Chapter 9
Normal Forms for Multimedia Databases

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ABSTRACT

In this chapter we present normal forms for the design of multimedia database schemes with reduced manipulation anomalies. To this aim we first discuss how to describe the semantics of multimedia attributes based upon the concept of generalized icons, already used in the modeling of multimedia languages. Then, we introduce new extended dependencies involving different types of multimedia data. Such dependencies are based on domain specific similarity measures that are used to detect semantic relationships between complex data types. Based upon these new dependencies, we have defined five normal forms for multimedia databases, some focusing on the level of segmentation of multimedia attributes, others on the level of fragmentation of tables.

INTRODUCTION

In the last decade multimedia databases have been used in many application fields. The internet boom has increased this trend, introducing many new interesting issues related to the storage and management of distributed multimedia data. For these reasons data models and database management systems (DBMSs) have been extended in order to enable the modeling and management of complex data types, including multimedia data. Researchers in this field have agreed on many characteristics on which to base the classification of multimedia DBMSs (MMDBMS). Some of them are (Narasimhalu, 1996):

- The data model for representing multimedia information. This should provide effective means to represent relationships among media types.

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- The indexing techniques used to enable content based retrieval of multimedia information.
- The query language. This should allow to efficiently express complex characteristics of data to be retrieved, like multimedia data.
- The clustering techniques on multimedia information to enhance its retrieval.
- Support for distributed multimedia information management.
- Flexible architectures.

The latter is a critical point, because multimedia information systems are in continuous evolution. Thus, it is important that the architectures of MMDBMSs be flexible enough to be extensible and adaptable to future needs and standards. A conspicuous number of MMDBMS products have been developed. Examples include CORE (Wu *et al.*, 1995), OVID (Oomoto & Tanaka, 1993), VODAK (Lohr & Rakow, 1995), QBIC (Flickner *et al*., 1995), ATLAS (Sacks-Davis *et al.*, 1995), etc., each providing enhanced support for one or more media domains among text, sound, image, and video. At the beginning, many DBMS producers would preferably rely on the object-oriented data model to face the complexity of multimedia data, but there have also been examples of MMDBMSs based on the relational data model and on specific, non-standard data models. However, in order to facilitate the diffusion of multimedia databases within industrial environments researchers have been seeking solutions based on the relational data model, possibly associated to some standard design paradigm, like those used with traditional relational DBMSs (RDBMSs). Extensible relational DBMSs have been an attempt in this direction. Such DBMSs store object data using the Binary Large Object (BLOB) data type (IBM, 1995). BLOBs store arbitrarily large objects in a database and allow an object to have complex metadata which may be interrogated using a general query interface.

In the last years DBMS vendors have produced extended versions of relational DBMSs (Rennhackkamp 1997), with added capabilities to manage complex data types, including multimedia. In particular, these new products extend traditional RDBMSs with mechanisms for implementing the concept of object/relational universal server. In other words, they provide means to enable the construction of user defined Data Types (UDT), and Functions for manipulating them (UDF). New standards for SQL have been created, and SQL3 (Elmasri & Navathe, 2003) has become the standard for relational DBMSs extended with object oriented capabilities. The standard includes UDTs, UDFs, LOBs (a variant of BLOBS), and type checking on user defined data types, which are accessed through SQL statements. Early examples of extensible RDBMSs include Postgres (Stonebraker & Kemnitz, 1995), IBM/DB2 version 5 (Davis, 1999), Informix (Rennhackkamp, 1997), and ORACLE 8 (Oracle, 1999).

More recent projects address the needs of applications for richer semantic content. Most of them rely on the MPEG-standards MPEG-7 and MPEG-21. MPEG-7 (Kosch, 2003) is an XML-based multimedia meta-data standard, which proposes description elements for the multimedia processing cycle from the capture, analysis/filtering, to the delivery, and interaction. MPEG-21 (Kosch, 2003) is the standard defining an open multimedia framework that will cover the entire multimedia content delivery chain encompassing content creation, production, delivery, personalization, consumption, presentation and trade. MARS realizes an integrated multimedia information retrieval and database management system, that supports multimedia information as first-class objects suited for storage and retrieval based on their semantic content (Chakrabarti *et al.*, 2000). Multimedia Data Cartridge is a system extension of the Oracle 9i DBMS providing a multimedia query language, access to media, processing and optimization of queries, and indexing capacities

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