Database Management Systems

Fall 2001

CMPUT 391: Object Oriented Databases

Dr. Osmar R. Zaïane

University of Alberta

Chapter 25 of Textbook

Course Content

- Introduction
- Database Design Theory
- Query Processing and Optimisation
- Concurrency Control
- Data Base Recovery and Security
- **Object-Oriented Databases**
- Inverted Index for IR
- XML
- Data Warehousing
- Data Mining
- Parallel and Distributed Databases
- Other Advanced Database Topics

Objectives of Lecture 6

Object-Oriented Databases

- Discuss limitations of the relational data model.
- Introduce object databases, databases that handle complex data types.
- Understand the difference between object-oriented databases and object-relational databases.

Object-Oriented Databases

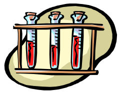
- Shortcomings of Relational Databases
- The Concept of Object data Model
- Object-Oriented Database Systems
- Object-Relational Database Systems
- CORBA

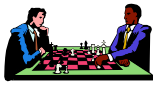
The Need for a DBMS

- On one hand we have a tremendous increase in the amount of data applications have to handle, on the other hand we want a reduced application development time.
  - Object-Oriented programming
  - DBMS features: query capability with optimization, concurrency control, recovery, indexing, etc.
- Can we merge these two to get an object database management system since data is getting more complex?

What are the Needs?

- Images
- Video
- Multimedia in general
- Spatial data (GIS)
- Biological data
- CAD data
- Virtual Worlds
- Games
- List of lists
- User defined data types





Shortcomings with RDBMS

- No set-valued attributes
- No inheritance in the Is-a relationship
- No complex objects, apart from BLOB (binary large object)
- Impedance mismatch between data access language (declarative SQL) and host language (procedural C or Java): programmer must explicitly tell how things to be done.

➔ Is there a different solution?

Existing Object Databases

- Object database is a persistent storage manager for objects:
  - Persistent storage for object-oriented programming languages (C^{++}, SmallTalk,etc.)
  - Object-Database Systems:
    - Object-Oriented Database Systems: alternative to relational systems
    - Object-Relational Database Systems: Extension to relational systems
- Market: RDBMS ($8 billion), OODMS ($30 million) world-wide
- OODB Commercial Products: ObjectStore, GemStone, Orion, etc.

Manipulating New Kinds of Data

- A television channel needs to store video sequences, radio interviews, multimedia documents, geographical information, etc., and retrieve them efficiently.
- A movie producing company needs to store movies, frame sequences, data about actors and theaters, etc. (textbook example)
- A biological lab needs to store complex data about molecules, chromosomes, etc, and retrieve parts of data as well as complete data.
- Think about NHL data and commercial needs.

Object-Oriented Databases

- Shortcomings of Relational Databases
- The Concept of Object data Model
- Object-Oriented Database Systems
- Object-Relational Database Systems
- CORBA

Object Data Model

- The object data model is the basis of object-oriented databases, like the relational data model is the basis for the relational databases.
- The database contains a collection of Objects (similar to the concept of entities)
- An object has a unique ID (OID) and a collection of objects with similar properties is called a class.
- Properties of an object are specified using ODL and objects are manipulated using OML.

Properties of an Object

- **Attributes**: atomic or structured type (set, bag, list, array)
- **Relationships**: reference to an object or set of such objects.
- **Methods**: functions that can be applied to objects of a class.

Abstract Data Type

- One key feature of object database systems is the possibility for the user to define arbitrary new data types.
- A new data type should come with its associated methods to manipulate it. The new data type and its associated methods is called abstract data type (ADT).
- DBMS has built-in types.
- How does the DBMS deal with new data types that were never seen before.

Encapsulation

- Encapsulation = data structure + operations
- It is the main characteristic of object-oriented languages.
- The encapsulation hides the abstract data type internals. ADT= opaque type.
- The DBMS does not need to know how the ADT's data is stored nor how the ADT's methods work. DBMS only needs to know the available methods and how to call them (input/output types of the methods)

Inheritance

•A value has a type
•An object belongs to a class

- Type hierarchy
  - System permits the definition of new types based on other existing types
  - A subtype inherits all properties of its supertype
- Class hierarchy
  - A sub-class C' of a class C is a collection of objects such that each object in C' is also an object in C.
  - An object in C' inherits all properties of C
- Multiple inheritance (inherits from more than just one superclass)
- Selective inheritance (inherits only some of the properties of a superclass)

Object-Oriented Databases

- Shortcomings of Relational Databases
- The Concept of Object data Model
- Object-Oriented Database Systems
- Object-Relational Database Systems
- CORBA

Object-Oriented Databases

- OODBMS aims to achieve seamless integration with an object-oriented programming language such as C++, Java or Smalltalk.
- OODBMS is aimed at applications when an object-centric view point is appropriate. (occasional fetch from object repository)
- No efficient implementations for DML. There are no good optimizations for a query language such as OQL in OODBMSs today.

ODD in OODBMS

- ODL supports atomic types as well as set bad, list array and struct type
- Interface defines a class

```
interface Movie (extent Movies key movieName)
          { attribute date start;
            attribute date end;
            attribute string   movieName;
            relashionship Set<Theater> ShownAt inverse Theater::nowShowing;
          }
interface Theater (extent Theaters key theaterName)
          { attribute string theaterName;
            attribute string address;
            attribute integer ticketPrice;
            relationship Set <Movie> nowShowing inverse Movie::shownAt;
            float numshowing() raises(errorCountingMovies);
          }
```

OML in OODBMS

- The most poplar query language is OQL which is designed to have a syntax similar to SQL.
- OQL is an extension to SQL. It has select, from and where clauses.
- The extensions are to accommodate the properties of objects and the operators on complex data types.

OQL Examples

Find the movies and theaters such that the theaters show more than one movie.

```
SELECT mname: M.movieName, tname: T.theaterName
FROM Movies M, M.shownAt T
WHERE T.numshowing() >1
```

Use of path expression
T is bound to each theater
Related to movie M by
relationship shownAt

Find the different ticket prices and the average number of movies shown at theaters with that ticket price.

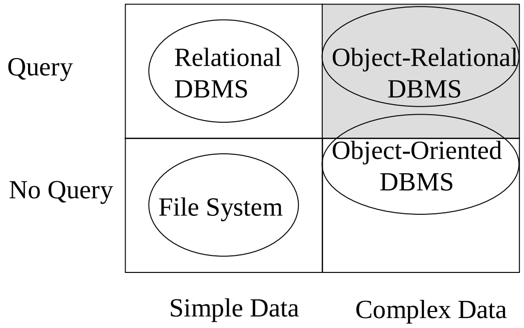
Partitioning in OQL

```
SELECT T.ticketPrice,
           avgNum:AVG(SELECT P.T.numshowing() FROM partition P)
FROM Theaters T
GROUP BY T.ticketPrice
```

Object-Oriented Databases

- Shortcomings of Relational Databases
- The Concept of Object data Model
- Object-Oriented Database Systems
- Object-Relational Database Systems
- CORBA

DBMS Classification Matrix



Query	Relational DBMS	Object-Relational DBMS
No Query	File System	Object-Oriented DBMS
	Simple Data	Complex Data

ORDBMS: What’s new?

- Support for storage and manipulation of large data types (BLOB and CLOB)
- Mechanisms to extend the database with application specific types and methods
  - User defined types
  - User defined procedures
  - Operators for structured types
  - Operators for reference types
- Support for inheritance

User Defined ADT

- A user must define methods that enable the DBMS to read in and to output objects for each new atomic type defined.
- The following methods must be registered with the DBMS:
  - Size: returns the number of bytes of storage
  - Import: creates a new object from textual input
  - Export: maps item to a printable form

```
CREATE ABSTRACT DATA TYPE jpeg_image
   (internallength =VARIABLE, input=jpeg_in,
   output=jpeg_out);
```

Structured Types

- Type constructors are used to combine atomic types and user defined types to create more complex structures:
- ROW(n_1, t_1, …n_n,t_n) : tuple of n fields
- listof(base): list of base-type items
- ARRAY(base): array of base-type items
- setof(base): set of base-type items without duplicates
- bagof(base): multiset of base-type items

Built-in Operators for Structured Types

- Path expression
- Comparisons of sets (⊂⊆=⊇⊃ ∈∪∩−)
- Append and prepend for lists
- Postfix square bracket for arrays
- -> for reference type

Object-Oriented Databases

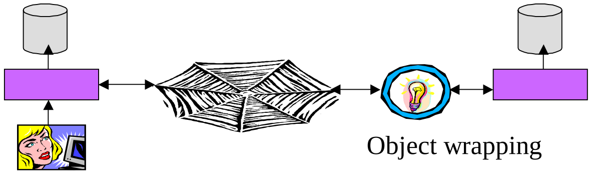
- Shortcomings of Relational Databases
- The Concept of Object data Model
- Object-Oriented Database Systems
- Object-Relational Database Systems
- CORBA

Distributed Objects

- To integrate different applications running on the same or different computers, we use a middleware for distributing objects.
- There are many technologies: COM/DCOM (Distributed / Component Object Model) from Microsoft, CORBA from OMG, RMI with Java, SOAP with XML, etc.
- Heterogeneity is due to:
  - **Engineering tradeoffs**: different solutions across the enterprise
  - **Cost effectiveness**: best system at the lowest price in ≠ times
  - **Legacy systems**: systems too critical or too costly to replace
- Dealing with heterogeneity in distributed computing enterprise & develop open applications is very challenging

Concepts of Middleware

- Objects are sent from one application to the other via a middleware.
- The middleware wraps objects with a network layer
- Some technologies rely on TCP/IP, other on HTTP



CORBA

- CORBA stands for Common Object Request Broker Architecture.
- It is defined and managed by the Object management Group (OMG)
- CORBA is known for Object Orientation, Interoperability, Heterogeneity and Transparent-Distribution.
- Not a product. It is a standard used to exchange data in a heterogeneous environment, large scale enterprise applications distributed on a network.

CORBA con't

- CORBA makes it easier to implement new applications that must place components on different hosts on the network or use different programming languages.
- CORBA encourages the writing of open applications, applications that can be used as components of large systems, each application is made up of components and integration is supported by allowing other applications to communicate directly with these components.

CORBA con't

- OO, Interoperability, and Distribution Out-of-the-box
- Interoperability across languages (Java, C/C++, Ada, Smalltalk, Common LISP, COBOL, etc.)
- Interoperability and Portability across Operating-Systems and Networks (CORBA is available on virtually every OS that you might want to use)
- Distribution / Location Transparency are Fundamental

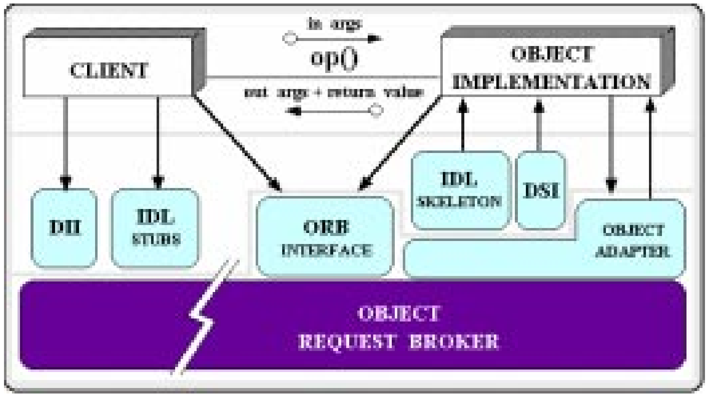
The Notion of Client-Server

- With CORBA there is not rigid notion of a client and a server; components communicate with others on a peer-to-peer basis
- Client and server are roles filled on a per-request basis
- A component can be a client and a server at the same time: client for other services and server for the services it provides

CORBA ORB Architecture

the program entity that invokes an operation on an object implementation

a CORBA programming entity that consists of an *identity*, an *interface*, and an *implementation*



S. Vinoski, CORBA: Integrating Diverse Applications Within Distributed Heterogeneous Environments, *IEEE Communications Magazine*, February, 1997.

References

Steve Vinoski, CORBA: Integrating Diverse Applications Within Distributed Heterogeneous Environments, *IEEE Communications Magazine*, February, 1997.
http://www.cs.wustl.edu/~schmidt/PDF/vinoski.pdf

http://www.cs.wustl.edu/~schmidt/tutorials-corba.html

http://www.omg.org/

http://www.iona.com/