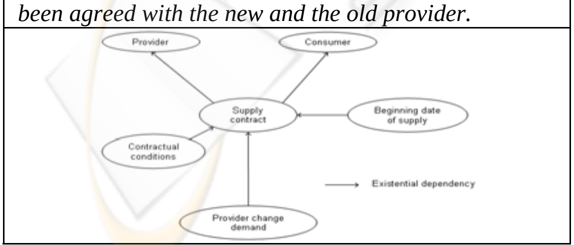


Table 2: Reception of the change demand.

Recommendation fragment: *"The DNM receives the change demand and will process it. The date of reception must be 10 business days before the beginning date of supply."*
Concepts extracted: *DNM, Provider change demand, Processing of provider change demand, Date of reception.*
Ontological roles: *DNM*
Ontological business rules: *The demand must be sent at least 10 business days before the beginning date of supply.*

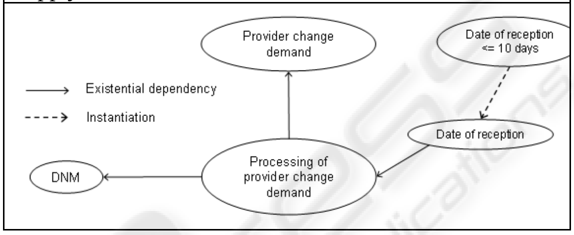


Table 3: Processing of the change demand.

Recommendation fragment: *"The DNM sends a confirmation or a refusal to the new provider immediately or maximum 5 business days after the date of reception and fixes a date of change. In case of refusal, the process has to stop and the old supply contract stays active. In case of acceptance, a final date of change must be fixed."*
Concepts extracted: *Decision, Provider change demand accepted, Provider change demand refused, Refusal motive, Date of change.*
Ontological roles: *DNM*
Ontological business rules: *The delay to send the decision by the DNM is 5 business days.*

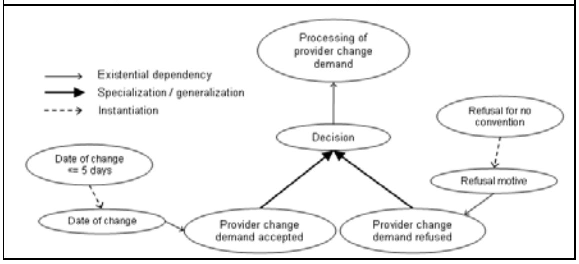
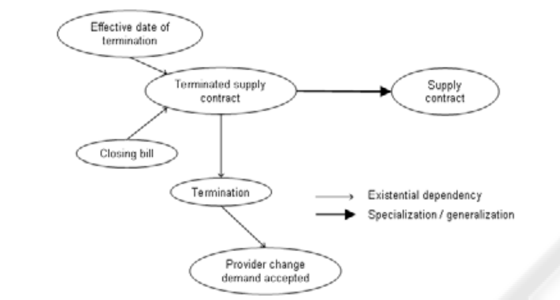


Table 4: Acceptation of the provider change demand and contract termination.

Recommendation fragment: *"When the change demand is accepted the old provider can send his closing bill to the consumer and an effective date of termination is established since when the new provider can supply the consumer. The closing bill can only be sent if the provider change demand has been accepted by the DNM and all the data's have been sent to all related actors."*
Concepts extracted: *Termination, Closing bill, terminated supply contract, Effective date of termination.*
Ontological roles: *DNM, Old energy provider, New energy provider, Consumer.*
Ontological business rules: *The old provider can send his closing bill only if his supply contract has been correctly terminated.*


The entire model of the change of energy provider is represented below. This kind of model corresponds to the ontological level from which we build the IS kernel and expresses all the concepts related to a change of provider.

As we notice here all the concepts have the same importance on an ontological model; the static, dynamic and integrity constraints aspects are not taken in account at this level. This kind of model cannot be directly implemented; it needs first to be translated into an information model that regroups all derived models from the IS ontology.

3.2.2 Construction of a Part of the Informational Kernel

A set of derivation rules is applied in order to pass from the ontological level to the informational level. These directives are described through some cases considering. These guidelines are described in (Khadraoui, 2007). If we apply those directives, we can have these results. The concepts *"Consumer"* and *"Provider"* become two classes from which a class *"Supply contract"* is existentially dependant while the two concepts '*Beginning date of supply*' and *"Contractual conditions"* are both translated into attributes of the class *"Supply contract"*. The concept *"Processing of provider change demand"* is translated in a transaction that will have an input class *"Provider change demand"* and will create an output class *"Decision"*. Concepts that are instantiations of other concepts are generally translated in value of attributes of the class. The concept *"Date of reception"* becomes for example an attribute of the class *"Provider change demand"*.

We developed an integrated model in (Turki 2005), (Pham Thi, 2005) and (Pham Thi, 2007) to integrate static and dynamic aspects into only one model. This integrated model is a bipartite graph where one kind of nodes correspond to classes and another kind of nodes corresponds to transactions.

The IS kernel can be completed with organizational aspects not described in laws. For this purpose a methodology is defined in (Khadraoui, 2007).

The aim is to support the identification of: (i) the activities that should be supported by IS; (ii) the existing business processes and transactions in which several actors (organizational actors, departments, authorities) are involved; (iii) the activities and processes that should be reorganized, transformed or created due to the IS development; (iv) the organizational roles; (v) the business rules, not described in laws, embedded into work practices.

4 CONCLUSIONS

During the work at SIG we first considered IEC (International Electrotechnical Commission)[6] norm which aims to facilitate inter-application integration and defines interfaces for the major elements of interfaces architecture of a distribution management system. The difficulties we encountered with the IEC standards came essentially from the specificity of the used terms. The complex structure of these standards represented an additional complication in order to apply the proposed approach.

After that we oriented our research on the national standards elaborated by the AES and our results were more relevant; we assume that we can apply the proposed approach to the electricity distribution domain using the AES recommendations as legal sources from which we build the IS ontology and from which some parts of the IS kernel can be built.

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[6] http://www.iec.ch/

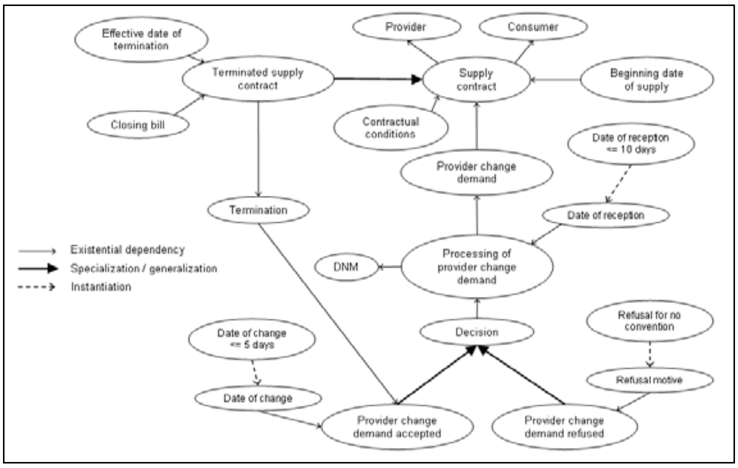

Figure 2: Conceptual model of the provider change demand.

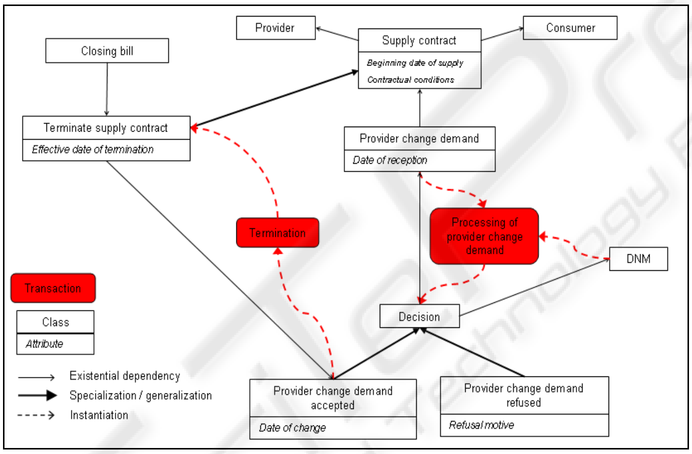

Figure 3: Part of the IS kernel related to the provider change demand.

We demonstrate it with a simple example and we build the ontological model of a process used in the case of change of energy provider.

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