# MECORI: a Method for Knowledge Base Semantic Verification based on Integrity Constraints

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## 1.Introduction

MECORI is a method which is able to detect inconsistencies defined by integrity constraints (ICs) in a Knowlegde base (KB). The approach of MECORI is similar to that of other methods like COVADIS [Rousset, 1988] or KB-REDUCER [Ginsberg, 1988]. However, the scope of MECORI is wider than the scope of these tools, since it allows us to verify KBs expressed in more powerful knowlegde reprentation formalism called CCR-2 [Martínez, 1993], and it also allows us detect a wider range of inconsistencies by supporting a flexible IC specification language.

## 2.Scope

CCR-2 supports the representation of a high number of object types in the Fact Bases (FBs): frame classes and instances, relationships, propositions, attribute values and attribute identifiers. Moreover, *uncertain reasoning may be represented* in CCR-2 by associating certainty factors to attribute values, to relation tuplas or to propositions. In CCR-2 it is also possible to represent actions that create or destroy objects while executing the KBS, as well as it is feasible to dinamically bind variables with these objects created by rules. This last characteristic allows us to represent *some types of non monotonic reasoning*. Facts in a CCR-2 KB will be classified into two catgories: a deducible fact will be a fact that is obtained for KBS executing; and a external fact will be fact which cannot be deduced by the KBS and can only be obtained form an extenal source.

## 3.Integrity Constraints

An IC defines a consistency criterion over input data, output data or input and output data. The IC form will be $A \Rightarrow \perp$ where A will be a first order logic formula in DNF (disjunctive normal form) that includes conditions over whatever type of CCR-2 object. In addition, it will be possible to specify quantifications for the variables.

## 4.Inputs and Outputs

The inputs to MECORI will be the KB, a set of ICs, the criterion of resolution of conflict set selected by the user and the type of logic that has been used in the KB (closed world hypothesys or trivaluated logic). *MECORI will provide as output the deductive paths which lead to the violation of some IC, as well asan specification of initial FBs that allow the execution of these deductive paths*.

## 5.H_Context

This specification (internally called H_context) will be formed by a set of H_subcontexts. Each H_subcontext will identify a set of conflict initial FBs, and will be formed by an enviroment and a set of deductive paths. An enviroment, in turn, will be a set of H_objects (an H_object is an object pattern) and a set of H_conditions (an H_condition is a constraint over atributte values and certainty factors). A H_object will accumulate during the execution of the method a set of constraints over the features of the CCR-2 object that represents. For example, if ITEM1 is an H_object that represents a frame instance, then some constraints over its features may be: “ITEM1 is a sport car”, “color attribute is white”, “John owns ITEM1” (“own” would be a binary relationship and “John” would be an instance of frame PERSON), etc.

## 6.Operations on H_contexts

Some operations over H_contexts that will be used by the method are: *creation, combination and concatenation*. The creation operation will be used to generate the H_context associated to an external fact; the combination operation will be used to obtain the H_context associated to a conjunction of facts from the H_contexts associated to each fact; and the concatenation operator will be used to obtain the H_context associated to a disjunction of conjunctions from the H_contexts associated to each conjuction, or to obtain the H_context associated to a deducible fact from the H_contexts associated to the rules that allow to deduce this fact.

## 7.MECORI's goal

In order to analize the consistency of a KB, MECORI will have to obtain the H_contexts associated to each IC. If this H_context results to be empty, that means that there is not any valid initial FB that leads to the violation of the IC. If the H_contexts of all ICs are empty, that means that the KB is consistent.

## 8.The method

### 8.1.Preprocessing of an IC

For each IC, in the first place, it will be necessary to bind each IC's variable to an H_object, and to associate each referenced CCR-2 object to an H_object. In this way, it will also be necessary to create some H_conditions, in order to represent the conditions over attribute values and certainty factors that could appear in the IC. Next, the constraints that can be deduced from the IC's conditions will be inserted into the H_objects. As the IC's variables can have universal or existential quantification, a constraint will also be inserted into the H_objects to represent this aspect.

### 8.2.H_context for a fact

Obtaining the H_context of an IC implies obtaining the H_context associated to each fact included in the IC.

If the fact is an external fact, its H_context will be created. The list of deductive paths will be empty and the enviroment will contain just the H_objects and the H_conditions that are directly derived from the fact. In order to obtain the H_context of a deducible fact, MECORI will have to generate the H_contexts associated to all the rules that permit the deduction of the fact (conflict set). To decide whether a rule permits the deduction of a fact, *it will be necessary to verify whether there exists some rule's action that is unificable with the fact*.

Since in CCR-2, *a rule can be executed one or more times consecutively*, it will be necessary to detect and represent this fact in the H_objects as well as in the deductive paths.

### 8.3.H_context for a rule

A CCR-2 rule premise contains a list of conjunctions joined by disjunction operators. Hence, to obtain the H_context of a rule it is necessary to obtain the H_context of each conjunction, and to concatenate them. In order to obtain the H_context of a conjunction it is necessary to obtain the H_context of each fact included in the conjunction and to combine them.

A preprocessing similar to that of an IC will be performed over each conjunction before of obtaining the H_contexts of the included facts. New H_objects and H_conditions will appear and some constraints will be added to the H_objects.

### 8.4.Invalid H_subcontexts

During this recursive process, invalid H_subcontexts could be built. An H_subcontext is invalid when its environment specifies an initial FB that would violate any of the ICs or when it includes any set of logically inconsistent conditions.

Inserting new constraints into an existing H_object could lead to an invalid H_subcontext. An invalid H_subcontext could also happen during the combination of two H_contexts due to the presence of contradictory constraints in the environments of two H_subcontexts, or the presence of contradictory actions belonging to two deductive paths included in two different H_subcontexts. Moreover, since an H_condition represents an arithmetic constraint (in different domains such as integer, real, etc), and a set of H_conditions could appear in an H_subcontext, it is necessary to include in MECORI *some algorithms to verify the satisfacibility of a set of H_conditions*. The dealing of H_conditions in MECORI will be similar to the dealing of constraints in constraint logic programming [Jaffar, 1994].

## 9.Dealing with non-monotonic reasoning

The creation and destruction of objects in the rules actions will be represented by positive or negative constraints in the H_objects. A negative constraint added to an H_object with a positive constraint can reflect the destruction of the object, and it will imply the replacement of a constraint and not an inconsistency as in a monotonic system. In this way, the non monotonic reasoning will be considered by MECORI.

## References


[Ginsberg, 1988] A. Ginsberg. "Knowledge-Base Reduction: A New Approach to checking Knowledge Bases for Inconsistency and Redundancy". Proc. AAAI-88, pp. 585-589.

[Martínez, 1993] L. Martínez Normand. "CCR2: Un Modelo Genérico de Representación del Conocimiento". Trabajo Fin de Carrera, Facultad de Informática, Universidad Politécnica de Madrid, 1993.

[Rousset, 1988] M. Rousset. "On the Consistency of Knowledge Bases: The COVADIS System". Proceedings ECAI-88, Munich, Alemania, pp. 79-84.

[Jaffar, 1994] J. Jaffar, M. J. Maher. "Constraint Logic Programing: A Survey". The Journal of Logic Programming 1994: 19, 20: pp. 503-581.