‘Modern’ Databases

Database Systems Lecture 18
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In This Lecture

- 'Modern' Databases
  - Distributed DBs
  - Web-based DBs
  - Object Oriented DBs
  - Semistructured Data and XML
  - Multimedia DBs
- For more information
  - Connolly and Begg chapters 22-28
  - Ullman and Widom chapter 4

Other Sorts of DB

- We have looked mainly at relational databases
  - Relational model
  - SQL
  - Design techniques
  - Transactions
- Many of these topics relied on relational concepts
- There are several other types of DB in use today
  - Distributed DBs
  - Object DBs
  - Multimedia DBs
  - Temporal DBs
  - Logic DBs

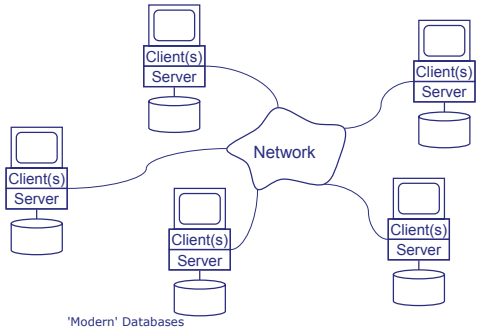
Distributed Databases

- A distributed DB system consists of several sites
  - Sites are connected by a network
  - Each site can hold data and process it
  - It shouldn’t matter where the data is - the system is a single entity
- Distributed database management system (DDBMS)
  - A DBMS (or set of them) to control the databases
  - Communication software to handle interaction between sites

Client/Server Architecture

- The client/server architecture is a general model for systems where a service is provided by one system (the server) to another (the client)
- Server
  - Hosts the DBMS and database
  - Stores the data
- Client
  - User programs that use the database
  - Use the server for database access

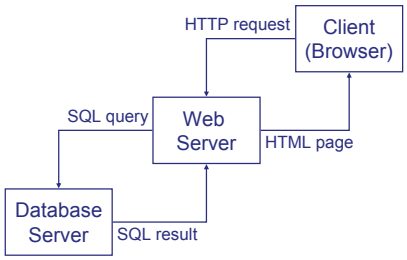
Distributed Databases



Web-based Databases

- Database access over the internet
  - Web-based clients
  - Web server
  - Database server(s)
- Web server serves pages to browsers (clients) and can access database(s)
- Typical operation
  - Client sends a request for a page to the web server
  - Web server sends SQL to database
  - The web server uses results to create page
  - The page is returned to the client

Web-based Databases



Web-based Databases

- Advantages
  - World-wide access
  - Internet protocols (HTTP, SSL, etc) give uniform access and security
  - Database structure is hidden from clients
  - Uses a familiar interface
- Disadvantages
  - Security can be a problem if you are not careful
  - Interface is less flexible using standard browsers
  - Limited interactivity over slow connections

Object Oriented Databases

- Relational DBs
  - The database can't see data's internal structure so can't use complex data
  - Relational model gives a simple, and quite powerful, structure - but is quite rigid
- Object Oriented DBs
  - Use concepts from object oriented design/programming
  - OO concepts
    - Encapsulation
    - Inheritance
    - Polymoprhism
  - OODBMS

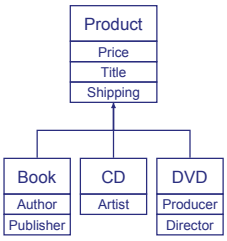
Object Oriented Databases

- An object oriented database (OODB) is a collection of persistent objects
  - Objects - instances of a defined class
  - Persistent - object exist independently of any program
- An object oriented DBMS
  - Manages a collection of objects
  - Allows objects to be made persistent
  - Permits queries to be made of the objects
  - Does all the normal DBMS things as well

OODB example

- In lecture 10 we had a store with different sorts of products
  - Books
  - CDs
  - DVDs
- This lead to missing data among the various types
- OODB solution
  - We make an abstract Product class
  - Book, CD, and DVD are each a concrete subclass of Product
  - The database is a persistent collection of Products

OODB Example



- Product is abstract
  - You cannot make a Product directly
  - You can, however, make a Book, CD, or DVD, and these are Products

Object Oriented Databases

- Advantages
  - Good integration with Java, C++, etc
  - Can store complex information
  - Fast to recover whole objects
  - Has the advantages of the (familiar) object paradigm
- Disadvantages
  - There is no underlying theory to match the relational model
  - Can be more complex and less efficient
  - OODB queries tend to be procedural, unlike SQL

Object Relational Databases

- Extend a RDBMS with object concepts
  - Data values can be objects of arbitrary complexity
  - These objects have inheritance etc.
  - You can query the objects as well as the tables
- An object relational database
  - Retains most of the structure of the relational model
  - Needs extensions to query languages (SQL or relational algebra)

Semistructured data

- Semistructured Data : A new data model designed to cope with problems of information integration.
- XML : A standard language for describing semistructured data schemas and representing data.

The Information-Integration Problem

- Related data exists in many places and could, in principle, work together.
- But different databases differ in:
  - Model (relational, object-oriented?).
  - Schema (normalised/ not normalized?).
  - Terminology: are consultants employees? Retirees? Subcontractors?
  - Conventions (meters versus feet?).
- How do we model information residing in heterogeneous sources (if we cannot combine it all in a single new database)?

Example

- Suppose we are integrating information about bars in some town.
- Every bar has a database.
  - One may use a relational DBMS; another keeps the menu in an MS-Word document.
  - One stores the phones of distributors, another does not.
  - One distinguishes ales from other beers, another doesn't.
  - One counts beer inventory by bottles, another by cases.

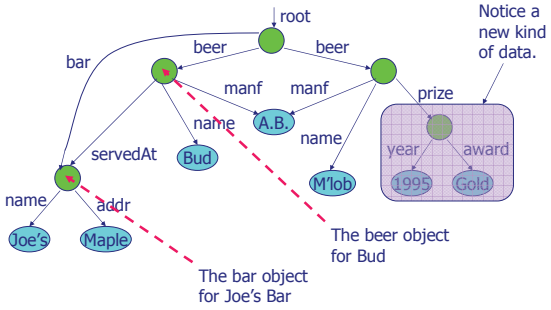
Semistructured Data

- Purpose: represent data from independent sources more flexibly than either relational or object-oriented models.
- Think of objects, but with the type of each object its own business, not that of its "class."
- Labels to indicate meaning of substructures.
- Data is self-describing: structural information is part of the data.

Graphs of Semistructured Data

- Nodes = objects.
- Labels on arcs (attributes, relationships).
- Atomic values at leaf nodes (nodes with no arcs out).
- Flexibility: no restriction on:
  - Labels out of a node.
  - Number of successors with a given label.

Example: Data Graph



XML

- XML = E**x**tensible **M**arkup **L**anguage.
- While HTML uses tags for formatting (e.g., "italic"), XML uses tags for semantics (e.g., "this is an address").
- Key idea: create tag sets for a domain (e.g., bars), and translate all data into properly tagged XML documents.
- Well formed XML - XML which is syntactically correct; tags and their nesting totally arbitrary.
- Valid XML - XML which has DTD (document type definition); imposes some structure on the tags, but much more flexible than relational database schema.

XML and Semistructured Data

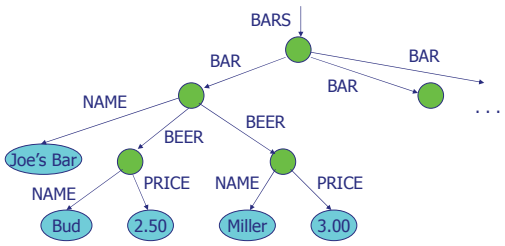
- Well-Formed XML with nested tags is exactly the same idea as trees of semistructured data.
- XML also enables non-tree structures (with references to IDs of nodes), as does the semistructured data model.

Example: Well-Formed XML

```
<? XML VERSION = "1.0" STANDALONE = "yes" ?>
<BARS>
   <BAR><NAME>Joe's Bar</NAME>
        <BEER><NAME>Bud</NAME>
              <PRICE>2.50</PRICE></BEER>
        <BEER><NAME>Miller</NAME>
              <PRICE>3.00</PRICE></BEER>
   </BAR>
   <BAR> …
</BARS>
```

Example

- The <BARS> XML document is:



XPATH and XQUERY

- XPATH is a language for describing paths in XML documents.
  - Really think of the semistructured data graph and *its* paths.
  - Why do we need path description language: can't get at the data using just Relation.Attribute expressions.
- XQUERY is a full query language for XML documents with power similar to OQL (Object Query Language, query language for object-oriented databases).

Multimedia Databases

- Multimedia DBs can store complex information
  - Images
  - Music and audio
  - Video and animation
  - Full texts of books
  - Web pages
- They can be used in a wide range of application areas
  - Entertainment
  - Marketing
  - Medical imaging
  - Digital publishing
  - Geographic Information Systems

Querying Multimedia DBs

- Metadata searches
  - Information about the multimedia data (metadata) is stored
  - This can be kept in a standard relational database and queried normally
  - Limited by the amount of metadata available
- Content searches
  - The multimedia data is searched directly
  - Potential for much more flexible search
  - Depends on the type of data being used
  - Often difficult to determine what the 'correct' results are

Metadata Searches

- Example - indexing films we might store
  - Title
  - Year
  - Genre(s)
  - Actor(s)
  - Director(s)
  - Producer(s)
- We can then search for things like
  - Films starring Kevin Spacey
  - Films directed by Peter Jackson
  - Dramas produced in 2000
- We don't actually search the films

Metadata Searches

- Advantages
  - Metadata can be structured in a traditional DBMS
  - Metadata is generally concise and so efficient to store
  - Metadata enriches the content
- Disadvantages
  - Metadata can't always be found automatically, and so requires data entry
  - It restricts the sorts of queries that can be made

Content Searches

- An alternative to metadata is to search the content directly
  - Multimedia is less structured than metadata
  - It is a richer source of information but harder to process
- Example of content based retrieval
  - Find images similar to a given sample
  - Hum a tune and find out what it is
  - Search for features, such as cuts or transitions in films

Content-Based Retrieval

QBIC™ (Query By Image Content) from IBM - searches for images having similar colour or layout

http://wwwqbic.almaden.ibm.com/cgi-bin/stamps-demo

Content-Based Retrieval

- Image retrieval is hard
  - It is often not clear when two images are 'similar'
  - Image interpretation is unsolved and expensive
  - Different people expect different things

- Do we look for?
  - Images of roses
  - Images of red things?
  - Images of flowers?
  - Images of red flowers?
  - Images of red roses?

Other Topics

- Temporal DBs
  - Storing data that changes over time
  - Can ask about the history of the DB rather than just the current state
  - System time vs real time
- Logic DBs
  - A database is a set of facts and rules for manipulating them (like a Prolog program)
  - The DBMS maintains and controls these facts and rules
  - A 'query' is made by applying the rules to the facts

Next week

- Wednesday 12-1: Revision and module evaluation lecture
- If you have suggestions for revision questions, please email me!
- Monday the 28th 9-10: Java and SQL lecture (optional – not in the exam)