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Theoretical Foundation for Relationship Construct in Information Modeling --Relation Element Theory

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Abstract

Information modeling is a critical process in software development. One of the key constructs in information modeling is the relationship construct. Though commonly used, the relationship construct is poorly defined and lacks a strong theoretical foundation. The objectives of this research are to define and classify the various relationships based on a theory in linguistic known as the relation element theory. This paper describes the theory, relates the theory to the relationship construct, and discusses the implication of the theory on the relationship construct.

1.0 Introduction

Information modeling can be defined as the process of creating an understandable and elegant specification of the business rules of an enterprise (Kilov & Ross, 1994) for the purpose of understanding and communication (Mylopoulos 1992). In addition to providing the abstraction required for thinking about the enterprise applications (Willumsen 1993), information models provide a formal basis for tools and techniques used in developing and using information systems (Rolland & Cauvet 1992).

The most important components of an information model are its modeling constructs which largely determine the expressive power of the model. One of the fundamental constructs in information modeling is the relationship construct. The relationship construct is hailed as a major construct in modeling the real world by the entity-relationship (ER) community (e.g., Chen 1976). Though some of the earlier object-oriented (OO) models ignored the relationship construct (e.g., Coad & Yourdon 1991), it has survived and resurfaced in many newly proposed object-oriented models (e.g., Rumbaugh et al. 1991, Champeaux et al. 1993, Satzinger & Orvik 1996).

Despite its importance and prominence, the term "relationship" means different things to different people at different times. Sometimes the term conjures up the meaning of generalization-specialization; other times, it represents aggregation or association. The use of fuzzy terms and constructs is detrimental to the progress of science. It is, thus, important to clearly and rigorously define the relationship construct.

In addition, the introduction of various types of relationship (e.g., aggregation, generalization-specialization) is based mainly on intuition and common sense. There is a need to provide a strong theoretical foundation for guiding the development of various types of relationship and defining their precise meanings.

The reference discipline used in this research is linguistic. One specific area of linguistic research has focused on understanding the representation and processing of semantic relations (e.g., Johnson-Laird et al. 1984; Chaffin & Herrmann 1988). And in this area, Chaffin and Herrmann (1984, 1987, 1988) developed the relation element theory. In this research, we will use the relation element theory as the theoretical foundation for understanding the different types of relationship in information modeling.

2.0 Relation Element Theory

The relation element theory postulates that each relationship (or relation) may be regarded as a composition of a set of simpler relation elements. Relations are no longer viewed as unanalyzable primitives, but as the set of relational properties that distinguish them. In other words, this approach accounts for the character and behavior of semantic relations in terms of more primitive relational elements (Chaffin & Herrmann 1987).

2.1 Relation Elements

According to the relation element theory, a semantic relation (R) between two concepts (x and y) is a complex structure composed of one or more primitive dyadic relation elements (Ea...En) that are supported by the meaning of the two concepts.

xRy (Ea...En)

Relations may share one or more elements. The greater the proportion of elements two relations have in common, the more similar they are. Thus, xRy is more similar to iRj than to mRn in the following example:

xRy (E1, E2, E3)

iRj (E1, E2, E4)

mRn (E1, E4, E5)

Relation elements may be hierarchically organized so that the presence of one dependent element (E2) can occur when another independent element is present.

xRy (E1(E2))

A list of relation elements were identified by Chaffin and Herrmann (1984, 1987) (not included in this paper due to space constraint). These elements were used to define the members in the relation families.

2.2 Relation Families

Chaffin and Herrmann (1984) developed an empirical taxonomy of relations by asking subjects to sort examples of relations. Thirty-one relations were identified in the psychological and linguistic literature. The study suggested that relations fall into five major groups: Contrast (night-day, hot-cool), Similar (car-auto, buy-purchase), Class inclusion (robin-bird, furniture-chair), Case (supplier-supply, artist-paint), and Part-whole (bike-wheel, car-engine). Table 1 describes the five families of semantic relations.

3.0 Matching Relationships in Information Modeling

Of the five families of semantic relations proposed by the relation element theory, the contrast and similar relations, to the best of our knowledge, have not been utilized in information modeling. This is of little surprise. Although contrast and similar relations are very common in everyday speech, they have little values in modeling information system applications (at least not yet).

The class, case, and part-whole relations, on the other hand, have been widely used. They correspond closely to the three common types of relationship that are defined in the IS literature: composition (Is-Part-Of or aggregation), generalization-specialization (IS-A), and object or class relationship (relationship or relationship set) (Martin & Odell 1992, Embley et al. 1992).

The class relation is similar to the notion of entity type in ER model and class in OO model. Also, some members of the class family corresponds to generalization-specialization relationship in information modeling. The part-whole relation, on the other hand, resembles the notion of aggregation in ER and OO modeling. Case relation is similar to the relationship or association construct in ER and OO models. Table 2 depicts the relation families derived from relation element theory and their corresponding constructs from different information modeling methods.

4.0 Discussion and Future Research

The relation element theory argues that people comprehend relations by identifying the elements which make up the relation between two words. When viewed this way, standard relations are not the unanalyzable primitive terms of a psychological explanation but are themselves decomposable into more basic elements. Based on this theory, five families of relations were identified. In this paper, we reviewed the relation element theory and showed that there is a good correspondence between the relation families identified by the relation element theory and those used in information modeling methods. We are currently in the process of defining the various types of relationship used in information modeling, including participation relationship such as partial and full, using the list of relation elements proposed by the relation element theory.

Contrast : This family consists of relations in which the meaning of one term contrasts, opposes, or contradicts the other term.
Similar : This family consists of terms that overlap in denotative meaning, connotative meaning, or both.
Class inclusion : Relations in this family involve one term whose denotative meaning subsumes that of the other term.
Case : The family of case relations includes relations between the arguments in the complex knowledge structure called "frames" or "scripts" that have been postulated to account for knowledge of everyday world.
Part-whole : There are a number of distinct part-whole relations. The relations in this family involve inclusion that is pragmatic rather than necessary, as is the case with class inclusion. In other words, the inclusion of part-whole relations is physical rather than an inclusion of the meaning of one term in another.

Table 1 : Five Families of Semantic Relations

Relation Family	Simple ER Model	Enhanced-ER Model	Object-Oriented Model
Contrast	None	None	None
Similar	None	None	None
Class Inclusion	Entity Type	Entity Type Gen-Spec IS-A	Class Gen-Spec
Case	Relationship Type	Relationship Type	Relationship Relation Association Link
Part-Whole	None	Aggregation Is-Part-Of	Aggregation Composition

Table 2 : Corresponding Constructs from Different Models

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