Chapter III

On the Representation of Temporal Dynamics

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ABSTRACT

Research in temporal database management has suggested that the Entity-Relationship model must be extended to compensate for its lack of constructs for representing the world’s dynamic nature. This claimed deficiency arises from the mistaken idea that Entity-Relationship diagrams represent only a snapshot of reality. Practitioners have long used Entity-Relationship diagrams without temporal extensions to design systems with rich support for temporality by using entities to represent the events that cause state changes, rather than by defining temporal attributes and relationships to record past states. While both approaches can represent temporality, only the event approach maintains modeling parsimony and represents why a particular state exists.
INTRODUCTION

Numerous authors recognize the importance of representing the temporal aspects of data, including Dey, Barron, and Storey (1995), Ozsoyoglu and Snodgrass (1995), Etzion, Jajodia, and Sripada (1998), Gregersen and Jensen (1999), and Snodgrass (2000). Managers frequently must know not only the most current data but also historical data. They require facts such as a specific customer’s account balance on a specific date (e.g., on the date that customer was refused additional credit) and the transaction history that lead to that account balance, or the length of time an employee has been at his or her current salary level and the history of salary reviews and salary changes, or the last date on which a stock-out was experienced for a specific inventory item and the history of sales and purchases for that item.

In a seminal book on temporal database research, theory, and implementation, Tansel et al. (1993) state the fundamental motivating assumption of temporal database research as follows: “Conventional databases were designed to capture the most recent data, that is, current data. As new values become available through updates, the existing data values are removed from the database. Such databases capture a snapshot of reality. Although conventional databases serve some applications well, they are insufficient for those in which past and/or future data are also required. What is needed is a database that fully supports the storage and querying of information that varies over time” (preface).

To address this problem, numerous extensions to the relational model and relational databases have been posed. These include the notion of temporal functional dependency (Wang et al., 1997), techniques to facilitate temporal queries (Dean, 1989; Gadia & Yeung, 1988), extensions to the relational model and relational algebra (Gadia, 1988; McKenzie & Snodgrass, 1987), and indexing algorithms to support temporal queries (Kouramajian et al., 1994; Kumar et al., 1998).

The complexity added by these extensions immediately suggests a need for temporal support at the conceptual level. Over a dozen temporally extended entity-relationship models have been proposed (Gregersen & Jensen, 1999; Dey et al., 1995). These modify the E-R model either by adding syntactic constructs or by changing the fundamental definitions of existing constructs. They are based on the assumption that, “The E-R model can at best represent a ‘snapshot’ of the real world at any point in time; it does not contain specific constructs to model the dynamic aspects of the real world. As a result, the E-R model is an inadequate tool for temporal database design” (Dey et al., 1995, p. 306).

Temporality in databases has arisen as a major problem not because of the nature of time or because of limitations to the E-R or relational models. It has arisen
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