

Fundamentals of Object Databases

Object-Oriented and Object-Relational Design

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Fundamentals of Object Databases: Object-Oriented and Object-Relational Design
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SYNTHESIS LECTURES ON DATA MANAGEMENT #12

ABSTRACT

Object-oriented databases were originally developed as an alternative to relational database technology for the representation, storage, and access of non-traditional data forms that were increasingly found in advanced applications of database technology. After much debate regarding object-oriented versus relational database technology, object-oriented extensions were eventually incorporated into relational technology to create object-relational databases. Both object-oriented databases and object-relational databases, collectively known as object databases, provide inherent support for object features, such as object identity, classes, inheritance hierarchies, and associations between classes using object references.

This monograph presents the fundamentals of object databases, with a specific focus on conceptual modeling of object database designs. After an introduction to the fundamental concepts of object-oriented data, the monograph provides a review of object-oriented conceptual modeling techniques using side-by-side Enhanced Entity Relationship diagrams and Unified Modeling Language conceptual class diagrams that feature class hierarchies with specialization constraints and object associations. These object-oriented conceptual models provide the basis for introducing case studies that illustrate the use of object features within the design of object-oriented and object-relational databases. For the object-oriented database perspective, the Object Data Management Group data definition language provides a portable, language-independent specification of an object schema, together with an SQL-like object query language. LINQ (Language INtegrated Query) is presented as a case study of an object query language together with its use in the db4o open-source object-oriented database. For the object-relational perspective, the object-relational features of the SQL standard are presented together with an accompanying case study of the object-relational features of Oracle. For completeness of coverage, an appendix provides a mapping of object-oriented conceptual designs to the relational model and its associated constraints.

KEYWORDS

EER, LINQ, object databases, object-oriented databases, object-relational databases, UML

*To my Jerry and Jeremy
With Love
S. W. D.*

*In memory of my mother,
Carolyn Christine Darling*

*To my husband, Joseph,
for all of his love and support
S.D.U.*

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Preface

This book covers the fundamentals of object databases from a design perspective. An object database is a term used to refer collectively to object-oriented databases (OODBs) and object-relational databases (ORDBs). The reader is assumed to have familiarity with an object-oriented programming language and relational databases with SQL. After introducing the history and fundamentals of object database features, side-by-side Enhanced Entity Relationship and UML diagrams present various conceptual design issues for object-based applications, such as class hierarchies, specialization constraints, and categories. The enterprises introduced in Chapter 1 are used throughout the book to illustrate the mapping of these object models to the ODMG OODB standard in Chapter 2, the object-relational features of the SQL standard in Chapter 3, and the relational model in the Appendix.

Chapter 2 covers OODBs using the ODMG standard for describing and querying database objects. After introducing ODL, the portable, language-independent data definition language for describing object-oriented schemas, Chapter 2 illustrates how to map the conceptual designs from Chapter 1 to ODL. The ODMG standard also includes an object query language, OQL, for querying collections of objects. This coverage provides the foundation for the discussion of the Language INtegrated Query (LINQ) language as a realization of an object query language available in practice. (LINQ can also query collections of tuples and collections of XML elements, although this exposition discusses LINQ's capabilities for querying object collections.) The db4o open-source OODB is used as a case study for illustrating the storage of objects with LINQ as a query language for retrieving objects.

Chapter 3 covers ORDBs using the object-relational features of the SQL standard and a case study in Oracle. After presenting the use of constructed types from the SQL standard, such as row types and arrays, the chapter focuses on the use of User-Defined Types (UDTs). A UDT provides extensibility to the SQL pre-defined types, where the behavior of the type is defined through the use of methods. UDTs can be formed into type hierarchies that support inheritance of attributes and methods. Object references can then be used to create relationships between object types. Substitutable tables are defined to store the objects associated with a UDT and its subtypes. Techniques are also presented for mapping EER and UML schemas to the SQL object-relational data model and for maintaining the constraints of the conceptual design. The Oracle case study elaborates on object extensions to the relational model, describing user-defined types, reference types, typed tables, and table hierarchies, as well as Oracle's support for collections in the form of variable-sized arrays and nested tables.

The appendix covers the mapping of the object-oriented conceptual models to the relational data model and the intricacies of enforcing the object-based constraints within this environment.

The various approaches for representing class hierarchies as tables are presented: table for each class, table for subclasses only, and a table to represent a flattened hierarchy. This coverage forms a basis for understanding the orchestration that object relational mapping (ORM) tools provide in order to view data stored in relational tables as objects.

Suzanne W. Dietrich and Susan D. Urban
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