A Spatial Data Infrastructure Review
Sorting the Actors and Policies from Enterprise Viewpoint

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Abstract: The Commission on Geoinformation Infrastructures and Standards of the International Cartographic Association (ICA) has proposed a model based on five perspectives to describe Spatial Data Infrastructure (SDIs) using the Reference Model for Open Distributed Processing (RM-ODP) framework. This model was later extended by other researchers to describe the hierarchical relationship among SDIs and the interactions related with policies of an SDI, using the RM-ODP elements for these descriptions. However, the elements initially proposed by the ICA and the extended elements differ in terminology and semantically. This paper proposes unifying these elements, more precisely the actors and policies of the Enterprise Perspective proposed in the ICA model and its extensions in order to create a single model to describe SDIs, thus guaranteeing a common language when designing an SDI, besides facilitating knowledge sharing among designers.

1 INTRODUCTION

Spatial Data Infrastructure (SDI) is a concept developed to help the use and sharing of geospatial data. Rajabifard and Williamson (2001) define SDI as an environment where users, through technology, are able to cooperate among themselves by using and sharing geospatial data in order to reach their goals at different political and administrative levels.

According Rajabifard and Williamson (2001), the use of SDI assists the data sharing, avoiding its duplication and allows the organization saves resources, like time and money. Further, the authors highlights that the SDI assists in the cooperation between stakeholders, increase in the awareness about de geospatial data importance and provides important information about the data, like quality, type and ownership.

Nevertheless, according to Hjelmager et al. (2008), this concept is too broad, which causes the development of different forms of SDIs. Aiming at reducing the differences among SDIs, the International Cartographic Association (ICA) has developed a formal model that describes SDIs regardless of technologies and implementations, which is documented in Hjelmager et al. (2008), Cooper et al. (2011), and Cooper et al. (2013), and

was expanded by other researchers in Béjar et al. (2012).

The ICA model was developed based on the Reference Model for Open Distributed Processing (RM-ODP) framework (ISO/IEC 10746-1, 1998). RM-ODP is an architectural framework standardized by the International Organization for Standardization and by the International Electrotechnical Commission (ISO/IEC), which enables complex systems to be specified by using five perspectives: Enterprise, Information, Computation, Engineering, and Technology. The use of perspectives enables a complex system to be described as smaller, interconnected models, each of which focusing on different issues of the system (Linington et al., 2011).

The SDI model developed by the ICA describes the Enterprise (Hjelmager et al., 2008) (Cooper et al., 2011), Information (Hjelmager et al., 2008), and Computation (Cooper et al., 2013) perspectives. According to Hjelmager et al. (2008), the Engineering and Technology perspectives have not been described since they are too dependent on technologies and implementations.

However, this model can't be considered as a standard yet, thus, according to Hjelmager et al. (2008), "*is necessary to validate the model in specific user communities and at different levels of SDI*",

don't existing works which validate the model completely.

Béjar et al. (2012) extend the Enterprise perspective developed by the ICA, enabling the description of relationships among the SDIs and of the participating organizations, the specification of the types of enterprise objects, the types of roles of SDI artifacts and processes, besides considering the interactions affected by the policies imposed in the IDE. In order to specify its extension in the SDI model, Béjar et al. (2012) used the profile UML4ODP, standardized by the ISO/IEC, which determines how the UML elements must be used to represent the RM-ODP concepts.

Further, Béjar et al. (2012) considered RM-ODP elements which weren't used in Hjelmager et al. (2008) and Cooper et al. (2011) as the communities, federations and behaviors. Community is an entity or an entity group which have an objective that will be accomplished through a determined behavior.

However, some elements specified by Béjar et al. (2012) differ semantically or terminologically from the elements specified by Hjelmager et al., (2008) and Cooper et al. (2011). This paper presents a comparison between the actors and policies of the ICA model and the extension proposed by Béjar et al. (2012) and proposes the unification of the actors and policies in the proposals to help create a unified model that formally describes an SDI.

The remaining of the paper is structured as follows. Section 2 presents the actors and policies of both proposals, comparing the actors of the ICA model with the actor roles of the extension by Béjar et al. (2012), besides comparing their policies. Section 3 presents the proposal for the unification of actors and policies of the ICA model and of the extension proposed by Béjar et al. (2012). Section 4 presents the conclusions of this study and the future studies.

2 ENTERPRISE PERSPECTIVE FOR SDIS

According to Linington et al. (2011), the Enterprise perspective focuses business goals, processes, policies, and rules that will make up the system. Regarding SDIs, the Enterprise perspective proposed by Hjelmager et al. (2008) approaches the possible actors that may interact with an SDI, being extended by Cooper et al. (2011), the main policies that rule it, and what parts make up an SDI and how they relate. Béjar et al. (2012) extended this perspective,

considering the relationship among SDIs and the interactions affected by the policies, such as the enterprise objects and processes, besides using the UML4ODP profile to describe the Enterprise perspective.

Only the actors and policies of an SDI defined by Hjelmager et al. (2008), Cooper et al. (2011), and Béjar et al. (2012) will be discussed in this section.

2.1 Actors of an SDI

Hjelmager et al. (2008) defined six actors that may interact and contribute with an SDI (Figure 1). They are: *Policy Maker*, *Producer*, *Provider*, *Value-Added Reseller*, *Broker*, and *User*.

The *Policy Maker* is the individual responsible for creating the policies that will rule the working of an SDI. The role of the *Producer* is to create the data and services that make up an SDI. However, it is not the *Producer's* responsibility to make the data and services available in the SDI, a role that belongs to the *Provider*. The *Broker* is responsible for aiding the dealings between the *User* and the *Provider*, for recovering metadata from the products offered by the *Provider*, and for generating catalogs based on these metadata so as to help a *User* to find a *Provider* holding the product that meets their needs. The *Value-Added Reseller* (VAR) adds new functionalities to the products that exist in the SDI, making them available as new products. The *User* is the actor who uses the data and services of an SDI to reach its goals (Hjelmager et al., 2008).
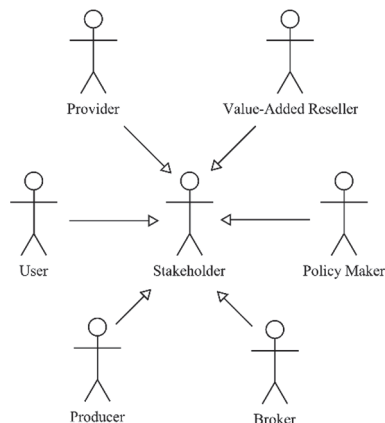

Figure 1: Possible stakeholders of an SDI – (Hjelmager et al., 2008).

However, these six actors have not been able to describe all the responsibilities an actor can have when interacting with an SDI. That is why Cooper et al. (2011) specialized each of the six actors in order

to more precisely delimit the roles of each actor and to fulfill new concepts, such as the use of volunteered geographical information.

The *Policy Maker* was specialized into the following actors: *Legislator*, who determines the SDI scope; *Decision Maker*, responsible for creating the SDI policies; *Secretariat*, the actor who will release the resources for the SDI to work; and *Champion*, whose role is to publicize the SDI, thus promoting its use (Cooper et al., 2011).

According to Cooper et al. (2011), the specialization of the *Producer* occurs through four groupings – *Status*, *Motivation*, *Role*, and *Skill*, as shown in Figure 2. The specializations of the group *Status* (*Official Mapping Agency*, *Commercial Mapping Agency*, *Community Interest*, and *Crowd Source*) are related to the influence they have in creating products in the SDI. The group *Role* (*Captor of Raw Data*, *Submitter of Revision Notice*, *Passive Producer*, and *Data Base Administrator*) has specialized actors according to the responsibilities they will have in the process of creating products in the SDI, i.e., the data and services. The group *Motivation* (*Special Interest*, *Economic*, and *Process*) specializes the *Producer* according to the reason why it creates SDI products, while the group *Skill* (*Neophyte*, *Interested Amateur*, *Expert Amateur*, *Expert Professional*, and *Expert Authority*) specializes according to the experience and quality of the products created by the *Producer*.
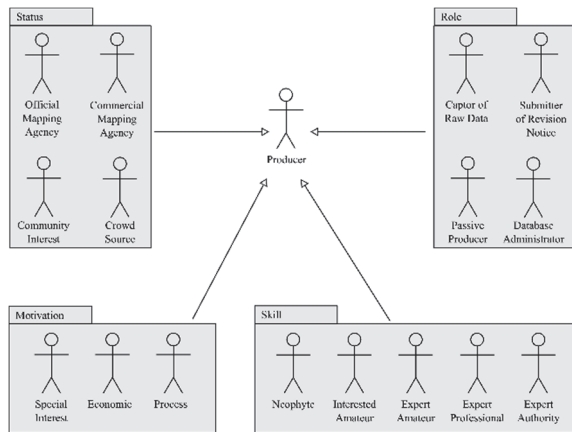

Figure 2: Specializations of the actor Producer – (Cooper et al., 2011).

Cooper et al. (2011) specializes the *Provider* into two groups according to the product it will make available in the SDI: data or services. Each group has three specializations, whose greatest difference is the product made available. The actor "*A Producer that is its own Data/Service Provider*" will take up the responsibility of making available the products it has created. The *Data/Service Distributor* will make the products created by the *Producer* available in the SDI. The *Data/Service Arbiter* selects the data and services that, according to its criteria, will be made available in the SDI, possibly adding value to the products.

The *Broker* was specialized according to its role as the negotiator between providers and clients. The *Crowd-sourcing Facilitator* acts as an intermediary between a task that must be concluded and the quality workforce that carried out this task. The *Clients/users Finder* will find new clients to the products a provider offers and the *Providers Finder* will find new product providers for the SDI. The *Harvester* will collect the metadata of the products offered by the provider and integrate them. With the metadata collected, the *Cataloguer* is responsible for building and maintaining the metadata catalogs. Finally, the *Négociant* helps a *User* find a *Provider* with the products that meet its demands, besides helping the negotiations between them (Cooper et al., 2011).

According to Cooper et al. (2011), the *Publisher* specialization of the *Value-Added Reseller* integrates the data from different sources and makes them available as a new product, possibly integrating its own data into this new format. The *Service Integrator* will integrate several services and will make them available as a new service and the *Data and Metadata Aggregator/Integrator* will edit, improve, and combine databases, offering aggregation and integration of the metadata, integration of the different databases, and the selection of the best versions of the features existing in different databases.

Finally, the *User* is the actor that will use the features and data, being specialized according to its knowledge level. The *Naive Consumer* has little knowledge of geospatial data and services, while the *Advanced User* has a higher level of knowledge and is able to provide revisions and suggestions to the products (Cooper et al., 2011).

Béjar et al. (2012) defined the Actor Roles a community may take up in an SDI. Communities, according to Linington et al. (2011), are a concept of RM-ODP that defines how a set of individuals that share a common goal must behave to reach said goal.

Actor Roles are the possible actions a community may perform and the interactions it may take part in. Besides the Actor Roles, Béjar et al. (2012) define the Artifact Roles, which are not discussed in the present study.

The actor role *User* will be the actor that will use the SDI data and services. The *Contributor* has the

responsibility of adding and removing data and services in the SDI. The *Custodian's* role is to create and maintain the main SDI products and guarantee the quality and availability of these products. The *Governing Body* is responsible for managing the policies, such as their creation, changing, and removal, besides taking part in the decision-making process in the SDI (Béjar et al., 2012).

Also according to Béjar et al. (2012), the actor *Operational body* takes up several responsibilities, which allow the SDI to work. Some examples provided by the authors are: system administration, technical support, and quality assurance. The *Contact* represents the interaction of a community with other SDIs and communities. Training the actors that interact through the SDI is the responsibility of the *Educator*.

The *Promoter* will promote the SDI to gather new users and contributors and will promote the changes that take place in the SDI to the other actors. The *Funder* is responsible for releasing resources to fund the SDI. The *Member* is a generic actor role used only to represent that a community is a member of an SDI. The two last actor roles are used to show their importance within the SDI: *Communication channel* and *SDI catalog*. The *Communication channel* is a means for communication among the SDI actors and the access to the data and services present in an SDI, while the SDI catalog is an undefined means to access the metadata of the geospatial data (Béjar et al., 2012).

The actor roles defined by Béjar et al. (2012) play a role similar to the actors defined by Hjelmager et al. (2008) and Cooper et al. (2011). However, many of the actor roles specified by Béjar et al. (2012) differ in terminology and semantics compared to the actors of the ICA model. Moreover, elements in either model have no match in the other one.

The comparison between the actors defined by Hjelmager et al. (2008) and Cooper et al. (2011) with those from Béjar et al. (2012) was carried out based on the functions each actor and actor role has.

The *User* is identical in either description, playing the same role and having the same name. The *Contributor* is the actor role responsible for making the SDI data and services available and is able to remove data, a responsibility similar to that of the actor *Provider* in the ICA model.

The actor role *Custodian* has roles related to the management of the main SDI data, which include adding, removing, updating, and guaranteeing quality of the main SDI data and services. In the ICA model, only the role of adding the main SDI data has an actor with an equivalent role, i.e., the specialization *Official*

Mapping Agency of the *Producer*. The ICA model does not report an actor with the role of removing or updating the SDI data and, although Hjelmager et al. (2008) states that the *Producer* is responsible for creating SDI data and services, in the *Producer* specializations proposed by Cooper et al. (2011), the SDI services are not taken into account.

The policy-creating role of the *Governing Body* is equivalent to the policy-creating role of the specialization *Decision Maker* of the *Policy Maker*. Nevertheless, the roles of updating or removing policies have not been stated in the ICA model, which also has no equivalent to the role of formally interacting with other organizations.

The actor role *Operational body* is responsible for the technical responsibilities that enable the SDI to work. Thus, it is the actor role with the largest number or functions in an SDI. This study considered the roles specified by Béjar et al. (2012), including the roles of *Catalog Manager* and *Gateway Manager* specified in Nebert (2014). Regarding the catalogs, the *Operational body* can create, update, and exclude catalogs, responsibilities similar to those of the specialization *Cataloguer* of the actor *Broker*. Although it is not mentioned by Béjar et al. (2012), the role of managing the SDI database can be considered technical, therefore it was considered the responsibility of the *Operational body*, which is equivalent to the *Database Administrator*, a specialization of the *Producer* in the ICA model. The remaining roles of the *Operational body* have no equivalent in the ICA model.

According to Béjar et al. (2012), the actor role *Contact* represents a community in its interaction with other SDIs, besides having some responsibilities of the actor *Broker*, proposed by Hjelmager et al. (2008). Hence, it has been defined that the *Broker's* negotiation-related roles would be the roles in common with the actor role *Contact*. In the ICA model, there is no actor with specific roles to educate the SDI actors or provide training, with no equivalent to the actor role *Educator* by Béjar et al. (2012).

The actor role *Promoter* will promote the SDI to incentive new users to use it, the same role performed by the actor *Champion*. Another role of the actor role *Promoter* is to keep the SDI members informed of changes in it, with no equivalent of this role in the ICA model. The role of releasing resources for the SDI to work exists both in the extension proposed by Béjar et al. (2012) with the actor role *Funder* and in the ICA model with the specialization of the *Policy Maker Secretariat*.

The three last actor roles, i.e., *Member*, *Communication channel*, and *SDI catalog*, are not

applicable in the ICA model. This occurs due to the semantics they receive from Béjar et al. (2012). While the actor role *Member* is generic, used only to model the SDI behavior in the UML4ODP diagrams, the actor roles *Communication channel* and *SDI catalog* can be considered, respectively, a means used by the SDI member to carry out a function and an artifact used during some SDI process.

Besides what has been presented, the ICA actor *Policy Maker* has the following roles that do not exist in the extension proposed by Béjar et al. (2012): Determining the SDI framework, creating a business plan, classifying the actors and aiding the communication among them, and guaranteeing the appropriate implementation of the policies. Another role that does not exist in Béjar et al. (2012), the actor *Producer*, also has the responsibility of correcting the data in the SDI and sending revision notices to the *Providers* whose data it considers require changes.

The actor *Value-Added Reseller* is the only actor that has no equivalent role in the extension by Béjar et al. (2012), while the *Broker*, except for the roles of negotiation between users and providers, has no match for its roles in the actor roles by Béjar et al. (2012).

2.2 SDI Policies

According to Hjelmager et al. (2008), the policies are one of the main components of an SDI. Figure 3 shows the SDI component, represented by a UML class, specialized into several policies, where, despite not being represented, the classes may relate among themselves. Hjelmager et al. (2008) did not detail the specializations scope of the components *Policies*, therefore the definitions ahead are interpreted by the authors of the present study.

The specialization *Best Practices* consist of the policies carried out with the practices that should be used and adopted in the SDI. Unlike the specialization Standards, the practices defined in *Best Practices* are not mandatorily adopted. The specialization *Standards* sets the standards that must be adopted in the SDI, i.e., their use is mandatory in the SDI.

The class *Constraints* is specialized into the classes *Legal Constraints* and *Business Agreements*. *Legal Constraints* are the policies that restrict the SDI based on some law enforced by the government to which the SDI is subjected. The *Business Model* are the restrictions imposed on how the system must operate to meet the user needs.

Béjar et al. (2012) also defined in their extension the policies that an SDI can have during its existence. Five main policies were defined, namely:

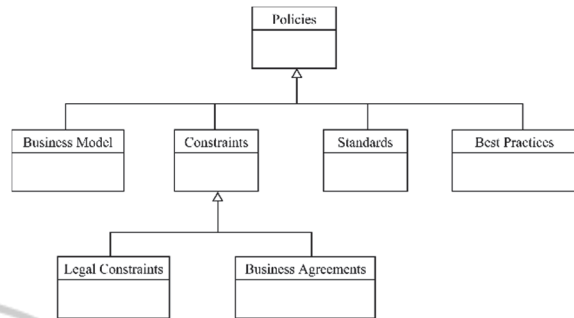*Governance*, *Access*, *Membership*, *Role assignment*, and *Infrastructure*.

Figure 3: Specializations of the component Policies – (Hjelmager et al., 2008).

The *Governance* policies will determine how the decision-making process and policy creation will be in the SDI. The *Role assignment* policies will determine which role a community will take up in the SDI and when it will do it. Despite the term used, the *Access* policies restrict the whole process of including and removing geospatial data in SDI. The *Membership* policies will regulate the rights of the SDI members, such as access, exit, and obligations.

According to Béjar et al. (2012), the *Infrastructure* policies are more directly related with the SDI components, regulating some of their characteristics. This policy was specialized into several other policies that are detailed ahead. The *Standards* policies define which standards will be adopted in the whole SDI and can be specialized into a policy called *Foundation*, which defines what the main SDI geospatial data will be. The quality of the SDI data and services will be defined by the *Quality* policy. A way of increasing product quality is providing training to the SDI members.

The way the training should take place will be described in the *Education* policies. The *Promotion* policy determines how the SDI will be publicized to its members and non-members. The last specialized policy of the *Infrastructure* is the *Funding* policy, which dictates how the SDI will receive and must employ the financial resources for it to work (Béjar et al., 2012).

Table 1 shows the comparison between the policies by Béjar et al. (2012) and the policies of the ICA model (Hjelmager et al., 2008). Except for the *Education* and *Promotion* policies, which have no equivalents in the ICA model, all other policies are in Table 1.

3 UNIFICATION OF ACTORS AND POLICIES

In order to facilitate the knowledge exchange among the designers who use the ICA model along with the extension proposed by Béjar et al. (2012), both proposals for actors and policies were unified based on the comparisons carried out in section 2.

As already presented, Hjelmager et al. (2008) propose six main actors that can exist in an SDI. One more actor will be added to these six main ones, *Operational body*, proposed by Béjar et al. (2012). Since the *Operational body* carries out a large number of technical activities that allow the SDI to work, it is not considered a specialization of the other actors. Figure 4 shows the proposal of the main actors that may exist in the SDI.
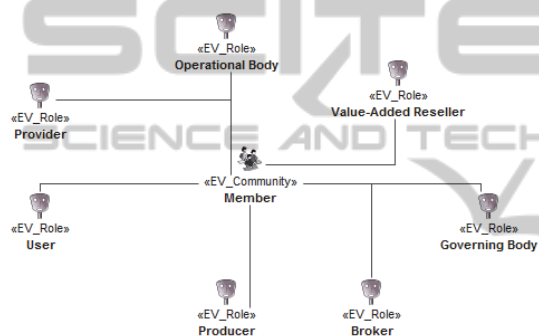

Figure 4: Unification of actors.

The *User* was not modified since its roles and terminology in both the ICA model and in the extension by Béjar et al. (2012) are the same. However, the specializations defined by Cooper et al. (2011), *Naive Consumer* and *Advanced User*, were maintained to set the user's level of knowledge and ability.

The name of the *Policy Maker* was changed to *Governing body* since it is not only responsible for the SDI policies, but also for all administrative issues and responsibilities in it. The specializations of the *Governing body* are structured as follows:

- *Legislator*: No changes in this specialization.
- *Policy Maker*: Former *Decision Maker*, responsible for creating policies that will rule the SDI, being also able to remove and change them.
- *Secretariat*: Maintained all of its roles and gained the responsibility of formally interacting with other organizations.
- *Promoter*: The term *Promoter*, proposed by Béjar et al. (2012), was used for more appropriately representing the role played than the term *Champion* proposed by Cooper et al.

(2011). This specialization maintains the role of promoting the SDI to new users and publicizing to the other SDI members the changes that take place in it.

- *Educator*: The ICA model has no actor responsible for training the SDI members, a gap that is filled by the *Educator* proposed by Béjar et al. (2012).

The *Producer* kept the same responsibilities and the categorization proposed by Cooper et al. (2011) was maintained. Only the categories *Role* and *Status* were changed, hence they are the only ones detailed below:

- *Status*
  - *Official Mapping Agency*: Main agency in the SDI regarding the production of data and services. Besides being responsible for the production of data and services, it is responsible for guaranteeing their quality in the SDI.
  - *Commercial Mapping Agency*: Has the same roles as the *Official Mapping Agency*, with the differential of being a profit-driven hired agency.
  - *Community Interest* and *Crowd Source*: No changes in these specializations.
- *Role*
  - *Submitter of Revision Notice* and *Database Administrator*: Both specializations were moved to specializations of the actor *Operational body* since the roles they play in the SDI are related more with the technical area than with the production of data and services.
  - *Captor of Raw Data* and *Passive Producer*: No changes in these specializations.

The *Provider* will keep the same attributions defined by Hjelmager et al. (2008) and Cooper et al. (2011), namely making the SDI data and services available. However, it now has also the power to change and remove the data and services it makes available, besides guaranteeing their availability.

The *Broker* and *Value-Added Reseller* are other actors that suffered no changes in their original proposals in Hjelmager et al. (2008) and Cooper et al. (2011). It must be pointed out, however, that the catalog-related roles – which, according to Béjar et al. (2012), belong to the actor *Operational body* – will be under the responsibility of the *Broker*, as proposed by Cooper et al. (2011).

The *Operational body* will be the actor with the largest number of responsibilities in the SDI and they are all linked to technical issues that allow the SDI to work. Given the large number or roles, only some will be detailed in this study, mainly the ones highlighted by Béjar et al. (2012):

Table 1: Comparison between the policies in the extension by Béjar et al. (2012) and the ones in the ICA model.

Béjar et al. (2012)				ICA		
Policies			Description	Description	Policies	
Governance	-	-	Determines the decision-making process	Policies that define the company's business model	-	BusinessModel
	-	-	Regulates the policy-creation process		-	
Access	-	-	Determines how the SDI products can be accessed and who can do it	Policies that define the company's business model	-	BusinessModel
Membership	-	-	Determines the relationships among the SDI members	Policies that define the company's business model	-	BusinessModel
Role assignment	-	-	Defines the responsibilities (actor roles) of the SDI users	Policies that define the company's business model	-	BusinessModel
Infrastructure	Standards	-	Defines the standards adopted by the SDI	Existing standards for the SDI components	-	Standards
		Foundation	Defines the main SDI products		-	
	Quality	-	Defines the quality levels established in the SDI	Policies that define the company's business model		BusinessModel
	Funding	-	Defines how the resources will be forwarded to develop and maintain the SDI	Policies that define the company's business model	-	BusinessModel
No equivalence				Restrictions imposed by laws of the State where the SDI is located	Legal Constraints	Constraint
No equivalence				Restrictions existing due to contract between companies	Business Agreements	
No equivalence				Practices that must be adopted by the users member of the SDI		BestPractices

- *Technical Support*: Responsible for the maintenance of smaller systems and equipment, besides helping SDI members according to the problem.
- *Quality Control*: Oversees the SDI processes and products to assure they are in accordance with the quality policies enforced.
- *Database Administrator*: Previously a specialization of the *Producer*, the *Database Administrator* is responsible for guaranteeing the data present in the database are consistent with their specifications.
- *Submitter of Revision Notice*: Another specialization belonging to the *Producer*, its responsibility is to send revision notes mainly to the *Producers* for SDI data reviewing and correction.

Hjelmager et al. (2008) presented the policies that an SDI may have, as already shown in Figure 3.

Nevertheless, due to the number of policies proposed and little explanation of each one, the policies by Hjelmager et al. (2008) are too generic and ambiguous. This problem was solved by Béjar et al. (2012) with a larger number of policies and a more detailed explanation for them. Béjar et al. (2012), however, by separating the *Governance*, *Membership*, *Access*, and *Role Assignment* policies from the *Infrastructure* policies, give the impression that these policies comprise more than the SDI, which is not their goal according to those same authors. This study proposes a reorganization of the policies, as shown in Table 2, with no changes required in their names and meanings.

Table 2: Unification of the policies by the ICA and from the extension by Béjar et al. (2012).

Policies	Specialization
Business Model	Governance
	Membership
	Quality
	Access
	Role Assignment
	Funding
Promotion	
Standards	Foundation
Education	Best Practices
Constraints	Legal Constraints
	Business Agreements

4 FINAL CONSIDERATIONS

Given the complexity of SDIs, the ICA developed a model that describes an SDI as a whole by using the RM-ODP framework. Béjar et al. (2012) extended the Enterprise perspective to consider the relationships among the SDIs, the relations affected by the policies, and to adequate some elements to the RM-ODP. However, there are differences between the elements in the ICA model and those in the extension proposed by Béjar et al. (2012).

The actors and policies of the two proposals were compared so that the semantic and terminology differences between them were found. As a result, a unification of the actors and policies between the proposals by the ICA (Hjelmager et al., 2008) (Cooper et al., 2011) and the extension by Béjar et al. (2012) was proposed. Unifying the models will allow designers to have a common language when designing an SDI, besides facilitating the sharing of knowledge among them.

Future studies intend to analyze the Information and Computing perspectives of the ICA model and adequate them to the RM-ODP framework, besides specifying them using UML4ODP. Although the Engineering perspective depends on technologies, the existing models can be used as "guides" for it in case a designer intends to use an architecture similar to these models.

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