SCIENTIFIC RELATION
CNR Program: *Short Term Mobility 2007*
Research Title: *Extensional and Intensional Aspects of Conceptual Design*

The Research developed by Dr. *Elvira Locuratolo* in collaboration with Dr. *Jari Palomaki* at the *Institute of the Tampere University of Technology/Pori* is concerned with the applicability of the Partitioning Method to the Concept Theory.

The Partitioning Method [1] is a formal mapping from a directed acyclic graph of classes supported by semantic data models into classes supported by object systems. This method has been designed in order to achieve the coexistence of *flexibility* and *efficiency*, two conflicting quality desiderata. Flexibility is given by the possibility of easily performing modifications on a database schema supported by semantic data models; and efficiency is obtained by means of a correct mapping from a database schema supported by a semantic data model into a schema which can be implemented on an efficient object database system.

The concept theory comprises the distinction between *intension* and *extension* of a concept, where the former is referred to the information content of a concept, whereas the latter to the set of objects which fall under the concept. The intensional and extensional aspects of concepts define two distinct levels of representation since different concepts can have the same extension. In the following, we will refer to the *intensional* aspects of concepts by *concept level*, whereas we will refer to the *extensional* aspects of concepts by *set theoretical level*. At the concept level, we have a relation between concepts. This relation allows us to say that the concept *a* contains intensionally the concept *b*, formally $a \geq b$ if indicates that the information content of *a* is greater or equal to the information content of *b*. Correspondently, at the set theoretical level, we have the inclusion relation between extensions. So, if concept *a* contains intensionally concept *b*, then the extension of concept *a* is a subset of the extension of concept *b*. There is a law of reciprocity between the intensional and the extensional aspects of concepts; i.e., the more intension, the less extension and vice versa.

The Partitioning has been applied to the extensional aspects of concepts. This is because both the directed acyclic graph of classes supported by a semantic data model, in the following called *semantic classes*, and the classes implemented on an object system, in the following called *object classes*, have been represented at the set theoretical level. The attributes are represented as functions in both semantic and object classes, whereas, the mapping from semantic classes into object classes is a collection π of subsets belonging to the root P of the semantic classes, such that:

- $\forall\, S \in \pi, \forall\, T \in \pi$ o $S \cap T = \varnothing$ o S = T
- $\bigcup_{S \in \pi} S = P$

Other algorithms of partition can be designed in order to map semantic classes into object classes; whereas a number of different graphs of objects classes can be obtained starting from a graph of semantic classes.

The idea of applying the Partitioning method to the intensional aspects of concepts is important from both a theoretical and a practical point of view. With regard to the theoretical point of view, the relation between a concept and its extension is many to one. A set of objects can be the extension of many non-identical concepts. We evidence that it is possible to go from the intensional to the extensional aspects of concepts, but not vice versa. With regard to the practical point of view,

we evidence that at the concept level, algorithms of concept constructions correspond to algorithms of partitions where the mathematical requirement of non-emptiness of the subsets can be dropped. Each constructed concept can be understood as a box with a label; even the empty boxes can have a label. Moreover, each object of the considered real world domain can belong to one and only one box.

In [2] an algorithm of partition has been applied to the intensional aspects of concepts as well. This algorithm is concerned with a specific graph of semantic classes, does not consider the attributes and determines object classes which are not recomposed into a directed graph of object classes. During the short term mobility program, in order to apply the method to a generic hierarchy of concepts in intensional containment relation, elementary cases of concept hierarchies have been examined. This addresses the approach generalization. Further, in order to have classes with attributes at the set theoretical level, concepts have been introduced through information contents. Operators of concept construction have been defined and for each elementary case all the concepts implicitly specified in the starting hierarchy have been constructed. A completeness property of concept construction has been determined. The information content of the starting hierarchy coincides with the information content of the constructed concepts. Correspondently, at the set theoretical level, two different types of directed acyclic graphs of classes with attributes have been modeled: a graph of object classes and a graph of semantic classes.

The following properties hold:

- *Object Classes*: each object instance belongs to one and only one class of the graph, thus ensuring efficiency.
- *Semantic Classes*: each object instance can belong to any class of the graph, thus ensuring flexibility

A number of graphs of object classes can correspond to the constructed concept for each elementary case. Each of them can be mapped into a graph of semantic classes. Many mapping algorithms that invert the Partitioning can be designed.

All these results are important for the derivation of practical implications.

References

[1] Locuratolo, E., and Rabitti, F., 1998: "Conceptual Classes and System Classes in Object Databases". *Acta Informatica* 35(3), 181-210.

[2] Locuratolo, E., and Palomaki, J. 2007: Extensional and Intensional Aspects of Conceptual Design. 17th European-Japanese Conference on Information Modeling and Knowledge Bases".Pori, Finland June 4-8, 2007

Dr. Rabitti Fausto

Dr. Locuratolo Elvira Immacolata

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