CSCI 1320
Creating Modern Web Applications
Lecture 15: Databases II
SQL INSERT Statement

- INSERT INTO table ( field, ..., field )
  VALUES ( val,...val)
  - List of fields is optional, but should be there
    - Avoids problems in future, reminds reader of what is what
  - Values can be
    - DEFAULT
    - Constants [ true, false, 0, ... ]
    - Built-in Functions [ CURRENT_TIMESTAMP ]
    - Variables – use $, $i, ? and pass values separately
    - Results of queries [ (SELECT id FROM Artist A WHERE A.name = 'nsync') ]

- INSERT INTO table (field, ..., field) SELECT ...
SQL UPDATE Statement

- UPDATE table SET field = value WHERE condition
  - SET field = value, field = value, ...
  - Values as in an insert statement
  - WHERE as in normal select
- Can update multiple rows at once
  - Be careful with the condition
SQL DELETE Statement

• DELETE FROM table WHERE condition
  • Removes all rows in table where condition is true
  • If condition is omitted, deletes all rows
Embedded SQL

• SQL is used inside programs
  • Actually built into some languages
  • Create a string representing the query
  • Pass that string to the database to interpret

• Concepts
  • **Connection**: connection to the database
    • Accessed by a URL giving type, host, database, user, pwd, ...
  • **Statement**: set of SQL statements to be executed as one
    • Typically a single query or set of updates
  • **ResultSet**: iterator over a returned table
    • Can iterate over tuples in the returned values
    • Can access fields of the current tuple

• Any-DB makes this a little easier
Using Embedded SQL Safely

• Queries and updates are built as strings
  • Provides flexibility
  • Lets program add user-entered values to the queries
  • Can be problematic if user values are non-standard

• Prepared statements
  • Queries with variables are defined as strings
  • Variables in the query are represented by $, $i, or ?
  • Values are passed when the query is used
  • Can be faster (database can optimize the query once)
  • Safer and more secure
  • Use when possible (and its always possible)
Relational Database Schema

- The tables define the **database schema**
  - Table names
  - Set of attributes/fields for each table
  - Each attribute is typed
  - Tables can have a KEY
  - Tables can have permissions
  - Tables can have constraints (e.g. NOT NULL, FOREIGN KEY)

- **Schema can contain other information**
  - Indices on the tables
  - Virtual tables (VIEWS)
Rules for Table Organization

• How the tables are organized is important
• Based on the relationships among data items
  • If x => y (e.g. DiskId => Title, length,...) put in same table
  • If x is used multiple times, make it a separate table
    • Especially if x has multiple values or long values
  • If x can occur multiple times for y, create a separate table
    • Just for relating x and y
  • If table will be referenced by other tables, add an id field
    • As a key field
Database Manager Position

• In general this is a difficult problem
  • Need to understand semantics of the data
  • Need to understand how the data will evolve
• If you get it wrong, what happens?
  • With only queries, not much
  • If the data is update, it might become inconsistent
    • Artist information for example
  • If the data relationships are updated, might not fit structure
    • Multiple artist CDs
• Database manager position
  • Handles setting up, changing, updating, etc. the database
Transactions

• Multiple operations might need to be done together
  • BEGIN TRANSACTION name
    • Operation
    • Operation
    • Operation
  • COMMIT TRANSACTION name
• Example: withdraw and deposit to transfer funds
• Database guarantees that transactions appear sequential
  • No intermediate changes by others
  • Operations all done or all not done (atomic)
  • ACID semantics
• Use any-db-transaction when using Node.JS
Batch Processing

- Large numbers of inserts (or updates) can be inefficient
  - But doing them all at once can be a lot faster
  - Can create BATCH updates
    - Like transactions (can use transactions for this)
    - Part of Statement interface for embedded SQL
  - Most databases provide a means for batch inserts
    - Insert multiple tuples into a relation
    - Data comes from a file
Schema Updates

• Tables are going to change
  • Applications evolve over time
  • New data is needed, old data no longer needed

• Adding tables is easy
• Modifying tables is possible
  • ALTER TABLE ADD newfield int DEFAULT 0
  • Can remove fields, add constraints, add indices, ...
  • Beware of constraints between tables

• This can be an expensive operation
  • And might require other computation (computing initial values)

• Can be tricky
  • Might involve dependencies, indices, constraints
  • Maintaining a test database and a production database

ALTER TABLE Statement

ALTER TABLE statement alters or modifies existing table.
Syntax: ALTER TABLE table-name {
  { ADD [ COLUMN ] column-definition } |
  { DROP [ COLUMN ] column-name |
    [ RESTRICT | CASCADE ] } |
  { ALTER [ COLUMN ] column-name |
    [ SET DEFAULT default-value |
    DROP DEFAULT ] } |
  { ADD table-constraint-definition } |
  { DROP CONSTRAINT constraint-name |
    [ RESTRICT | CASCADE ] }
}
Permissions

• External database systems control access
  • Users (independent of system users)
  • Permissions (on a table-by-table basis)

• When you set up the database you can set up users
  • With different permissions on different tables

• This can provide a safeguard in your application
  • Application normally runs as a limited access user
  • Administrative tasks run with more privileges

• Think about permissions when you set up your database
  • Create a separate user for your application
Which SQL Database System to Use

• Sqlite3, Derby
  • Only for experimentation, small-scale applications
  • Embedded use only (single access point)

• MySQL, PostgreSQL
  • Most common for web applications
    • Extensions to both to handle scaling are available
  • Roughly equivalent
    • PostgreSQL has better extensibility

• Db2, SqlServer, Oracle
  • For larger databases, better support
SQL Databases

• Pros
  • ACID semantics (transactions, guaranteed consistency)
  • Queries handled by the database engine (little code)
  • Portable
  • Data consistency through the schema
  • Supports complex indices, triggers, constraints

• Cons
  • Replication of the database is difficult
  • Don’t scale that well to huge databases
  • Not good at storing unstructured documents (blobs)
  • Complex Database Manager issues
  • Changing schema requires thought and effort

• Can we do better for web applications?
Question

Suppose we want to go beyond SQL databases. NoSQL databases are a response to the needs of modern web applications. Which is not a characteristic of such databases?

A. They can be accessed directly from HTML5 using database extensions
B. They support eventual consistency rather than immediate consistency
C. They typically use a simple or specialized query language.
D. They provide the ability to easily shard or replicate data
E. They provide specialized implementations suitable for particular types of applications.
NOSQL Databases

• **No SQL**
  • Essentially key-value stores
    • Arbitrary values, single key; look up by key
    • Indexed by key
  • Eventual consistency (no transactions)

• **Not-Only SQL**
  • Trend to make these more like SQL databases
  • NewSQL databases combine SQL queries with No-SQL-style stores

• **Index on particular fields**
  • Field value -> { key } is what is in index

• **Simple queries**
  • Given a set of field values, find corresponding data values
  • Done my intersecting key sets
  • Take resultant key set and allow iteration over values
MongoDB: a simple (sophisticated) NoSQL

- Store JSON objects

```javascript
db.cds.insert({
  diskid: '2a04b804',
  title: 'Body & Soul',
  artist: 'SPEED',
  length: 1210,
  genre: 'jpop',
  year: 1996,
  tracks: [
    { name: 'Body & Soul', artist: 'SPEED', length: 302, number: 0, offset: 187 },
    { name: 'I Remember', artist: 'SPEED', length: 278, number: 1, offset: 22892 },
    { name: 'Body & Soul (hand Bag Mix)', artist: 'SPEED', length: 323, number: 2, offset: 43777 },
    { name: 'Body & Soul (instrumental)', artist: 'SPEED', length: 302, number: 3, offset: 68070 }
  ]
});
```
MongoDB Collections

• Basic Storage is a collection
  • Set of json objects
  • Each has a unique identifier (generated by Mongo)
  • Fast lookup based on identifier

• Access methods on a collection
  • `db.<collection>.find(query, projection)`
  • Query: `{ field: { $eq: <value> }, ... }` ($eq,$gt, ...)
    • Field can be “field” or “field.subfield”
    • Can do most queries over a single collection
  • Projection: `{ field: 0|1, .... }`
    • 1 => include field, 0 => exclude field
MongoDB Indices

- `db.<collection>.createIndex(keys,options)`
  - Keys: `{ field : 1 }` (for ascending)
  - `ensureIndex` in some versions

- **Mongo supports text indexing**
  - Keys: `{ field : ‘text’ }`
  - Keys: `{ "$**" : "text" }`

- **Text query**
  - `db.<collection>.runCommand('text', { search: 'words' })`
  - Words: if multiple, then OR of the words (ala Google, w/ ranking)
  - Can use ‘"word1" "word2" "word phrase" ‘ as well (and)
MongoDB CRUD

- `db.<collection>.insert ( { ... } )`
  - Newer versions support `insertMany`
- `db.<collection>.update( { query}, { update })`
  - Query: similar to a find query
  - Update: `{ $set : { field : ‘value’ } }`
- `db.<collection>.remove( { query } )`
- `db.<collection>.bulkWrite( [ ... ] )`
  - Bulk operations via `bulkWrite`
Distributed Mongo

- Mongo makes it easy to split up a collection
  - Into distinct portions called shards
  - Based on mongo-generated key or on user key
    - Can shard database to match different servers
  - Makes very large databases possible
  - Makes very large databases faster
- Also does distributed processing
  - Handles scaling to very large databases
Mongo Transactions

• No ACID guarantees
  • Clients may see writes before they are committed
  • If a query updates multiple documents, might read some updates and not others

• BASE instead
  • High availability
  • Eventual consistency

• Newer versions provide transactions
NOSQL Databases

• Pros
  • Can store arbitrary objects
  • Easy to set up and use (little management)
  • Easy to change
  • Scales nicely

• Cons
  • No transactional guarantees
  • Data consistency is up to the user
  • Complex queries need to be coded explicitly
What Type of Database to Use

• How important are ACID guarantees
  • Newer versions of Mongo provide some of this

• How important is data consistency
  • SQL provides constraints and triggers

• How important is scalability
  • Newer versions of SQL database provide sharding, etc.

• How varied and complex are the queries
  • Complex, unanticipated NoSQL queries require code

• How complex is the data and how often does the schema change
  • Complex data is much easier in NoSQL

• Might want a combination of databases
  • Some for complex data
  • Some for users, authentication, etc. where ACID is useful
Elevator Talks

• Three Minute Sales Pitch (includes 1 minute for questions)
• Convince a someone to invest in your project
• Important points
  • What is the problem
  • What is your solution
  • Why is this important
  • Why should the audience be interested
Next Time

• Database LAB
  • Do the pre labs
  • Look up Six Degrees of Kevin Bacon

• Monday/Wednesday: Elevator talks