Especifying the Enterprise and Information Viewpoints for a Corporate Spatial Data Infrastructure using ICA's Formal Model

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Abstract: The International Cartographic Association (ICA) has proposed a formal model to describe Spatial Data Infrastructure (SDI) using three of the five viewpoints of the RM-ODP (Reference Model for Open Distributed Processing) framework, which was later adapted by other researchers. However, the adapted ICA model has not been validated for corporate-level SDI. The *Companhia Energética de Minas Gerais* (Minas Gerais Power Company - Cemig) seeks to develop an SDI to aid in discovering and reutilizing spatial data within and outside the corporation. The present study aimed to assess the use of the model proposed by the ICA to specify corporate-level SDI using SDI-Cemig as a case study by describing the viewpoints Enterprise and Information. These viewpoints from the adapted ICA model have proved appropriate to describe SDI-Cemig, whose differences are due to the SDI's peculiarities. Although a single study cannot validate the ICA model for a whole SDI level, this research shows that the adapted ICA model can be used to describe the viewpoints Enterprise and Information in corporate SDI.

1 INTRODUCTION

Geospatial data are those referenced in relation to the ground surface and are essential to aid in an organization's decision-making and planning. However, according to Nebert (2004) and Rajabifard and Williamson (2001), geospatial data are a costly resource both in time and money involved in surveying them. In order to cut down the costs associated with using and obtaining geospatial data, the Spatial Data Infrastructure (SDI) concept was created.

There are several definitions for SDI. Rajabifard and Williamson (2001) define SDI as an environment in which the users reach their goals by using technologies and collaboration. Harvey et al. (2012) consider the SDI a concept that aids in sharing data and geospatial services among different users of a given community.

In order to help share and discover geospatial data and services, the SDIs are organized hierarchically. Figure 1 presents the SDI hierarchy and the nomenclatures used in the present study.

According to Hjelmager et al. (2008), the SDI concept is very broad and leads to different forms of development both at the organizational and technical level, as pointed out by Cooper et al. (2013). Thus, the International Cartographic Association (ICA) has developed a model to describe SDI regardless of the technologies or implementations (Hjelmager et al., 2008), a concept that was later extended by Cooper et al. (2011); Béjar et al. (2012); Cooper et al. (2013); and Oliveira and Lisboa-Filho (2015).

However, the use of ICA's formal model for SDI has not been evaluated to develop corporate-level SDI yet. The *Companhia Energética de Minas Gerais* (Cemig) is a mixed-economy company acting in the electricity sector composed of over 200 partners and controlled by the government of the

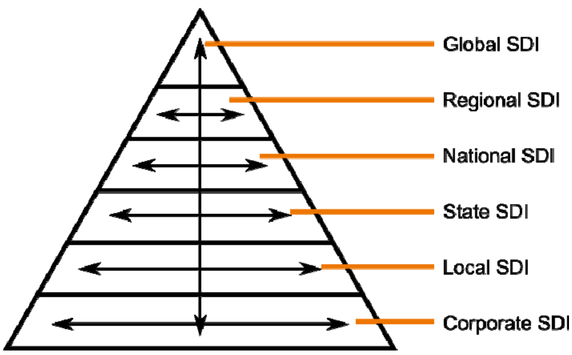

Figure 1: SDI hierarchy – Adapted from Rajabifard and Williamson (2001) and Crompvoet (2001).

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state of Minas Gerais (Brazil). Cemig seeks to develop an SDI, named SDI-Cemig, to standardize the processes that use the company's geospatial data, thus helping such data be shared and surveyed.

The present study presents the use of ICA's formal SDI model under SDI-Cemig's specification while detailing the viewpoints Enterprise and Information and verifying whether this model allows a corporate SDI to be appropriately described.

The remaining of the paper is structured as follows. Section 2 describes ICA's formal SDI model, detailing the viewpoints Enterprise and Information of an SDI. Section 3 presents the specification of the viewpoints Enterprise and Information for SDI-Cemig. Section 4 discusses the results found in the present research, while Section 5 presents some final considerations of the study.

2 ICA'S FORMAL MODEL

According to Hjelmager et al. (2008), ICA's formal SDI model (henceforth called only formal model) is a model that describes SDI regardless of technologies, policies, or implementations. In order to describe SDI, the ICA chose to use the RM-ODP (Reference Model for Open Distributed Processing) framework.

RM-ODP is an architectural framework standardized by the International Organization for Standardization/International Electrotechnical Commission (ISO/IEC) that is able to describe heterogeneous distributed processing systems by using viewpoints (Farooqui et al., 1995).

According to Raymond (1995), the use of the viewpoint concept allows describing complex distributed systems as smaller models, each of which describes different relevant issues to different users of the system. RM-ODP uses the following viewpoints: Enterprise, Information, Computation, Engineering, and Technology. Figure 2 presents the five viewpoints and the relationship among them.

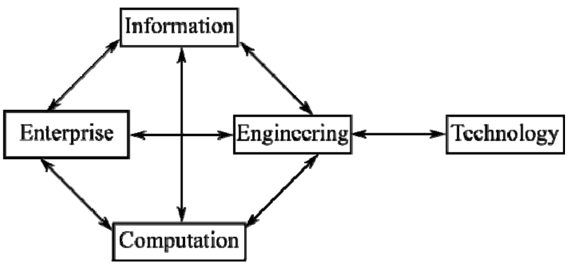

Figure 2: RM-ODP framework viewpoints – Adapted from Hjelmager et al. (2008).

The viewpoint Enterprise describes the system's policies, scope, goal, and requirements for the organization. The viewpoint Information details the data semantics and the behavior in the system, whose behavior will be restricted/determined by the policies defined in the viewpoint Enterprise (Farooqui, Logrippo and de Meer, 1995) (Hjelmager et al., 2008). According to Cooper et al. (2013), the viewpoint Computation describes the components that make up the system and their interactions through the interface with no concern about the components' physical distribution. The viewpoint Engineering, according to Farooqui, Logrippo and de Meer (1995), "identifies the requirements and features needed for the system to support the model described in the viewpoint Computation." Finally, the viewpoint Technology details the technological devices used by the system.

ICA's formal model describes only the viewpoints Enterprise, Information, and Computation. According to Hjelmager et al. (2008), the viewpoints Engineering and Technology heavily depend on the implementation and are not considered in ICA's model. The viewpoints Enterprise and Information will be described in the sub-sections below. The viewpoint Computation will not be described since it is not relevant for this study.

2.1 Enterprise Viewpoint

The viewpoint Enterprise, according to Hjelmager et al. (2008), describes the actors and the relation among the different parts of the system.

Figure 3 shows the relationship among the different compounds that make up the SDI through a diagram of UML classes. In the diagram, the SDI is the central compound and its attributes are the scope and a plan for its implementation. An SDI is formed by products, which are in turn formed by geospatial data and services from the SDI. The acquisition and use of these products is the reason why a user will use the SDI. Hence, the *Product* can be considered the core part of the SDI (Hjelmager et al., 2008).

The *Metadata* will describe and be used by the *Product*, and will be managed by the *Processing Tools* to aid in the discovery and use of geospatial data and services. The component *Processing Tools* represents the systems that carry out some sort of geospatial data processing and will connect to the SDI through the component *Connectivity*, which will use a certain *Technology* to perform its role.

According to Hjelmager et al. (2008), the component *Policies* is responsible for defining the

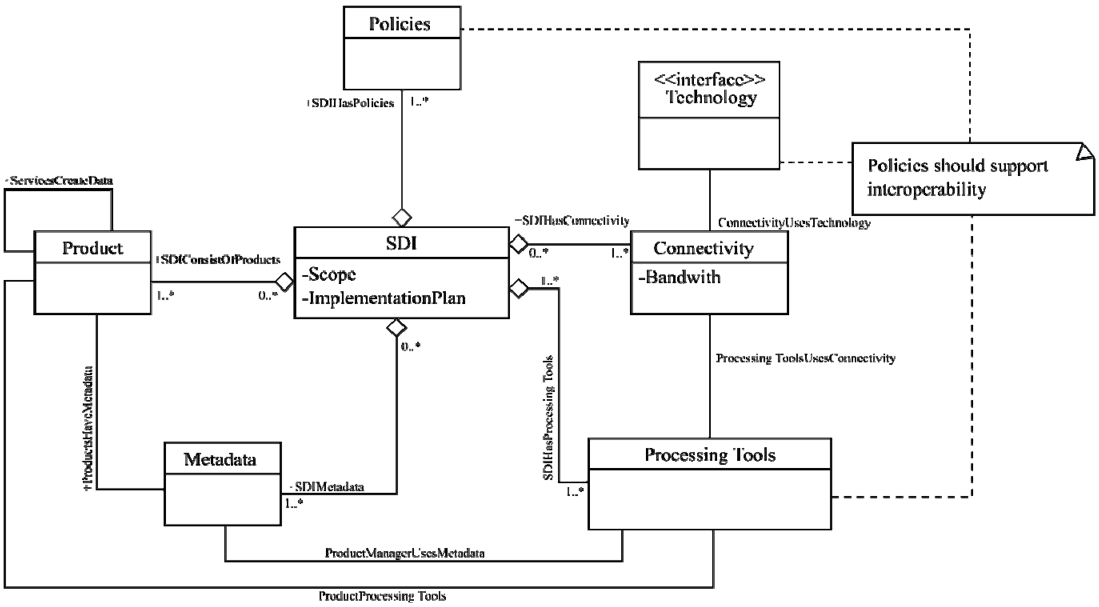

Figure 3: Components that make up an SDI – Hjelmager et al. (2008).

policies that will restrict and determine the SDI's functioning and evolution. Although this component is represented by a single class, the component *Policies* may be specialized into several other classes, which will be shown ahead.

The actors are individuals with a stake on the SDI's success and may use it or contribute to it. Hjelmager et al. (2008) defined five main actors for the SDI, which were expanded by Cooper et al. (2011) and Béjar et al. (2012). However, there are differences in semantics and terminology between the actors by Hjelmager et al. (2008) and Cooper et al. (2001) and those proposed by Béjar et al. (2012). This same characteristic holds true regarding the SDI's policies.

Oliveira and Lisboa-Filho (2015) unified the actors and policies proposed by the ICA with those proposed by Béjar et al. (2012). This way, the designers that may use ICA's model will have a single set of possible actors and policies, which facilitates communication and knowledge exchange among designers.

Figure 4 presents the six main actors an SDI may have: *User*; *Producer*; *Operational Body*; *Governing Body*; *Broker*; *Value-Added Reseller*; and *Provider*.

According to Oliveira and Lisboa-Filho (2015), the *User* is the actor that will use the resources offered by the SDI to reach his or her goals. The *Producer* is responsible for producing the SDI's data and services while the *Provider* makes these data and services available. The *Governing Body* is responsible for the SDI's administration and its attributions include creating, changing, and removing policies. The *Broker*'s role is to aid in the negotiations between providers and users. The *Value-Added Reseller* (VAR) modifies an existing product and makes it available in the SDI as a new product. Finally, the *Operational Body* is responsible for all the technical side of the SDI's functioning. All actors are specialized to describe their attributions in more details. The specializations can be found in Oliveira and Lisboa-Filho (2015).

Table 1 presents the policies unified by Oliveira and Lisboa-Filho (2015). The policies were specialized into: *Business Model*, *Promotion*, *Standards*, *Education*, and *Constraints*. The descriptions and specializations of each type are shown in Table 1.

2.2 Viewpoint Information

According to Hjelmager et al. (2008), the viewpoint Information in the RM-ODP framework describes the system data, from their semantics to their behavior, which are regulated by the policies defined in the viewpoint Enterprise. In the case of an SDI, Hjelmager et al. (2008) consider as data the products offered by the SDI, i.e., the geospatial data and services.

Figure 5 describes the relationship of the products with the other SDI components using the UML class diagram. The class *Product*, for being the most relevant object in the viewpoint Information, is the center of the diagram. The class

Table 1: SDI policies after the unification – Oliveira and Lisboa-Filho (2015).

Policies		Description
Business Model	Governance	Determines the decision-making process
		Regulates the policy-creation process
	Membership	Determines the relationships among the SDI members
	Quality	Defines the quality levels established in the SDI
	Access	Determines how the SDI products can be accessed and who can do it
	Role Assignment	Defines the responsibilities (actor roles) of the SDI users
	Funding	Defines how the resources will be forwarded to develop and maintain the SDI
Promotion	-	How the SDI will be advertised
Standards	-	Defines the standards adopted by the SDI
	Foundation	Defines the main SDI products
Education	-	Determines the trainings the SDI users may take part in
	Best Practices	Practices that must be adopted by the users member of the SDI
Constraints	Legal Constraints	Restrictions imposed by local laws of where the SDI is located
	Business Agreements	Restrictions existing due to contract between companies

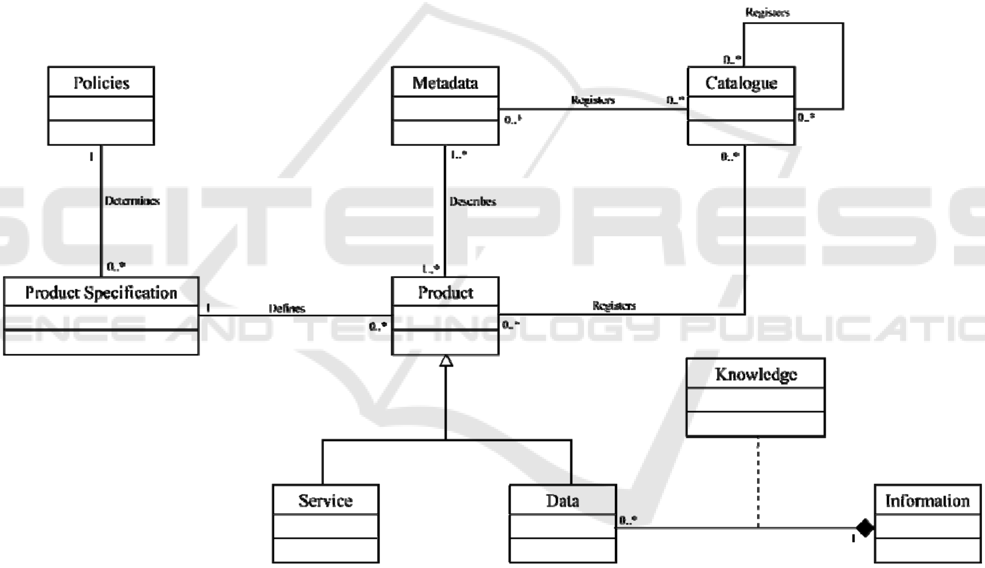

Figure 5: Class diagram for the viewpoint information – Hjelmager et al. (2008).

Policies represents the policies defined in the viewpoint Enterprise, which will restrict and target the product specifications, which are represented by the class *Product Specification* (Hjelmager et al., 2008).

The *Products* are described by the metadata (class *Metadata*) and both are recorded in catalogs (class *Catalog*), which may contain other catalogs to allow for a hierarchy to be created. The products can be classified into ervices and data (either geospatial or not). The data are used, aided by previous knowledge, as a source of information, which may generate new knowledge (Hjelmager et al., 2008).

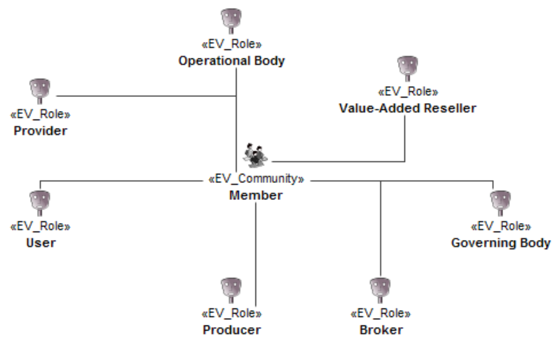

Figure 4: Main actors of an SDI after the unification – Oliveira and Lisboa-Filho (2015).

3 SDI-CEMIG

As specified in Section 1, Cemig seeks to develop an SDI to help share and use geospatial data in the companies that make up the conglomerate. The model adapted from the ICA was used to specify the SDI-Cemig so as to guarantee that the basic SDI concepts in the literature would be contemplated during the specification phase. The sub-sections below describe the viewpoints Enterprise and Information of SDI-Cemig.

3.1 Viewpoint Enterprise

As described in sub-section 2.1, the ICA has described the parts that make up the SDI and the possible actors that may interact with it. The components and actors were identified in SDI-Cemig to check whether they properly describe corporate SDI.

3.1.1 Components of SDI-Cemig

The SDI is considered the central element in Figure 3 and has a scope and implementation plan (Hjelmager et al., 2008). The scope of SDI-Cemig is to make available online a set of geospatial layers considered essential to the companies in the electric sector and that may be used by Cemig's employees and clients, besides offering services to visualize and discover geospatial data. The implementation plan of SDI-Cemig will be publicized by the end of the SDI's development.

The component *Product* is made up of the SDI's geospatial data and services. SDI-Cemig has the data of the geospatial layers considered basic for Cemig, i.e., they are essential layers to the working of the processes that involve geospatial data and are described by the *Foundation* policies and detailed in the conceptual model in sub-section 3.2.1.

SDI-Cemig must provide services for the discovery, visualization, and recovery of geospatial data, which must be compatible with the OGC standards. The use of services based on the OGC standards allows SDI-Cemig to interact with other SDIs at different levels, such as the INDE (*Infraestrutura Nacional de Dados Espaciais* – National Spatial Data Infrastructure), the INSPIRE (Infrastructure for Spatial Information in the European Community), and the CGDI (Canadian Geospatial Data Infrastructure). For a new service to be considered compatible with the OGC standard, its operations must follow the specifications proposed in the documents provided by the OGC.

Although Figure 3 shows that the component *Product* is self-related, since a service may generate new data, SDI-Cemig has no processing service able to produce new geospatial data at first.

The SDI products will be described by *Metadata*, which are specified according to the *Metadata Geospatial do Brasil* (Geospatial Metadata of Brazil - MGB) profile (CONCAR, 2009). The MGB profile defines the elements existing in the metadata that describe the geospatial data to be introduced into the INDE.

The metadata may be used by the *Processing Tools* to help discover new geospatial data and services and to obtain relevant information on them, e.g., which features are offered by the services and in which format the geospatial data is being made available. In SDI-Cemig, the *Processing Tools* are the legacy systems and desktop applications that use the SDI's geospatial data and services. Cemig has several applications and legacy systems to process geospatial data that are very important in the company's processes.

The component *Connectivity* specifies how the *Processing Tools* interact with the SDI, which is possible by using a *Technology*. Cemig's legacy systems and desktop applications interact with SDI-Cemig by exchanging files in the XML format using the GML standard as schema. Besides using files, the desktop applications can interact with SDI-Cemig through web services in case they are supported.

SDI-Cemig specifies at least one policy for each type present in Table 1, except for *Governance* and *Business Agreements*, which have no policy defined yet. The policies will not be presented due to space constraints. However, some policies will be pointed out along the text.

3.1.2 Communities and Roles in SDI-Cemig

Besides the components in SDI-Cemig, the viewpoint Enterprise specifies the communities that make up the SDI and the possible roles they may play to reach their goals.

A community is a concept of RM-ODP and is a set of one or more entities that have similar behavior and seek to reach a given common goal (Linington et al., 2011). The behavior the communities may take on are described through roles to facilitate them being reused. In the case of SDI-Cemig, the possible roles the communities may take on were described by Hjelmager et al. (2008), Cooper et al. (2011), and Béjar et al. (2012), were adapted and unified by Oliveira and Lisboa-Filho (2015), and are used to specify the communities.

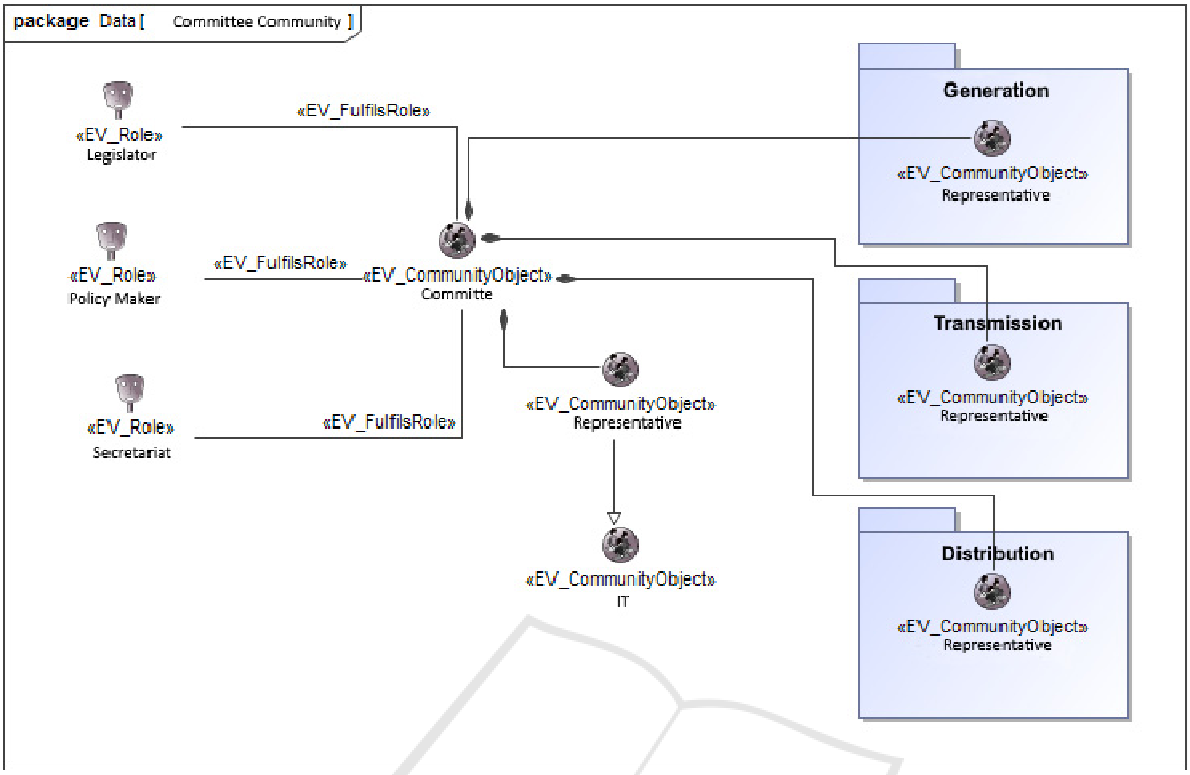

Figure 6: Community Committee and its respective roles.

According to Linington et al. (2011), a community is specified by the roles it can take on, its possible behaviors, the enterprise objects it uses, and the goal it must reach. This sub-section, however, details only the roles they may take on and whether these roles match the roles unified by Oliveira and Lisboa-Filho (2015).

Figures 6, 7, 8, and 9 present the communities identified in Cemig's environment and the roles they may take on when interacting with SDI-Cemig. In Figure 6, the community *Committee* is formed by members of different sectors at Cemig, represented by the communities *Representative*, such as *Information Technology (IT)* and the sectors *Generation*, *Transmission*, and *Distribution*, and its attribution is to define the working of certain processes carried out by these sectors. Hence, the *Committee* takes on the roles of *Legislator*, *Secretariat*, and *Policy Maker* and is responsible for all of SDI-Cemig's administrative area.

The community *GIS Analyst* (Figure 7) represents the IT individuals with positions homonymous to the community, who are responsible for carrying out and analyzing the procedures performed in a Geographic Information System (GIS) to manipulate geospatial data.

As shown in Figure 7, the *Geoprocessing Analyst* may take on the roles of *Data/Service Distributor*, *Data and Metadata Aggregator/Integrator*, and *Négociant*. The community is responsible for providing the geospatial data and services produced by the *Producers* in SDI-Cemig.

The community is also responsible for purchasing the geospatial data the users require, then acting as a *Négociant*. Finally, the *Geoprocessing Analyst*, when carrying out procedures on the geospatial data in a GIS, is able to generate new geospatial data or to expand existing data, thus taking on the role of *Data and Metadata Aggregator/Integrator*. Moreover, the *IT* will be in charge of creating and maintaining the catalogs of data and services made available by SDI-Cemig by using user-produced metadata.

Cemig has several sectors that act in the processes of electric energy generation, transmission, and distribution. The generation process consists in the generation of electricity through power plants and Cemig has hydroelectric, thermal, wind, and solar plants. Transmission consists in a network that carries the energy produced by the power plants to the large consuming centers. Finally, distribution is the network that serves energy to small- and medium-sized companies and to residential consumers (Leão, 2009).

The generation, transmission, and distribution groups are represented in Figure 8 by packages comprising all the sectors related to each group. Since there is a large number of sectors related to each group, they are represented by the communities *Generation*, *Transmission*, and *Distribution*. Besides these communities, each group has a G*eospatial Data Manager* and a *Representative*.

Each group has its *Spatial Data Manager* community, which is responsible for guaranteeing data consistency for each group, hence it takes on the role of *Database Administrator*. However, it must be pointed out that Cemig has a position called Database Administrator, although its role is different from the one defined by Cooper et al. (2011). At Cemig, the position Database Administrator is in charge of guaranteeing that the database and the hardware supporting it are in order.

The community *Representative* is a generic community used to illustrate the individuals that represent the interests of each group in the community *Committee*. Finally, each group has a homonymous community (*Generation*, *Transmission*, and *Distribution*) that represents the different sectors at Cemig that work directly or indirectly with the data of that group. The communities *Generation*, *Transmission*, and *Distribution* are considered *Official Production Agencies* since they are the main data producers in SDI-Cemig and since their sectors belong to Cemig. These communities are also responsible for publicizing the data they produce in the SDI, thus taking on the role of *A Producer that is its own Data/Service Provider*.

SDI-Cemig interacts with other communities besides those within Cemig itself by interacting with other SDIs and organizations, as shown in Figure 9. The community of the *Instituto Brasileiro de Geografia e Estatística* (Brazilian Institute of Geography and Statistics - IBGE) is the federal public organ that produces nationwide geospatial data, besides being responsible for defining the standards to be used by the other geospatial-data-producing organizations, thus taking on the role of *Producer*. The data produced by the *IBGE* are publicized through the INDE. SDI-Cemig interacts with the *INDE* and recovers the data available through web services, which makes the *INDE* a *Provider* of SDI-Cemig.

Besides the *INDE*, SDI-Cemig will obtain and publicize information to the *Sistema de Informações Geográficas do Setor Elétrico* (Geographic Information System of the Power Sector - SIGEL) belonging to the *Agência Nacional de Energia Elétrica* (National Electric Energy Agency - ANEEL). *ANEEL* is responsible for regulating and overseeing the Brazilian electric energy market to guarantee that the companies working in the country follow the regulations in effect. The *SIGEL* is a system that allows the visualization and obtention of some geospatial data made available by the utility companies to *ANEEL*. Therefore, *ANEEL* takes on the role of *User* in SDI-Cemig by recovering the

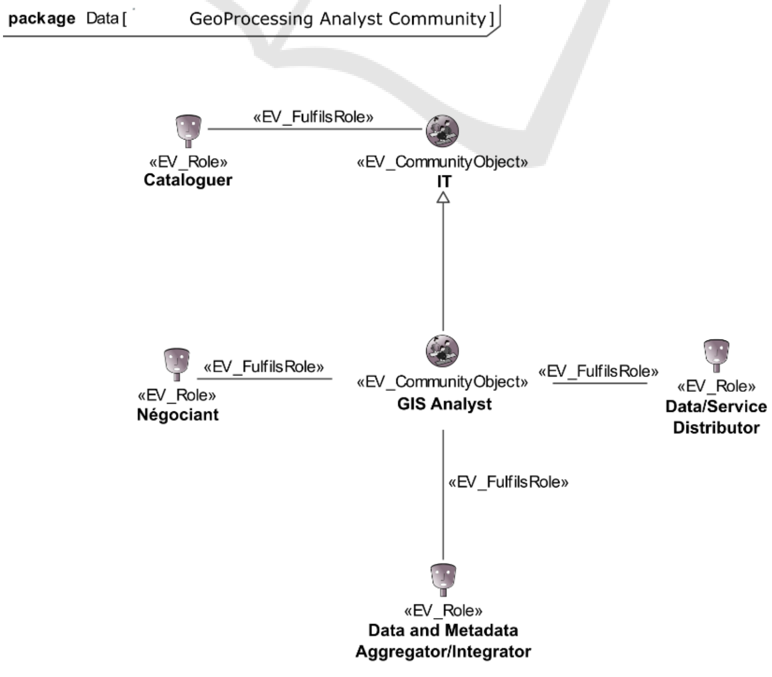

Figure 7: Geoprocesing Analyst Community and its respective roles.

data through the GeoPortal or through web services, while the *SIGEL* takes on the role of *Data Provider* by making available to SDI-Cemig the data provided to *ANEEL* by the other utility companies.

3.2 Viewpoint Information

As well as in the viewpoint Enterprise, the components defined by Hjelmager et al. (2008) for the viewpoint Information, shown in Figure 5 in sub-section 2.2, are identified in SDI-Cemig.

According to Linington et al. (2011), the viewpoint Information is responsible for "modeling the shared information that is handled by the system." Therefore, the invariant scheme of the geospatial database used in SDI-Cemig is modeled. The dynamic and static schemes are not modeled because SDI-Cemig, having only geospatial data, contains little or no dynamically generated data due to an action. When geospatial data are represented in alphanumeric format, comparing them to the original data to check whether the representation is consistent becomes difficult.

According to Hjelmager et al. (2008), the model presented in Figure 5 begins with the component Policies, which defines the basic geospatial data (layers) the SDI must have, besides allowing the link with the viewpoint Enterprise. The basic data SDI-Cemig has are described in the policies *Foundation*. It must be pointed out that much of the data in SDI-Cemig are related to the electricity generation, transmission, and distribution.

The members of SDI-Cemig may request new products (data and services) by opening a ticket with Cemig's helpdesk, being limited by the policies. Such tickets are considered the products' specifications (component *Product Specification*).

The Products are described by *Metadata*, which allows the users to assess whether the product meets their needs, besides facilitating searching for them. According to the policy *Legal Constraints* "*Adoção do Decreto de Lei Nº 6.666 – Uso do perfil MGB para a documentação de metadados geoespaciais produzidos em território nacional,*" the products in SDI-Cemig will be described using metadata documented following the specification of the MGB profile (CONCAR, 2009).

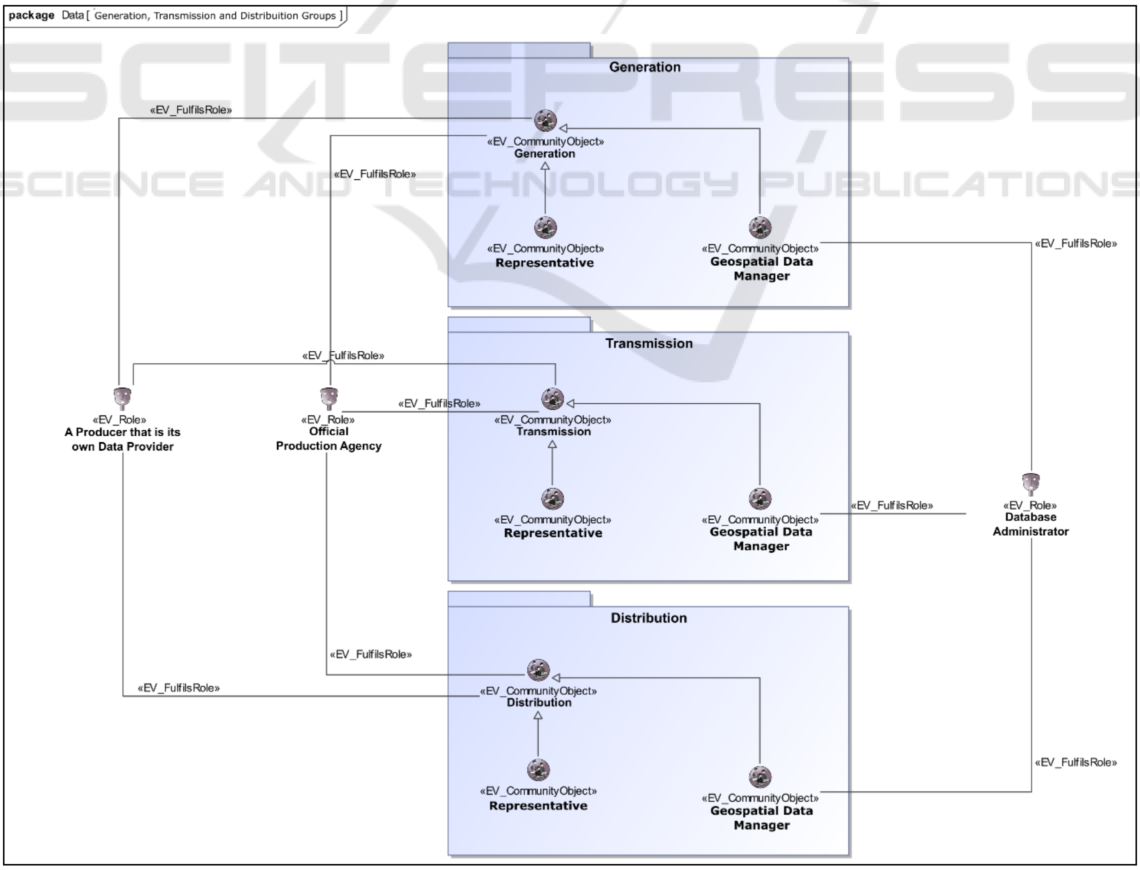

Figure 8: Groups Generation, Transmission, and Distribution with their respective communities and roles.

Both *Metadata* and *Products* will be recorded in a *Catalog* to aid in their discovery. The catalogs will be created according to the topics of the geospatial data offered by SDI-Cemig such as hydrography, generation, transmission, distribution, infrastructure, etc. According to the model in Figure 5, the data generate information based on pre-established knowledge. In SDI-Cemig, the data are used to generate information used by the different sectors at Cemig through reports and maps. Such information is generated based on the knowledge of employees specialized in geoprocessing, usually Geoprocessing Analysts.

3.2.1 Conceptual Database Modeling

According to Béjar et al. (2012), the policies of the type Foundation define the basic data and services the SDI must have. However, only the database description is not able to show the relationship among the data or how they will behave in the system, which is one of the goals the viewpoint Information aims to represent.

Figure 10 presents the conceptual scheme of the database adopted by SDI-Cemig. Due to space constraints, only the layers related to electricity generation, transmission, and distribution will be represented.

The UML class diagram extended with geographical and topological builders of the OMT-G (Borges, Davis Jr. and Laender, 2001) was used to create the scheme.

The package Distribution Grid has layers related to Cemig's regional distribution grid and layers that help manage this grid. The layer *Malha_Regional_Distribuicao* represents the limit of the distribution areas, which contain a headquarters (*Malha_Regional_Sede*) inside them. The business units (*Unidades_Negocio*) are areas defined according to the type of business Cemig intends to establish in a given region, which aids in planning and in the decision-making process. As well as the regional grid, the business units have a headquarters (*Unidades-Negocio_Sede*).

The area where Cemig can work in the state of Minas Gerais, negotiated with the state's government, is represented by the class *Areas_Concessao_Distribuicao*, while the class *Local_Cemig_Concessao* represents the area where Cemig is currently working. To help in the decision-making process, Cemig has divided the state of Minas Gerais into several regions called transmission regions (*Regionais_Transmissao*). As well as the distribution grid, the transmission regions are divided according to criteria that meet the company's business rules.

The packages Generation, Transmission, and Distribution contain the classes that represent the elements that make up the electric grid administered by Cemig. Cemig's electric grid nodes comprise structures, namely *Estruturas_LT* for *Generation*, *Estrutura_LT_230-500* for *Transmission*, and *Estrutura_LT_34-161* for *Distribution*. The classes

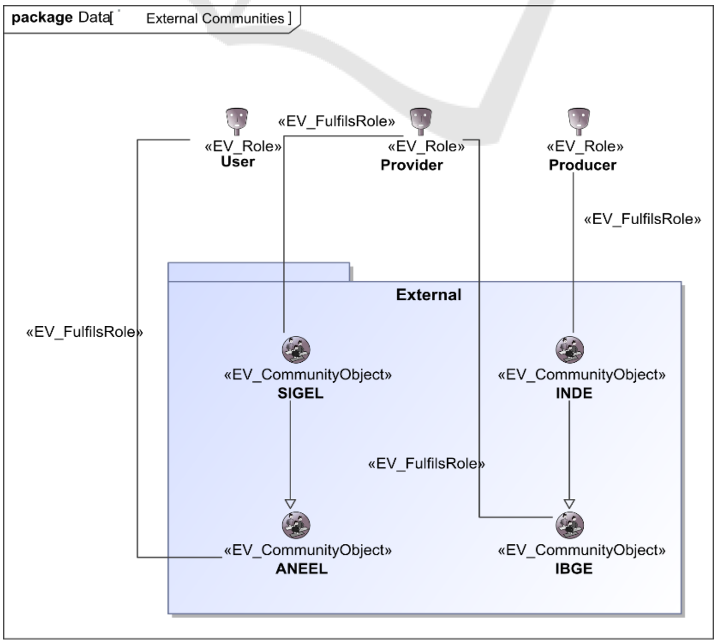

Figure 9: External communities that interact with SDI-Cemig.

Vao_LT, *Vao_LT_230-500*, and *Vao_LT_34-161* represent, respectively, the arcs of *Generation*, *Transmission*, and *Distribution.*

The structures that make up the *Generation* nodes comprise power plants, which can be hydroelectric, wind, or solar (*Usinas_Hidreletricas*, *Usinas_Eolicas*, *Usinas_Solares*, respectively), and by *Centrais_Geradoras_Hidreletricas*, *Subestacoes_Geracao*, and *Pequenas_Centrais_Hidreletricas*. Although it is said in the subsection 3.1.2 that Cemig owns thermal power plants, they are not considered, at the first moment, in the conceptual model.

In Transmission, the only structures that make up the network are the transmission sub-stations (*Subestacoes_Transmissao*). In *Distribution*, the structures comprise *Postes* (poles) and *Subestacoes_Distribuição*. The poles may have a transformer. *Generation*, *Transmission*, and *Distribution* have, respectively, the classes *Linhas_Transmissao*, *Linhas_Transmissao_230-500*, and *Linhas_Transmissao_34-161*. These classes are used to identify a portion of the network, which must comprise at least an arc and its respectively beginning and end nodes.

4 DISCUSSION OF RESULTS

The adapted ICA model proved appropriate to describe the viewpoints Enterprise and Information of SDI-Cemig. The differences found between the model and the specification are due to the specific characteristics of SDI-Cemig.

One such difference is that there are no geoprocessing services. In the viewpoint Enterprise, the lack of geoprocessing services impacts the component Product, which cannot be self-related.

In addition, the existence of the component Technology in ICA's formal model contradicts the goal of the viewpoint Enterprise in the RM-ODP framework, which is to describe the system's scope, policies, and requirements. This contradiction can be extended to the component *Connectivity*, however, further studies are needed to state that.

Also regarding the viewpoint Enterprise, during the specification of the actors in SDI-Cemig, the concentration of positions in the IT community becomes visible, which are responsible for providing data to SDI-Cemig, performing maintenance in smaller systems, negotiating new geospatial data, and creating new policies. Many of these responsibilities are beyond the scope IT should take on in SDI-Cemig.

Regarding the policies, the ones related to the type *Governance* have not been defined yet. Moreover, other types of policies have a small number of policies specified (usually a single policy has been specified for each type).

The viewpoint Information of SDI-Cemig has all the components specified by the adapted ICA model, with no need to change their behavior or semantics.

Although the adapted ICA formal model describes SDI at all levels and, thus, guarantees the basic concepts in the literature are contemplated in the specification phase, there is no description of how the model should be used. For instance, how many details are required to describe the components of the viewpoint Enterprise, or what could be considered a product specification?

5 FINAL CONSIDERATIONS

Using the adapted ICA formal model allows the key components of an SDI to be contemplated in the design phase, besides allowing a better understanding of the basic concepts such as the SDI structure, who the users will be and what roles they will take on when using an SDI, how the policies will impact the SDI development, etc.

The viewpoints Enterprise and Information in ICA's formal model properly describe these viewpoints in SDI-Cemig and, although the specification of a single corporate SDI does not ensure the model will be applicable at any corporate level, it does indicate the viewpoints Enterprise and Information in ICA's formal model can be applied to other corporate SDIs. Moreover, the present study may help other designers wanting to use ICA's model to specify new SDIs regardless of their level.

As future works, we intend to specify the viewpoint Computation in SDI-Cemig to verify whether it is in accordance with the viewpoint Computation specified in the adapted ICA model.

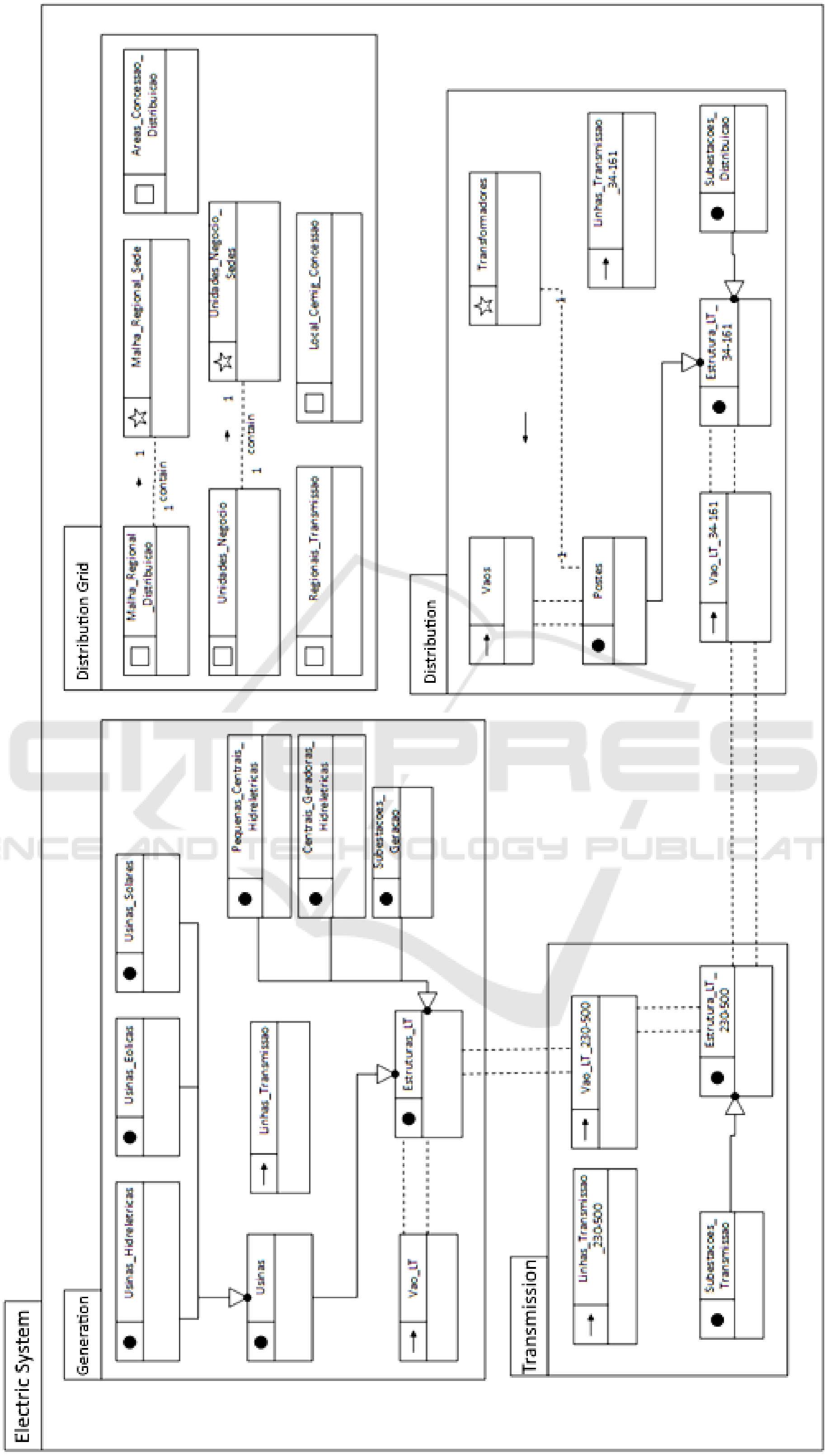

Figure 10: Layers related to the electric system and the distribution grid of the state of Minas Gerais from the conceptual scheme of SDI-Cemig's database.

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