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A Description Logics Based Approach for Building Multi-Viewpoints Ontologies

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***Abstract*—**We are interested in the problem of building an ontology in a heterogeneous organization, by taking into account different viewpoints and different terminologies of communities in the organization. Such ontology, that we call multi-viewpoint ontology, confers to the same universe of discourse, several partial descriptions, where each one is relative to a particular viewpoint. In addition, these partial descriptions share at global level, ontological elements constituent a consensus between the various viewpoints. In order to provide response elements to this problem we define a multi-viewpoints knowledge model based on viewpoint and ontology notions. The multi-viewpoints knowledge model is used to formalize the multi-viewpoints ontology in description logics language.

***Keywords*—**Description logic, knowledge engineering, ontology, viewpoint.

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I. Introduction

In recent years ontologies played a major role in knowledge representation. For example, applications of the Semantic Web [1] (i.e., e-commerce, knowledge management, web portals, etc.) are based on ontologies. In the Semantic Web an ontology is a formal conceptualization of a domain of interest, allowing the actors (human and software) to share knowledge. It provides a way of expressing the meaning of concepts in a formal knowledge representation language.

Description Logics (DLs) is a designation for a family of knowledge representation languages that are widely used in ontological modelling. An important practical reason for this is that they provide one of the main underpinnings for the OWL Web Ontology Language as standardised by the W3C [2].

Since there are generally several ways of apprehending knowledge of a domain, the ontologies construction is therefore not an easy task. This is due primarily to the difficulty of finding consensus definitions of concepts in a domain satisfying the definition of each user, which reflect his viewpoint on the domain.

The difficulty of building ontologies is mainly related to the existence of several user communities who can be interested in the same domain but with different viewpoints. These communities evolving in a multidisciplinary environment coexist and collaborate among themselves. Each community has its own interests and perceives differently the conceptual entities of the same universe of discourse [3].

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Most methods and methodologies of ontology construction do not deal with the variety of perceptions related to the same universe of discourse and offer tools and directives to create a single model for a single vision of the observed world. The viewpoint approach is opposed to this monolithic approach and makes it possible to model the same reality according to different points of view [2].

In this paper, we are interested in the problem of multi-representation in ontologies. We believe that the most appropriate way is to use viewpoint notion in order to build ontologies called "multi-viewpoints ontologies". The latter is defined in [3], [4] as an ontology which is used to group different possible conceptualizations of the domain modeled according to different perspectives in a single ontology

The objective of this work is to present a method for building ontologies that take into account different view points of users. Thus, to attain this objective, our approach is as:

– At the conceptual level, a multi-viewpoints ontological model is defined. The latter is based on ontology and viewpoint notions. Ontology represents domain knowledge shared by several actors and the viewpoint represents domain knowledge that is relevant and visible according to the perception of a single actor.
– At the formal level and based on the multi-viewpoints ontological model, we use a sub-language of the DLs $\mathcal{SHOIQ}$ [4] to express notions inherent to viewpoints such as global and local concepts, bridges, stamps, etc.

The remainder of this paper is organized as follows. Section II briefly summarises the multi-representation paradigm based on stamping mechanism. Section III provides an overview of the multi-viewpoints approach. In Section IV we present our approach for building multi-viewpoints ontologies. Finally, Section V concludes this paper.

II. Multi-Representation Based on Stamping Mechanism

The multi representation problem is commonly known in the discipline of information modelling. In databases field, many works address specific facets of multi-representation.. The work presented in [6] has investigated the problem and proposed an extension of existing ER-based model. Hence, a stamping mechanism of data elements (concepts, attributes, instances) and relationships is suggested to enable manipulations of data elements from several representations.

A DLs stamping technique has been studied in [7], respecting the preceding characteristics, to allow multiple representations of concepts in the same ontology. The stamping technique is particularly interested in multiple representations of data. It allows attributes to have multiple definitions, i.e. different cardinalities or different domains of values (according to several contexts). This proposal can be illustrated through use of a simple example. Let us consider two representations of the real world, identified by the stamps s1and s2, corresponding to *Road traffic* and *Driving school* contexts. The description of stamped concept *Vehicle* is as:

Type Vehicle (s1, s2)
s1: Speed (1, 1): number
s1: RegistrationDate (1, 1): date
s2: CarModel (1, 1): string
s2: RegistrationDate (1, 1): string
s1, s2: AssurancePolicy (1, 1): string

A list of stamps is written before each attribute name. Thus, in the context *s*1, the *Vehicl*e concept is described by the attributes *Speed* and *RegistrationDate* (of domain Date), while in the context *s*2, it is described by the attributes *CarModel and RegistrationDate* (of domain string). In the two contexts (s1 and s2) *Vehicle* concept is described by the attribute *AssurancePolicy*.

III. Multi-Viewpoints Approach

For a given domain of knowledge, several criteria can be used to observe an object. These different perceptions of the world are called viewpoints or perspectives.

Several interpretations of viewpoint notion are possible. One of the first references to viewpoints was proposed by [8]: Viewpoints correspond to different perceptions of an object with respect to observer's position. The second interpretation is a knowledge domain one: Viewpoints correspond to the different ways to translate knowledge with respect to the social position, know-how and competence of an expert. In this interpretation, a viewpoint includes context and the perception of a person or group of persons. Examples of systems that implement viewpoints in object representations are [9]-[13]. A good overview is given in [14].

In the following, we identify the main objectives in integrating viewpoints into computer systems. Note that there is no single use of this concept that includes all of these objectives.

The viewpoint as a means of providing multiple descriptions of an entity: The viewpoint concept seems to naturally result from the multiple views of objects of a specific study. As a matter of fact, a real world entity can have many behavioural contexts and many states from which the notion of multiple descriptions has been derived. In this case, it is defined as the fact of conferring several partial descriptions to the same universe of discourse each of which describes it in a given viewpoint.

The viewpoint as a means of mastering system complexity: Several research works are based on the viewpoint concept with the principal objective of explicitly taking into account the complexity of the system. The result of the study is then held by dividing it into partial descriptions according to different and complementary aspects.

The viewpoint as an approach for the modelling and distributed development of systems: Many authors state that the modelling of complex systems as defined in [15] cannot be handled with the same techniques as used for simple systems. Different works suggest a distributed development approach based on viewpoint notion. Hence, every development process can be represented by correlated viewpoints.

In the following, we adopt the term *Multi-viewpoints ontology* to emphasize the importance of viewpoint in solving the multiple representation problems, providing a better visibility and access to ontological elements (concept, roles, individual) and allowing a collaborative modular development among diversified communities in the same domain. In the framework of this study, we are interested in ontologies represented by the DL language.

Our goal is to present a method for building ontologies, by taking into account the viewpoint notion. The method we present is complete, insofar as, starting from brut data it allows to arrive at a multi-viewpoints ontology represented in DL language. To do this, three main steps are followed in order to explain and to guide the building of the multi-viewpoints ontology.

A. Requirements Specification Step

The purpose of this step is to establish requirements specification document. This latter allows describing the multi-viewpoints ontology through the following four aspects:

1) *Domain Knowledge:* This aspect consists of delimiting as precisely as possible the domain that the ontology going to cover.
2) *Viewpoints:* When a domain is sufficiently large and complex, it is often organized according to several services, several tasks several working groups or several communities. This organization provides a division of domain into viewpoints. For example, in the area of *"real estate"* we can distinguish the following viewpoints: *"Finance"*, *"Size"* and *"Location"*.
3) *Domain experts:* This aspect consists of determining among domain experts, those which are better able to model the knowledge of each viewpoint, according to their specialties.
4) *Ontology scope:* This aspect consists of determining the most important global terms referring entities of domain knowledge to represent. In the example of *real estate* domain, we can be determine the following global terms: {Habitat, Apartment, Tenant, Agency}.

B. Conceptualization Step

Conceptualization deserves particular attention because it determines the rest of the ontology construction. The objective is to organize and structure knowledge, using semi formal representations (tables and graphs) that are independent of the paradigms of knowledge representation in which the ontology will be formalized. During this step, we construct, for each viewpoint, a local representation as perceived by experts from

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the considered viewpoint. Then the various local representation will be connected by intermediate links. To do so, we distinguish the following main activities:

1) *Building a Glossary of Local Terms:* A term may be a relevant representation of a domain entity called, concept or a binary relationship between two concepts. This activity consists in building a glossary of local terms. This last collects terms of the domain which are useful under the considered viewpoint and associates to each term identified a natural language description.

- Example 1: Under the viewpoint Size we may collect the following terms: {SmallApartment, Studio, F2, ...}.
- Example 2: Under the viewpoint Finance, we may collect the following terms: {ExpensiveApartment, HLM, Rich-Tenant …}.

2) *Building a Hierarchy of Local Concepts*: Under a viewpoint, the hierarchy of Local concepts organizes a group of concepts, in the form of a taxonomy, by using the generalization relationship (i.e. class/subclass).
3) *Building a Dictionary of Concepts:* The dictionary of concepts consists of describing all concepts represented in the hierarchy of local concepts, by representing for each concept his attributes that are visible from the considered viewpoint. An attribute marked by * is an attribute which is viewed from all viewpoints. In addition, the set of attributes marked by * is called the concept key. This latter allows to distinguish an instance of any other instances of its concept (see Tables I, II).
4) *Building a Table of Instances:* When looking at an instance according to a particular viewpoint, we only see the instance attributes that are relevant to this viewpoint*; we* have a partial view of the instance (see Table III).
5) *Linking Local Representation:* This activity consists of linking the different local representations of different viewpoints by intermediate links. Four types of links are distinguished: Equivalence bridge, inclusion bridge, exclusion and *global relationship.*

- The equivalence bridge between two local concepts, stemming from two different viewpoints enables to identify two concepts having the same meaning but used in two different contexts.
- The inclusion bridge enables to express that the meaning of the first concept (i.e. source concept) implies that of the second one (i.e. target concept).
- The exclusion link enables to identify the local concepts that cannot be at the same time representations of the same individual.

The description of the different bridges is done through a table of logical axioms (see Table IV).

- *Global Relationship:* A global relationship ***R*** is a lexical link that connects the sub-concepts hierarchized differently according to different viewpoints and allows to express a general fact about members of the concepts involved in this relationship. It is defined by a source concept ***C*** called the domain of the relation ***R*** and a destination concept ***D*** called the co-domain of the relation ***R***. This corresponds to the following assertion: $\forall\ x \in$ VP_{source}:**C**, $\exists\ y \in$ $PV_{destination}$:**D**, such as the instance *x* is related to the instance *y* by the relation **R**

Example: A rich tenant is a person who *lives* i n an apartment in downtown.

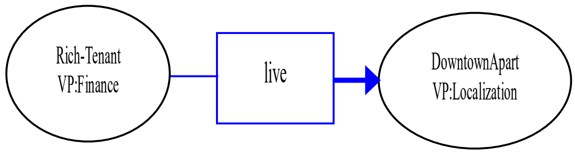

Fig. 1 A rich tenant is a person who *lives* i n an apartment in downtown

TABLE I
THE CONCEPT "*APARTMENT*" IS DESCRIBED FROM THE VIEWPOINT *SIZE* AS POSSESSING ONLY THE ATTRIBUTES RELEVANT TO THIS VIEWPOINT

Viewpoint	Concept	Attributes
Size	Apartment	*adress** *roomNumber* *surface* ....

TABLE II
FROM THE VIEWPOINT FINANCE, THE CONCEPT APARTMENT CONTAINS ATTRIBUTES RENT, CHARGES...

Viewpoint	Concept	Attributes
Finance	Apartment	*adress** *rent* *charges* ....

TABLE III
THE INSTANCE "*AT_BENALI*" IS CONSIDERED AS *F1* FROM THE VIEWPOINT "*SIZE*" AND POSSESSING ONLY THE ATTRIBUTES RELEVANT TO THIS VIEWPOINT: *SURFACE*, *ROOMNUMBER*

VP	Instance	Concept	Attributes	Values
Size	At-Benali	F1	*adress** *roomNumber* *Surface*	*Lamar 6th street Algeria* *1* *55* ...

TABLE IV
EQUIVALENCE BRIDGE RULE

Concept & source VP	Concept & Target VP	Description	Logical expression
HLM (VP:Finance)	Suburbs_Apart (VP:Localization)	All HLM apartments are in the suburbs and all suburbs apartments are HLM.	$\forall$ X, HLM(X) $\Leftrightarrow$ Suburbs_Apart(X)

C. *Formalization Step*

The conceptual ontology obtained in the previous step must be formalized. The representation formalism used in this step is the DL. The basic modelling elements in DL are concepts, roles and individuals. Concepts are only variable-free unary predicates represented as classes, and used to group individuals with similar properties. In DL, roles are also variable-free binary predicates and are used to associate any two concepts or any two individuals.

For our requirements of multi-viewpoints ontology representation, we introduce in DLs the following notions:

- *Multi-Viewpoints Ontology* is a multiple description of the same universe of discourse according to various viewpoints. It is defined as a 4-tuple of the form O = (C^G, R^G, Vp, M), where C^G a set of global concepts, R^G a set of global roles, Vp a set of viewpoints, and M a set of bridge rules.
- *Viewpoint* is defined as a triple VP_K= (C^L, R^L, A^L), where C^L a set of local concepts, R^L a set of local roles, and A^L a set of local individuals.
- *Global Concept* is used to represent a concept or entity of the real word which is observed from two or several viewpoints, at the same time, with basic and common properties (i.e. attributes).
- *Local Concept* is used to represent a concept which is viewed and described locally according to a given point of view.
- *Global Role* is a relationship between two local concept defined in two different viewpoints.
- *Local Role* is a relationship between two local concepts defined in the same point of view.
- *Stamps*: We adapt the stamping mechanism used in [7] to allow multiple representations of concepts. In our approach, stamps (i.e. labels) permit each ontological element (i.e. concepts, roles, individuals) to be known by the viewpoint that it belongs to.
- *Bridge Rule*: The particularity of the multi-viewpoints representation is the existence of a communication channel among various viewpoints. This communication channel, called bridge rule, allows representing links between local concepts of different viewpoints.
- *Multi-Instantiation*: The multiple instantiation mechanism allows an individual to belong to more than one local concept according to different viewpoints.

Definition 1 *(Syntax of global classes).* Let S= {vp_1, …, vpk,…, vpm} be a set of viewpoint names. A global concept, denoted by $\mathbf{C^{\hat{o}}}$, can be formed by using the classical Boolean constructors (conjunction, disjunction) and the global restriction constructors (see Table V) that allow properties to have different cardinalities or different domains of value according to several viewpoints

Definition 2 *(Syntax of local concept).* Let $vp_i \in$ S. A local concept, noted $\mathbf{vp_i{:}C}$, can be defined according to the following syntax:

$$\mathbf{vp_i{:}C} \rightarrow \text{(Global-Concept)} \mid (\neg\, C) \mid (C \sqcap C) \mid (C \sqcup C) \mid (\exists\, R.\, C) \mid (\forall\, R.\, C) \mid (\geq n\ \ R) \mid (\leq n\ \ R) \mid (R.\,\{a, b \ldots\})$$

Definition 3 *(Syntax of local role).* A local role, noted $\mathbf{vp_i}$**: R**, can be defined according to the following form:

$$vp_i\text{: R (C, D)}$$

where R is local role name defined in the viewpoint $\mathbf{vp_i}$, C and D are two local concepts defined in the same viewpoints $\mathbf{vp_i}$.

Definition 4 *(Syntax of global role).* A global role, denoted by $\mathbf{R^{\hat{o}}}$, can be defined according to the following form:

$$R^{\hat{o}}\ (vp_i\text{: C, } vp_j\text{: D)}$$

where R is global role name, C and D are two local concepts defined in two different viewpoints.

TABLE V
GLOBAL RESTRICTION CONSTRUCTORS

Global restriction constructors	Descriptions
$\forall_{\,vp1,\ldots,\,vp\,k}$ R.C	Defines a concept all of whose instances are related via the property R only to individuals of C, in the viewpoints vp_1 to vp_k
$\exists_{\,vp1,\ldots,\,vpk}$ R.C	Defines a concept all of whose instances are related via the property R to at least one individual of C only in the viewpoints vp_1 to vp_k
$\leq_{vp1,\ldots,\,vpk}$ n R $\geq_{vp1,\ldots,\,vpk}$ n R $=_{vp1,\ldots,\,vpk}$ n R	Indicates cardinality number of property in the viewpoints vp_1 to vp_k

Definition 5 *(Syntax of subsumption relationships).* Under a viewpoint VP_i, a local hierarchy, denoted vpi/$\mathcal{H}$, is defined by the triplet ($\mathcal{C}^L$, ∂, $\sqsubseteq$) where:

- $\mathcal{C}^L$ is a set of local concepts,
- ∂ is a function from $\mathcal{C}^L$ to $\mathcal{C}^G$ which associates each root concept (i.e. more general concept) S $\in \mathcal{C}^L$ to one global concept $C^{\hat{o}} \in \mathcal{C}^G$,
- $\sqsubseteq$ is the subsumption relationship used to explicitly express a partial ordering relation according to the two following forms:

$$\text{vpi: D} \sqsubseteq \text{vpi: C} \tag{1}$$

where C and D are two local concepts defined in the same viewpoint VP_i

$$vp_i\text{: S} \sqsubseteq C^{\hat{o}} \tag{2}$$

where S is the more general local concept defined in the viewpoint VP_i and $C^{\hat{o}}$ is global concept name.

Definition 6 *(Syntax of bridge rules).* Two types of bridges are possible: unidirectional and bi-directional. Bi-directional bridges represent set equality and set exclusion relations; while unidirectional ones represent set inclusion relation. A bridge rule is a statement of one of the four following forms:

$$\text{vpi: X} \xrightarrow{\sqsubseteq} \text{vpj: Y} \tag{3}$$

Means that an individual which is an instance of the source concept X under the vpi is also an instance of the target concept Y under the vpj

$$\text{vp1: } X_1 \sqcap \ldots \sqcap \text{vpk: } X_k \xrightarrow{\sqsubseteq} \text{vpj: Y} \tag{4}$$

Means that an individual which is an instance of each of the source concepts under disjoint viewpoints is also an instance of the destination concept.

$$\text{vpi: X} \xleftrightarrow{\equiv} \text{vpj: Y} \qquad (5)$$

Means that the sets of possible extensions of the two local concepts under different viewpoints are equal.

$$\text{vpi: X} \xleftrightarrow{\perp} \text{vpj: Y} \qquad (6)$$

Means that the concept X and the concept Y are incompatible.

Definition 7 *(Syntax of local individual).* A local individual is an instance of local concept defined in particular view point. Each local individual is described as following:

$$vp_i\text{: C (a)}$$

where **C** is a local concept defined in the view point $\mathbf{vp_i}$ and **a** is a local individual name.

D. Simple Modeling Example

We illustrate our multi-viewpoints knowledge model through a simple modeling example. It concerns the representation of real estate domain. In this example, three viewpoints are considered: Size, Finance and Localization, designed by vp1, vp2 and vp3 respectively. Each one contains only information that is relevant to it. In addition, the global level is simplified to a unique global concept Apartment (see Table VI).

IV. Conclusions

In this paper, we have presented an approach for building an ontology with multiple viewpoints. The underlying key of our approach is to allow the description of such ontology, without eliminating heterogeneity but by merging heterogeneity (at local level) and consensus (at global level). For each viewpoint corresponds a local representation. In addition, the different viewpoint share at a global level, ontological elements and bridge rules. These last, allow to link different local concepts from different viewpoints and thus to infer information from a viewpoint based on those known in another.

In the multi-viewpoints proposed model, we have not introduced relationships between viewpoints. For example, a viewpoint cannot be defined as a sub-viewpoint of another viewpoint. This ability may be affected by considering that a viewpoint corresponds to a set of criteria which characterize the context defined by the viewpoint, and the addition of other criteria (characteristics) to this set will create another viewpoint, which will be a sub-viewpoint of the considered viewpoint.

TABLE VI
Multi-Viewpoints Ontology Modeling

Global Concept
Apartment $^{\hat{o}} \equiv (\forall_{vp1}$ roomNumber.Number$) \sqcap (\forall_{vp2}$ rent.Number$) \sqcap (\forall_{vp1, vp2, vp3}$ hasAdress.String)
Defines a global concept *Apartment* with an attribute *roomNumber* according to vp_1, an attribute *rent* according to vp_2 and a common attribute *hasAddress* according to vp_1, vp_2 and vp_3.
Local Concept
vp_1: SmallApartment ≡ Apartment $^{\hat{o}} \sqcap$ (roomNumber. {1, 2})
Defines a local concept *SmallApartment*, under the viewpoint vp_1, as a sub-concept of the global concept *Apartment* and the value of the attribute *roomNumber* is one of {1, 2}.
Subsumption relationship
vp_2: CheapApartment ⊑ Appartement $^{\hat{o}}$
Expresses a subsumption link between the local concept *CheapApartment*, defined in the viewpoint vp_2, and the global concept *Apartment*.
vp_2 : HLM ⊑ vp_2: CheapApartment
Expresses a subsumption link between two local concepts defined in the same viewpoint vp_2. In fact, under Finance viewpoint, all HLM apartments are not expensive.
Local /Global Role
vp_2: live_by (ExpensiveApartment, Rich-Tenant)
Defines a local role between two local concepts defined in the same viewpoint vp2
live $^{\hat{o}}$ (vp_2: Rich-Tenant, vp_3: DowntownApartment)
Defines a global role between two local concepts defined under two different viewpoints.
Bridge Rule
vp_2 : HLM $\xleftrightarrow{\equiv}$ vp_3: ApartmentSuburbs
States that the two local concepts *HLM* and *ApartmentSuburbs*, defined under Finance VP and Localisation VP respectively, are equivalent. In fact, all HLM apartments are in the suburbs and all suburbs apartments are HLM.
Multi-instanciation
vp_1: SmallApartment (at-john) vp_3: ApartmentSuburbs (at-john)
Says that the individual *at-john* is an instance of *SmallApartment* in vp_1 and is an instance of *ApartmentSuburbs* in vp_3

References

[1] Berners-Lee, T., Hendler, J., Lassila, O., (2011). The Semantic Web. Scientific American. Vol. 284, pp 35–44.
[2] Hemam, M., Boufaida, Z. (2011). Towards a Multi-Viewpoints Ontological Model for Knowledge Sharing in E-health. Int Journal of Information Science and Intelligent System, Vol. 3, N° 3, 5–14.
[3] Hemam, M., Boufaida, Z. (2011). MVp-OWL: A Multi-Viewpoints Ontology Language for the Semantic Web. Int. J. Reasoning-based Intelligent Systems, Inderscience Publishers, Vol. 3, 147–155.
[4] Djezzar, M. and Boufaida, Z. (2015) Ontological classification of individuals: a multi-viewpoints approach, Int. J. Reasoning-based Intelligent Systems, Vol. 7, Nos. 3/4, 276–285.
[5] Ian Horrocks, Ulrike Sattler. (2007). A Tableaux Decision Procedure for *SHOIQ*. *J. of Automated Reasoning*, Vol. 39, 249–276.
[6] Balley S., Parent C., et Spaccapieta S., (2004). Modeling Geographic Data with Multiple Representation. In journal Geographical Information science, Vol 18, 327–352.
[7] Benslimane, D., Arara, A., Falquet, G., Maamar, Z., Thiran, P., & Gargouri, F., (2006). Contextual Ontologies: Motivations, Challenges, and Solutions. In Fourth Biennial International Conference on Advances in Information Systems, Springer.
[8] Minsky, M. ((1975). A framework for representing knowledge. In Winston, P., ed.: The Psychology of Computer Vision. McGraw Hill, New York.
[9] Bobrow, D., Winograd, T. (1977). An overview of KRL, a knowledge representation language. Cognitive Science 1, 3–45
[10] Stefik, M., Bobrow, D. (1985). Object-oriented programming: Themes and variations. The A.I. Magazine 6, 40–62
[11] Carre, B. (1989). Méthodologie orientée objet pour la représentation des connaissances. PhD thesis, Laboratoire d'Informatique Fondamentale de Lille, France.

[12] Davis, H. (1987). VIEWS: Multiple perspectives and structured objects in a knowledge representation language. Bachelor and Master of Science Thesis, MIT.
[13] Djezzar, M., Hemam, M., Boufaida, Z., (2012). Ontological Re-Classification of Individuals: A Multi-Viewpoints Approach", In Second International Conference on Model and Data Engineering (MEDI'2012), 7602, LNCS, Springer, 91-102.
[14] Mariño, O. (1993). Raisonnement classificatoire dans une représentation à objets multi-points de vue. PhD thesis, Université Grenoble 1, France.
[15] Benchikha, F. and Boufaida, M. (2007). The Viewpoint Mechanism for Object-oriented Databases Modelling, Distribution and Evolution, Journal of Computing and Information Technology, Vol. 15, No. 2, 95–110