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Implementation of a Relational Database Query-Processing System

Hawk Weisman

Department of Computer Science Allegheny College

December 8th, 2014

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Query processing:

- An application of many concepts from compilers
- Vital to today's world (databases are everywhere)

■ DeeBee:

- A very small relational database (<1500 LoC)
- Implements a subset of the Structured Query Language
- For educational purposes only (don't use this in production)
- Written in the Scala programming language

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- "The primary data model for commercial data-processing applications." [13, 39]
- A database consists of multiple tables of values, called relations [13, 8, 4]
- A relation consists of: [13, 8, 4]
 - a set of rows, or tuples
 - a set of columns, or attributes
- So how does this relate to compilers?

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■ Users and client software interact with databases through query languages [13, 8, 4]

- These are domain-specific languages for accessing and modifying the database
- Query languages are declarative rather than imperative [13, 8, 4]
- Just like other programming languages, query languages must be parsed, analyzed, and compiled or interpreted. [13, 8, 4]

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SQL is the Structured Query Language.

- It is the query language used by most modern RDBMSs
- SQL consists of two components:
 - Data definition language (DDL): defines the structure of the database [13, 8]
 - creating and deleting tables
 - adding relationships between tables
 - et cetera
 - Data manipulation language (DML): accesses and modifies data stored in the database [13, 8]
 - selecting rows
 - adding, deleting, and modifying rows
 - et cetera
- SQL = DDL + DML

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Example (SQL CREATE TABLE statement (schema))

```
CREATE TABLE Writers (
    id
                   INTEGER NOT NULL PRIMARY KEY,
    first name
                          VARCHAR (15) NOT NULL,
    middle name
                          VARCHAR (15),
    last name
                          VARCHAR (15) NOT NULL,
    birth_date
                          VARCHAR (10) NOT NULL,
                          VARCHAR (10),
    death date
    country_of_origin
                          VARCHAR (20) NOT NULL
);
```

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Example (SQL SELECT statement)

```
SELECT * FROM test;
SELECT test1, test2 FROM test;
SELECT * FROM test WHERE test1 = 9 AND test2 = 5;
SELECT * FROM test LIMIT 5;
```

Example (SQL DELETE statement)

```
DELETE FROM test WHERE test2 > 3 LIMIT 100;
```

Example (SQL INSERT statement)

```
INSERT INTO test VALUES (
  1, 'a string', 2, 'another string'
);
```

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Steps in Query Evaluation

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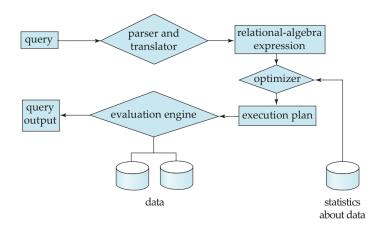


Figure: Steps in query processing [13, 583].

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Query Processing

A query processor is essentially a compiler!

- Some stages in the query evaluation process
 - Parsing
 - Semantic analysis

 - Optimization

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- A query processor is essentially a compiler!
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 - Parsing
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DeeBee implements a subset of SQL

- Chosen to balance functionality with time constraints
 - SELECT statements
 - Projections (SELECT a, b FROM ...)
 - Filtering by predicates (SELECT * FROM table WHERE ...)
 - Nested predicates (WHERE ... AND ...)
 - LIMIT clauses
 - No JOINS
 - INSERT statements
 - DELETE statements
 - WHERE and LIMIT clauses
 - Same implementation as SELECT
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Parsing Demo Query Processin ■ The actors model [6, 7, 1]

- A construct for concurrent programming
- Actors communicate through message passing
- Messages are:
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 - Event-driven (good for databases)
- In Scala, the Actors model is provided by the Akka framework

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 - sending query results to the querying entity
 - creating and deleting table actors
- A table actor is responsible for:
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 - (possibly) updating its' state
 - responding with query results or errors

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SQL queries are internally represented using an abstract syntax tree (AST)

- Connection actors recieve query strings, parse them, and send the AST to the database actor
- Database actor either:
 - processes DDL queries by creating/deleting tables
 - dispatches DML queries to the target child table
- Queries are interpreted (not compiled) against a context

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- This is a functional-programming approach to text parsing
 - A parser is a function which accepts some strings and rejects others
 - A parser-combinator is a higher-order function which takes as input two or more parsers and returns combined parser
 - By repeatedly combining simpler parsers into more complex ones, a recursive-descent parser can be created

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- DeeBee's query processor parses queries using combinator parsing [11, 14, 2, 12]
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Scala's parsing library follows the philosophy of embedded DSLs [5, 9, 11, 12]

■ It allows parsers to be specified in BNF-like syntax

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Packrat parsers add a memoization facility [10, 3]

- Guarantees unlimited lookahead and linear parse time
- Allows parsing of left-recursive grammars
- Parser functions are replaced by lazily-evaluated values

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- - Type checking
 - In a compiler, context is preceeding program statements
 - In DBMS, context is the schema of the target table
 - Predicate interpretation
 - Convert AST nodes to Scala partial functions
 - Constraints validation

 - Eventually, this will be deferrable for transaction

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 - Nested predicates are constructed from leaves to roots
 - Constraints validation
 - Ensure queries don't violate table constraints
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Appendix References

References

- [1] Gul Abdulnabi Agha. Actors: a model of concurrent computation in distributed systems. 1985.
- [2] Jeroen Fokker. Functional parsers. In *Advanced Functional Programming*, pages 1–23. Springer, 1995.
- [3] Richard A Frost, Rahmatullah Hafiz, and Paul Callaghan. Parser combinators for ambiguous left-recursive grammars. In *Practical Aspects of Declarative Languages*, pages 167–181. Springer, 2008.
- [4] Hector Garcia-Molina, Jeffrey D Ullman, and Jennifer Widom. *Database System Implementation*, volume 654. Prentice Hall Upper Saddle River, NJ:, 2000.
- [5] Debasish Ghosh. *DSLs in action*. Manning Publications Co., 2010.



References II

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Appendix

References

- [6] Munish Gupta. *Akka Essentials*. Packt Publishing Ltd, 2012.
- [7] Philipp Haller. On the integration of the actor model in mainstream technologies: the scala perspective. In Proceedings of the 2nd edition on Programming systems, languages and applications based on actors, agents, and decentralized control abstractions, pages 1–6. ACM, 2012.
- [8] Jan L Harrington. *Relational database design and implementation: clearly explained*. Morgan Kaufmann, 2009.

References III

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Appendix References

References

- [9] Christian Hofer, Klaus Ostermann, Tillmann Rendel, and Adriaan Moors. Polymorphic embedding of DSLs. In *Proceedings of the 7th International Conference on Generative Programming and Component Engineering*, pages 137–148. ACM, 2008.
- [10] Manohar Jonnalagedda, Martin Odersky, and Tiark Rompf. Packrat Parsing in Scala. Technical report, Ecole Polytechnique Fédérale de Lausanne, 2009.
- [11] Adriaan Moors, Frank Piessens, and Martin Odersky. Parser combinators in Scala. Technical report, Katholieke Universiteit Leuven, 2008.
- [12] Martin Odersky, Lex Spoon, and Bill Venners. *Programming in Scala*. Artima Inc, 2008.
- [13] A. Silberschatz, H. Korth, and S. Sudarshan. *Database System Concepts*. McGraw-Hill Education, 2010.

References IV

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Appendix References

References

[14] S Doaitse Swierstra. Combinator parsers: From toys to tools. *Electronic Notes in Theoretical Computer Science*, 41(1):38–59, 2001.