



## **Chapter VII**

# **Index Structures for Fuzzy Object-Oriented Database Systems**

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## **Abstract**

*This chapter gives an overview of indexing techniques suitable for fuzzy object-oriented databases (FOODBSs). First, typical query patterns used in FOODBSs are identified, namely, single-valued, set-valued, navigational, and type hierarchy access. The description of the patterns does not follow a particular fuzzy object-oriented data model but is kept general enough to be used in different FOODBS contexts. Second, for each query pattern, index structures are presented that support the efficient evaluation of these queries. These range from standard index structures (like B-trees) to sophisticated access methods (like Join Index Hierarchies). Due to space constraints, an explanation of the basic techniques is given rather than an exhaustive description. However, the interested reader is supplied with a broad list of references for further reading. Finally, a summary and outlook conclude the chapter.*

## Introduction

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One important technique used to accelerate the associative access in database management systems (DBMS) is the use of index structures. When searching for data, we want to avoid the worst case, i.e., having to scan through the whole database and test every data object, because this is inefficient. Index structures help here as they allow fast access to data by content.

Due to the semantic richness of object-oriented DBMSs, we have different methods for indexing than, e.g., in relational DBMSs. Adding fuzziness increases the number of possibilities even further. Unfortunately, publications on indexing in fuzzy object-oriented DBMSs are few and far between. Although indexing in advanced DBMSs (e.g., object-oriented, spatial, image, temporal, or XML databases) is an established research topic (for overviews see Bertino, 1997; Liu, 1996; Luk, 2002; Manolopoulos, 1999; Mueck, 1997), indexing in fuzzy databases has not yet received much attention.

This chapter is organized as follows. First, we give a brief introduction to the concepts of object-oriented DBMSs needed in the remainder of the chapter. Next, we give an overview of the different aspects of accessing data in fuzzy object-oriented DBMSs. In the next section, we investigate several index structures supporting these access patterns. We then express our opinion on future trends in the area of access methods for FOODBs systems. Finally, in the last section, we conclude with a brief summary.

## Preliminaries

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### Storage Hierarchy

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In every computing system, also in every DBMS, we have several layers of storage (Figure 1). Generally, the higher a memory type is positioned in this hierarchy, the faster, the costlier, and the smaller it becomes. The differences between the levels are usually several orders of magnitude. We divide this hierarchy into three subcategories: *primary*, *secondary*, and *tertiary* storage. Primary storage consists of CPU-registers, cache memory, and main memory; secondary storage comprises the disk level; and tertiary storage includes the tape level. We restrict ourselves to the levels that are most important for index structures in DBMSs: main memory and disks.

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