A Formal Ontology Framework to Represent Norm Dynamics

A.Gangemi, D.M. Pisanelli, G. Steve
CNR - ITBM
Ontology and Conceptual Modelling Group
{gangemi,pisanelli,steve}@itbm.rm.cnr.it

In this paper we briefly describe the conceptual tools employed in a project aimed at representing and managing norm dynamics across different versions of banking regulations. We only give some hints of the ontological part of the project: formal ontology, conceptual integration, normative concept classification and comparison.

1. Introduction

1.1 The problem: Norm dynamics across different textual versions

The aim of this work is to compare at conceptual level two or more sets of regulations which are known or supposed to consist of equivalent or amended norms. The experiment has been conducted on a set of regulations of “Banca d’Italia” (the Italy Central Bank) aimed at preventing money laundering.
The conceptual modelling of norms is essential in order to grasp their semantics and understand the possible differences among them. For example: given two texts issued at different times by the same authority on the same topic, we can reasonably expect strong relationships between them.
However, such relationships can be put in evidence by a human expert but not by an information system working only at terminological level: a conceptual level at which making comparison is needed for this task.

1.2 The solution: Ontological analysis and conceptual integration

Our approach is:

- to identify terms and semantic relationships among them in the context of a norm in order to extract its information content from its textual version
- to represent terms and relationships in a conceptual model (ontology), one for each textual version (an ontology is composed by concepts, relationships and instances. Concepts and relations can be either primitive or characterised by properties (logically represented by axioms).
- to design ontologies with reference also to conceptual models either general purposes or pertaining law and other domains
- to model a scenario consisting of the *activities planned* in the norm, the *agents involved* in the activities and the possible *object exchanged* (in case of economic transactions); such a modeling strategy is based on the re-use of an generic ontologic component (*APE template*) used also in other domains (see section 3)
- to classify the concepts of the ontologies (ontologies are represented by means of a description logic allowing automatic classification of concepts)

From the conceptual point of view, given two sets of norms T ($n^A_{1...n}$) and T1 ($n^B_{1...n}$) concerning the same topic and given T1 explicitly issued in substitution of T, we can feature the relationships between norms in this way (adapted and enriched from Gärdenfors, 1992):

Equivalence: $n^A_i = n^B_i$
Difference: $n^A_i \neq n^B_i$
  Amendment
    Derogation: $n^A_i = (n^B_i \,\&\, p)$ (a property is canceled)
    Extension: $n^B_i = (n^A_i \,\&\, p)$ (a property is added)
    Substitution of a property

Negation of a property
Partial negation of a property (negation of a property)
Total negation of a property (negation of all the properties of a norm)
Unrelatedness (difference not classifiable as an amendment)
Insertion of a new norm
Deletion of a norm

2. The formal framework: Ontology integration

We put the problem of comparing different norms into the framework of *ontology integration*. Norms are considered complex concepts defined into a "local" ontology (in this case the set of concepts, relationships and individuals needed in order to conceptualise a normative text). Therefore, the different texts to compare turn into different local ontologies to compare (obviously assuming that it makes sense to compare their respective domains).

In this paper we do not deal with the methodology to define local ontologies starting from textual norms (see Gangemi, Pisanelli, Steve, 1999 about how general ontologic components are needed and how we employ morphologic, synctactic and textual analysis of norms together with the conceptual representation of the intended meaning of the lexical items identified).

In this formal framework the comparison of ontologies is regarded as a particular case of integration of ontologies i.e. the building of a "global" ontology G mapping the local ontologies L1 and L2. Such a mapping is made less complex by the fact that L1 and L2 already share many ontological components.

In the global ontology G we can retrieve (according to the ontology integration paradigm of Calvanese, De Giacomo, Lenzerini, 2001):

- those conceptually equivalent norms, 'retained' in the most recent version
- the subsumption between norms, in particular those 'derogated' and 'extended' (see § 1.2)
- the norms 'amended' by means of substitution or negation of a property in the most recent version

To perform this service we use tools that exploit description logics (see § 4.)

3. The conceptual framework: Formal ontology of plans, activities, participants, representation, and modalities

Ontology integration is less complex if local ontologies are built with reference to other shared ontologies. In our case study, which deals with comparison of sets of norms that are homogeneous both structurally and by topic, shared ontologies are already employed in the building of local ontologies.
In particular, we have reused general ontological components that specify plans, activities, participation relations, and modal relations.

Currently, we are using a set of *formal ontology* criteria (Gangemi, Guarino, Masolo, Oltramari, 2001) that helped us to select a useful *top-level* to re-organise taxonomies (Gangemi, Guarino, Oltramari, 2001), to perform ontological analysis, and to build domain ontologies. Among the others, the current top-level makes a commitment towards *objects*, *events*, and *abstract entities*.

3.1 Plans and relational components

Other important ontological components that we have employed in the norm dynamics ontologies are *participation*, *representation*, and *modality* relations. Participation relations (agent, patient, host, instrument, final state, etc.) range over events and entities: they relate entities that enter a situation to the event occurring in that situation. Representation relations range over abstract entities and other entities. Modality relations range over agents and plans.

In our ontology, a *plan* is an abstract entity that represents *activities*. *Activity* is a kind of *event*.

Abstract entities are not instantiated as individuals, but they *represent* other entities whatsoever. For example, a geometrical shape may represent a natural shape, a picture may represent an object, a conceptual space represents ordered sets of qualities (color, texture) wrt cognitive organization, etc.
A plan represents an activity in the sense that it provides a *method* to describe, check, and perform activities. In this broad sense, a plan characterises also the intentional structure underlying types of activities (occurred, possible, desired, imagined, etc.). In fact, an activity may consist of *intervention*, *decision*, and *modal* phases. Decisions and modalities are the functional aspects of activities, much as design and project are the functional aspect of artifacts ("made by skill"). Therefore (intentional) activities could be named *artiacts*, say artificial events ("performed by skill").

3.2 Plans vs. activity types

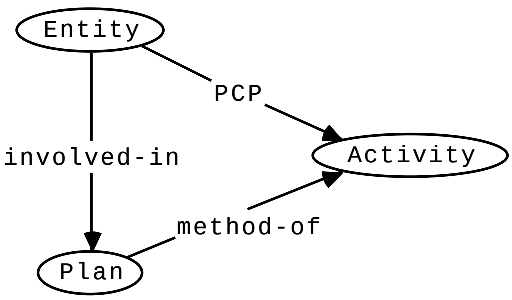
Can one commit to activity types only, and exclude plans from the ontology? There are two problems that prevent such a solution in practice: firstly, there is only a partial correspondence between *phases* of activities and *steps* of plans (cf. Pisanelli, Gangemi, Steve, 2000), secondly, plans are often poorly characterised (e.g. maxims, sayings, approximate indications).
The main correspondence is that between temporal sequences of phases and abstract sequences of steps. But even here there can be differences. In many cases a decision or modal step does not follow an intervention step in the same way the corresponding phases occur:

- With reference to an *alternative decision step*, once a decision is taken, only one activity is performed, while two or more possibilities persist in the plan.
- With reference to a *parallel step*, there is no corresponding actitivy.
- With reference to *modality steps* (necessity, obligations, competences, desires, orders, etc.), these do not correspond to activities that can be easily figured out within the temporal setting of the procedure. By the way, the case of normative obligation is quite clear: an agent E is obliged to follow a certain plan P when (s)he participates to a certain activity A. In this case, the modal activity M - consisting of E's cognitive commitment to conform his/her actions to P - enters when (and endures until) E participates in A.
- Some plans only provide indications concerning participants to an activity and modalities that are relevant to the conformity conditions of represented activities. This is the case of regulations, norms, contracts, etc. These plans may "inherit" their temporal planning from other plans that describe the same activities. As a matter of fact, most existing legal ontologies distinguish between normative and other kinds of plans (see § 3.4).

A detailed axiomatization for plans is an ongoing research.

3.2 The APE Template

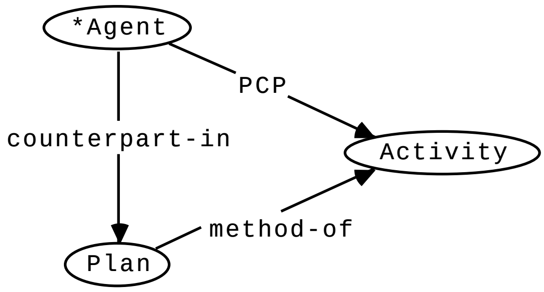
The APE (Activity-Plan-Entity) template (Fig. 1) that we reused in this application is a fragment of the ontologies mentioned so far. It has been already used by us for modelling clinical guidelines standards (Pisanelli, Gangemi, Steve, 2000).



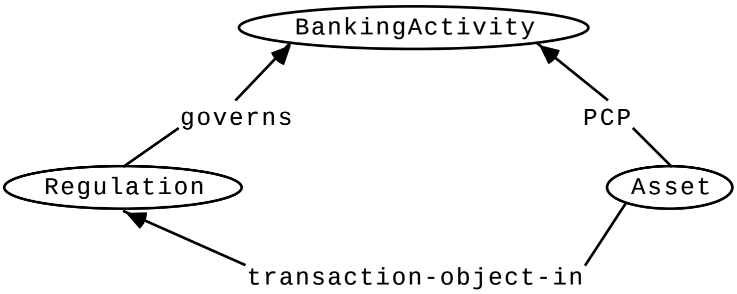
In APE, *PCP* is any participation relation, *method-of* is a representation relation holding between plans and activities, and *involved-in* is a composed relation:

$$involved\text{-}in(x,y) =_{df} \quad z.\ Activity(z) \quad PCP(x,z) \quad method\text{-}of(y,z)$$

APE can be specialised to agents:



In Fig.2, *involved-in* is specialised as *counterpart-in* (with the legal counterpart intended meaning), and **Agent*[1] is an intentional entity that enters only certain participation roles in an activity (e.g. *performer, host*).
If different kinds of participants are distinguished, APE can be used to model the economics aspects of the domain. To this purpose, the notion of *Asset* is interpreted as a kind of owned entities that can be exchanged in economic activities (such as banking ones):



In Fig.3, *involved-in* is specialised as *transaction-object-of* (with the legal transaction object intended meaning), and *governs* is a specialisation of *represents*.
A plan is further axiomatised through the application of the following relations:

- *Sequential* and *decisional*, holding among parts (*steps*) of plans (Pisanelli, Gangemi, Steve, 2000).
- *Modal* (of necessity, deontic, epistemic, intentional, of competence, etc.), holding between plans and involved agents. A detailed ontology of modality relations is an ongoing research. Beyond classical studies in analytical philosophy (Austin, von Wright), law (Hohfeld), AI (Allen), semiotics (Benveniste), and cognitive semantics (Sweetser), a promising direction is suggested by (Wallin, Gärdenfors, 1995).

3.3 Compatibility with legal ontologies

The APE ontology is substantially compatible with two relevant legal ontologies. For example, in terms of Valente's functional legal ontology (Valente, Breuker, Winkels, 1997), regulations would be plans of the *normative knowledge*, while planning that is inherited from non-normative plans would concern plans of *world knowledge*.

Another compatible ontology is that developed by Visser and van Kralingen (Visser, Bench-Capon, 1998, Van Kralingen, 1997), that distinguished between *norms* (rules, standards and principle of behaviour), and *acts* ("dynamic aspects which effect changes in the state of the world"), as well as characterises norms through *legal modalities* and *act identifiers* (the represented activities in our ontology). Moreover, our participation relations cover five of the action aspects used by (van Kralingen, 1997), the sixth one - setting - being covered by our spatio-temporal localization relations.

4. Classification within the integrated ontology and kinds of transformations

The scenario presented by the experts of banking regulations in the project has brought us to generalise the components and resources of the task to be accomplished as follows:
What models, systems, data and required output do we deal with?

[1] The star marks so-called *role-like* concepts (cf. Guarino, Welty, 2000).

- Ontologies decribing plans and activity types (and organisations, persons, etc.).
- Description-logic based classifier systems to manage conceptual models.
- Information systems that acquire and manage data about activity instances.
- We are required to classify activity instances in the information system as activity types in the classifier system. Then, such activities can or cannot be addressed by a certain norm.

Notice that this generalisation can be applied to several domains, for example:
- Does a surgical procedure (instance) conform to the activities suggested by a certain guideline?
- Does an employee behaviour conform to the activity prescribed by a certain code?
- Does the service provided by a firm conform to the conditions prescribed by a contract?
- Does a bank customer's operation conform to the activities described by a money laundering preventing norm?

In our case study, we have:
- Some banking information systems (BIS).
- Different regulatory texts (T) including norms concerning plausibility of bank customers' operations.
- Some knowledge representation systems (KRS) based on description logics (Icom, cf. Franconi, Ng, 2000, and Loom, cf. MacGregor, 1994).
- An ontology library (OL) with general, economic, legal, and dedicated domain ontologies.

By interfacing BIS and KRS, we obtain the indication that a certain activity *a* is classified in the activity type *A* that is addressed by the norm I^T.
If I^T is no more valid because a new regulation T1 has been promulgated, then we should integrate and compare the related ontologies at KRS level.
For the sake of this presentation, we make a minimal commitment to the complexity of norm dynamics. In fact, we assume that the comparison is performed between norms sharing the same properties (modality, decisional structure, promulgation, etc., cf. van Kralingen, 1997, Biagioli, 1997), except (possibly) for the represented activity.

4.1 Comparison relationships

A *comparison relationship* is here a *mapping relationship* (cf. Calvanese, De Giacomo, Lenzerini, 2001, Gangemi, Pisanelli, Steve, 1999) between any two concepts *A* and *B* that characterise the conceptualisation of two norms from two different regulatory texts T and T1 promulgated at different times (T1 being the newer one). The set of concepts characterizing the norms from a text is a *context*. *A* belongs to the context CX_1, *B* belongs to the context CX_2. CX_1 and CX_2 are distinct (at least since they are the characterisation of texts promulgated at different times), but not disjoint, since they share at least some concept C_i belonging to an included context CX_3 containing more general concepts.

If any two activity types ϕ and ψ, represented by *A* and *B* respectively, are classified as equivalent (they arethe same kind of activity), then *A* and *B* are *equivalent*:

EQ(A,B) ← $\phi \equiv \psi$
(*equivalence*)

If an activity type ϕ represented by *A* is subsumed by a different activity type ψ represented by *B* (namely ϕ is equivalent to the conjunction of ψ and an additional property χ), then three mappings can hold between *A* and *B*.
If the norm representing the subsumed activity type belongs to the context that represents the older text, then the new norm *derogates* the older one:

D(A,B) ← $\chi. \neg(\phi \rightarrow \chi) \quad (\psi \rightarrow \chi)$
(*derogation*)

If the norm representing the subsumed activity type belongs to the context that represents the newer text, then the new norm *expands* the older one:

$EX(A,B)$ (*expansion*) $\leftarrow \quad \chi.\ (\phi \rightarrow \chi) \quad \neg(\psi \rightarrow \chi)$

In case *A* and *B* belong to the same context, the institution that promulgated the text failed to recognise a *sub-norm*:

$SN(A,B)$ (*sub-norm*) $\leftarrow \quad \chi.\ (\phi \rightarrow \chi) \quad \neg(\psi \rightarrow \chi)$, with $A \in CX_1, B \in CX_1$

If any two different activity types φ and ψ, represented by *A* and *B* respectively, have a *common direct super-concept* χ (they should be "siblings") except the most general concept for the domain at hand, and there exists no activity type θ such that either φ or ψ are directly subsumed by θ *before* the integration of CX_1 and CX_2, and $\chi = \theta$, then *A amends B*:

$$AM(A,B) \leftarrow \chi\ (\phi \rightarrow \chi) \quad (\psi \rightarrow \chi)$$
$$\neg \quad \theta^{CX1}.\ ((\phi \rightarrow \theta^{CX1}) \quad (\chi = \theta^{CX1}))$$
$$\neg \quad \theta^{CX2}.\ ((\psi \rightarrow \theta^{CX2}) \quad (\chi = \theta^{CX2}))$$

(*amendment*)

In other words, an amendment is implicitly defined here as the substitution of a property P with another property Q (two siblings may have two different properties that characterise them against the common super-concept). Notice that such an amendment is a special case of the conjunction of a derogation and an expansion:

$$AM(A,B) \quad (D(A,B) \quad EX(A,B))$$

In (Gärdenfors, 1992), his definition of *amendment* requires that the property substituted is *negated* in the activity represented by the amended norm (P and Q should be *contradictory*). In our framework, property contradiction is a kind of amendment, with an additional condition holding:

$$CO(A,B) \leftarrow AM(A,B) \quad \kappa,\lambda.\ (\phi \rightarrow \kappa) \quad (\psi \rightarrow \lambda) \quad (\kappa \setminus \lambda)$$

If a norm *A* in CX_1 has no comparison relation with any norm B_i in CX_2, then A has been *inserted.*
If a norm *B* in CX_2 has no comparison relation with any norm A_i in CX_1, then B has been *deleted.*

5. Conclusions

In this paper we have described a preliminary framework to represent norm dynamics as a special case of ontology integration. The framework uses the ontology integration paradigm with classification services through expressive description logics, the formal ontology paradigm with a principled top-level and libraries of relational components, a set of domain ontologies built from texts and semi-formal material, and a set of dedicated mapping relations, called *comparison relationships*, that allow to highlight properties that are subject to change through norm dynamics and that pave the way to the textual markup of conceptual change in legal texts.
Preliminary results within one of the tasks addressed by the European project IKF show that this kind of representation is fruitful and can even improve the presentation of legal texts as a byproduct.

Acknowledgements
This work has been done in the framework of the European Eureka project E!2235 "IKF" (Intelligent Knowledge Fusion). We would like to thank Nicola Guarino, Claudio Masolo, Alessandro Oltramari, Chris Partridge, Milena Stefanova, Tarcisio Teofilatto, Giovanni Martelli, Rita Lattanzi, and Carmine Iorio for the useful discussions.

Bibliography

Biagioli C. Towards a Legal Rules Functional Micro-Ontology. Proceedings of the First International Workshop on Legal Ontologies, Un. Of Melbourne, Law School, Melbourne, Victoria, Australia, 1997.

Breuker J, Valente A, Winkels R. Legal ontologies: A Functional View. Proceedings of the First International Workshop on Legal Ontologies, Un. Of Melbourne, Law School, Melbourne, Victoria, Australia, 1997.

Calvanese D, De Giacomo G, Lenzerini M. A Framework for Ontology Integration. Proc. of 2001 Int. Semantic Web Working Symposium (SWWS 2001).

Franconi E, Ng G. The ICOM Tool for Intelligent Conceptual Modelling. 7th Intl. Workshop on Knowledge Representation meets Databases (KRDB'00), Berlin, Germany, August 2000.

Gangemi A, Guarino N, Masolo C, Oltramari A. Understanding Top-Level Ontological Distinctions, in: H. Stuckenschmidt (ed), *Proceedings of the IJCAI 2001 Workshop on Ontologies and Information Sharing*, 2001.

Gangemi A, Guarino N, Oltramari A. Conceptual Analysis of Lexical Taxonomies: The Case of WordNet Top-Level, in: C Welty, B Smith (eds.), *Proceedings of the 2001 Conference on Formal Ontology and Information Systems,* Amsterdam, IOS Press, 2001.

Gangemi A, Pisanelli DM, Steve G. An Overview of the ONIONS Project: Applying Ontologies to the Integration of Medical Terminologies. *Data and Knowledge Engineering*, 1999, vol.31, pp. 183-220, 1999.

Gärdenfors P, The Dynamics of Normative Systems. *Expert Systems in Law*, ed. by A.A. Martino, Elsevier, 1992.

Guarino N, Welty C. Identity, Unity, and Individuality: Towards a Formal Toolkit for Ontological Analysis. In Werner Horn (ed.) ECAI-2000: Proceedings of the 14th European Conference on Artificial Intelligence, pp. 219-223, IOS Press, Berlin, Germany, 2000.

Kralingen R van. A Conceptual Frame-based Ontology for the Law. Proceedings of the First International Workshop on Legal Ontologies, Un. Of Melbourne, Law School, Melbourne, Victoria, Australia, 1997.

MacGregor RM. A Description Classifier for the Predicate Calculus. *Proc. of AAAI 94,* 1994.

Pisanelli DM, Gangemi A, Steve G, "The Role of Ontologies for an Effective and Unambiguous Dissemination of Clinical Guidelines", in R Dieng, O Corby (eds.), "Knowledge Engineering and Knowledge Management. Methods, Models, and Tools", Berlin, Springer-Verlag, pp. 129-139, 2000.

Visser P, Bench-Capon T. A Comparison of Four Legal Ontologies for the Design of Legal Knowledge Systems, *Artificial Intelligence and Law*, Vol. 6, No. 1, pp. 27-57, 1998.

Wallin S, Gärdenfors P. Linguistic Modality as Expressions of Social Power. *Nordic Journal of Linguistics*, 18, 1995, pp. 137-166.