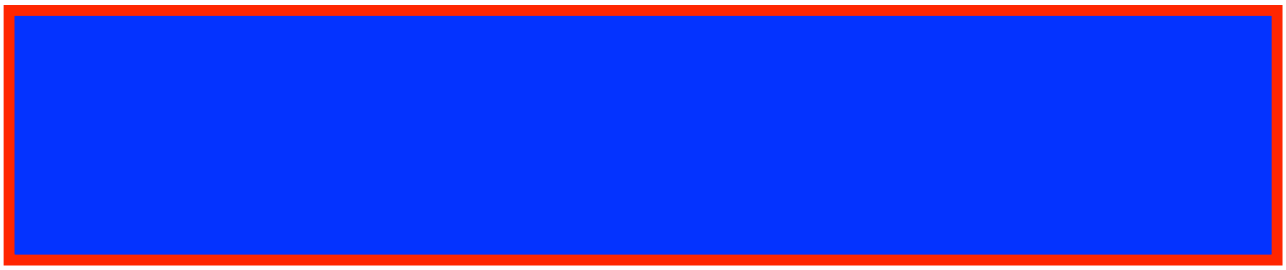
2.7 Summary

- The relational data model is based on a collection of tables. The user of the database system may query these tables, insert new tuples, delete tuples, and update (modify) tuples. There are several languages for expressing these operations.
- The schema of a relation refers to its logical design, while an instance of the relation refers to its contents at a point in time. The schema of a database and an instance of a database are similarly defined. The schema of a relation includes its attributes, and optionally the types of the attributes and constraints on the relation such as primary and foreign-key constraints.
- A superkey of a relation is a set of one or more attributes whose values are guaranteed to identify tuples in the relation uniquely. A candidate key is a minimal superkey, that is, a set of attributes that forms a superkey, but none of whose subsets is a superkey. One of the candidate keys of a relation is chosen as its primary key.
- A foreign-key constraint from attribute(s) A of relation r_1 to the primary-key B of relation r_2 states that the value of A for each tuple in r_1 must also be the value of B for some tuple in r_2. The relation r_1 is called the referencing relation, and r_2 is called the referenced relation.

- A schema diagram is a pictorial depiction of the schema of a database that shows the relations in the database, their attributes, and primary keys and foreign keys.
- The relational query languages define a set of operations that operate on tables and output tables as their results. These operations can be combined to get expressions that express desired queries.
- The relational algebra provides a set of operations that take one or more relations as input and return a relation as an output. Practical query languages such as SQL are based on the relational algebra, but they add a number of useful syntactic features.
- The relational algebra defines a set of algebraic operations that operate on tables, and output tables as their results. These operations can be combined to get expressions that express desired queries. The algebra defines the basic operations used within relational query languages like SQL.

Review Terms

- Table
- Relation
- Tuple
- Attribute
- Relation instance
- Domain
- Atomic domain
- Null value
- Database schema
- Database instance
- Relation schema
- Keys
  - Superkey
  - Candidate key
  - Primary key
  - Primary key constraints
- Foreign-key constraint
  - Referencing relation
  - Referenced relation
- Referential integrity constraint
- Schema diagram
- Query language types
  - Imperative
  - Functional
  - Declarative
- Relational algebra
- Relational-algebra expression
- Relational-algebra operations
  - Select σ
  - Project Π
  - Cartesian product $\times$
  - Join $\bowtie$
  - Union $\cup$
  - Set difference $-$
  - Set intersection $\cap$
  - Assignment $\leftarrow$
  - Rename ρ

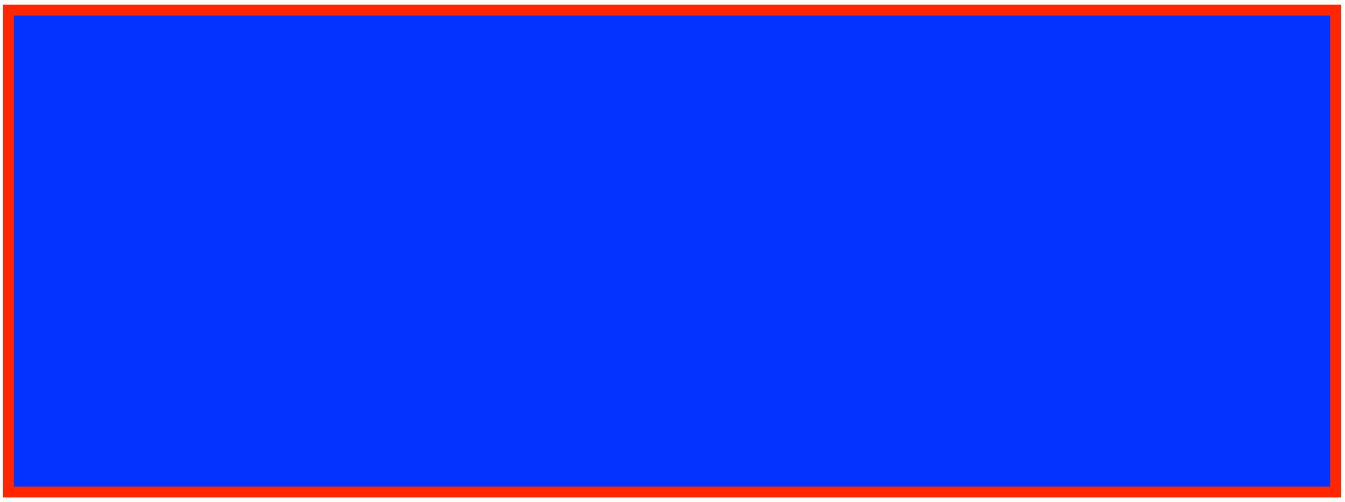


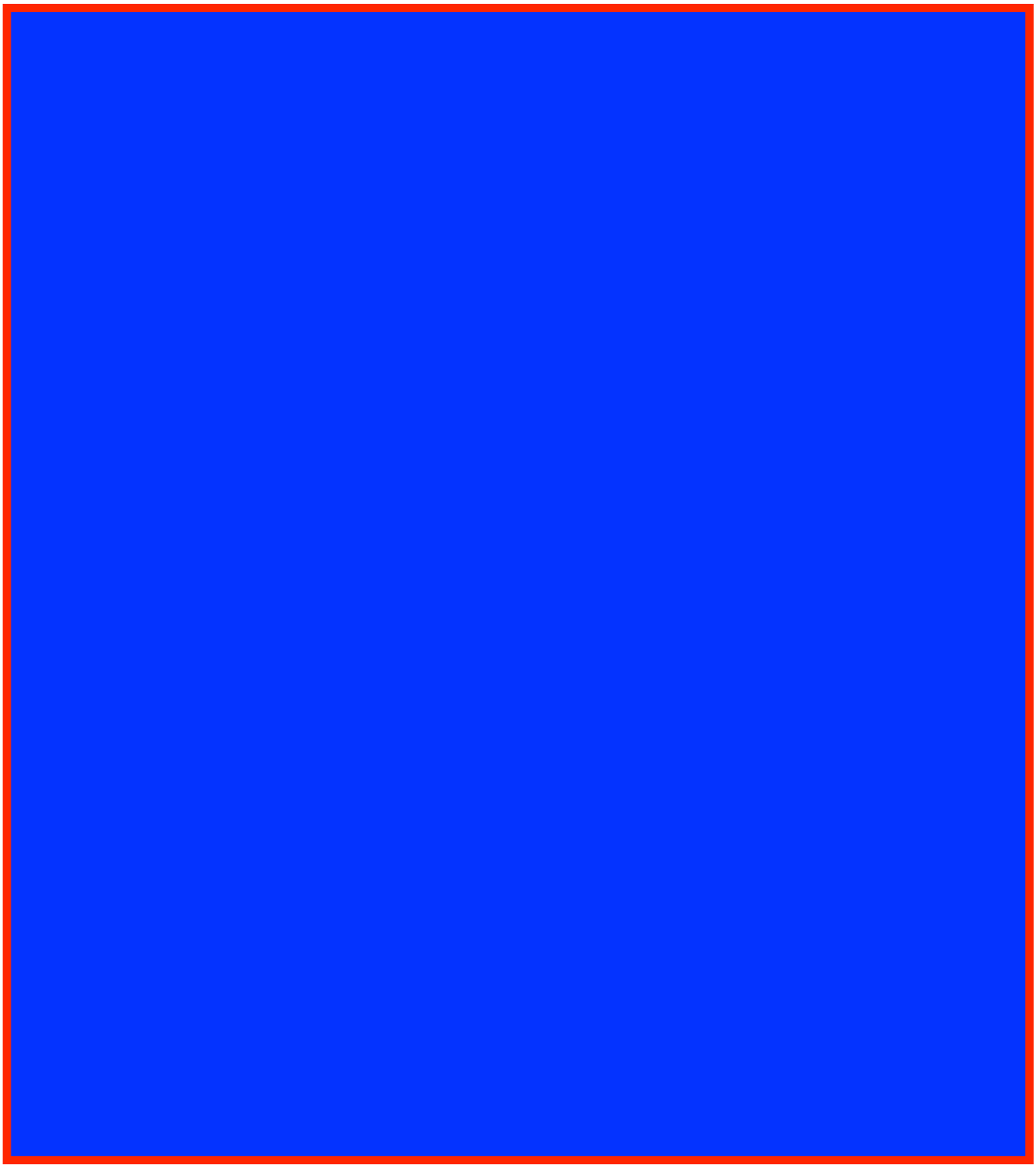
3.10 Summary

- SQL is the most influential commercially marketed relational query language. The SQL language has several parts:
  - **Data-definition language** (DDL), which provides commands for defining relation schemas, deleting relations, and modifying relation schemas.
  - **Data-manipulation language** (DML), which includes a query language and commands to insert tuples into, delete tuples from, and modify tuples in the database.
- The SQL data-definition language is used to create relations with specified schemas. In addition to specifying the names and types of relation attributes, SQL also allows the specification of integrity constraints such as primary-key constraints and foreign-key constraints.
- SQL includes a variety of language constructs for queries on the database. These include the **select**, **from**, and **where** clauses.
- SQL also provides mechanisms to rename both attributes and relations, and to order query results by sorting on specified attributes.
- SQL supports basic set operations on relations, including **union**, **intersect**, and **except**, which correspond to the mathematical set operations $\cup$, $\cap$, and $-$.
- SQL handles queries on relations containing null values by adding the truth value "unknown" to the usual truth values of true and false.
- SQL supports aggregation, including the ability to divide a relation into groups, applying aggregation separately on each group. SQL also supports set operations on groups.
- SQL supports nested subqueries in the **where** and **from** clauses of an outer query. It also supports scalar subqueries wherever an expression returning a value is permitted.
- SQL provides constructs for updating, inserting, and deleting information.

Review Terms

- Data-definition language
- Data-manipulation language
- Database schema
- Database instance
- Relation schema
- Relation instance
- Primary key
- Foreign key
  - Referencing relation
  - Referenced relation
- Null value
- Query language
- SQL query structure
  - **select** clause
  - **from** clause
  - **where** clause
- Multiset relational algebra
- **as** clause
- **order by** clause
- Table alias
- Correlation name (correlation variable, tuple variable)
- Set operations
  - **union**
  - **intersect**
  - **except**
- Aggregate functions
  - **avg, min, max, sum, count**
  - **group by**
  - **having**
- Nested subqueries
- Set comparisons
  - {<, <=, >, >=} { **some, all** }
  - **exists**
  - **unique**
- **lateral** clause
- **with** clause
- Scalar subquery
- Database modification
  - Delete
  - Insert
  - Update





4.8 Summary

- SQL supports several types of joins including natural join, inner and outer joins, and several types of join conditions.

- Natural join provides a simple way to write queries over multiple relations in which a **where** predicate would otherwise equate attributes with matching names from each relation. This convenience comes at the risk of query semantics changing if a new attribute is added to the schema.
- The **join-using** construct provides a simple way to write queries over multiple relations in which equality is desired for some but not necessarily all attributes with matching names.
- The **join-on** construct provides a way to include a join predicate in the **from** clause.
- Outer join provides a means to retain tuples that, due to a join predicate (whether a natural join, a join-using, or a join-on), would otherwise not appear anywhere in the result relation. The retained tuples are padded with null values so as to conform to the result schema.

- View relations can be defined as relations containing the result of queries. Views are useful for hiding unneeded information and for gathering together information from more than one relation into a single view.
- Transactions are sequences of queries and updates that together carry out a task. Transactions can be committed, or rolled back; when a transaction is rolled back, the effects of all updates performed by the transaction are undone.
- Integrity constraints ensure that changes made to the database by authorized users do not result in a loss of data consistency.
- Referential-integrity constraints ensure that a value that appears in one relation for a given set of attributes also appears for a certain set of attributes in another relation.
- Domain constraints specify the set of possible values that may be associated with an attribute. Such constraints may also prohibit the use of null values for particular attributes.
- Assertions are declarative expressions that state predicates that we require always to be true.
- The SQL data-definition language provides support for defining built-in domain types such as **date** and **time** as well as user-defined domain types.
- Indices are important for efficient processing of queries, as well as for efficient enforcement of integrity constraints. Although not part of the SQL standard, SQL commands for creation of indices are supported by most database systems.
- SQL authorization mechanisms allow one to differentiate among the users of the database on the type of access they are permitted on various data values in the database.

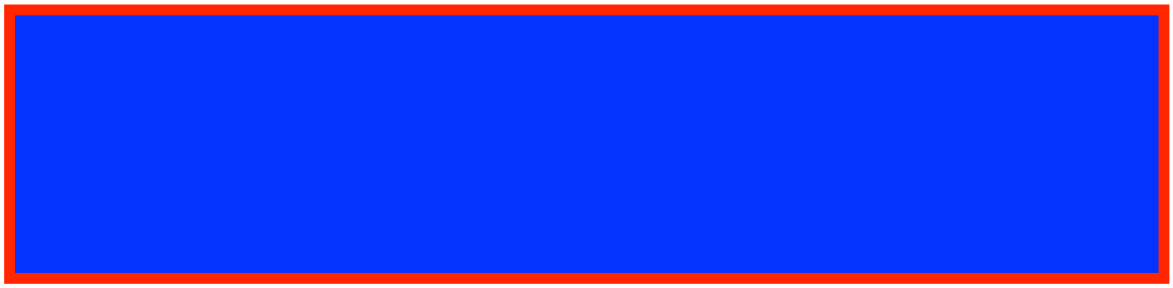
- Roles enable us to assign a set of privileges to a user according to the role that the user plays in the organization.

Review Terms

- Join types
  - Natural join
  - Inner join with **using** and **on**
  - Left, right and full outer join
  - Outer join with **using** and **on**
- View definition
  - Materialized views
  - View maintenance
  - View update
- Transactions
  - Commit work
  - Rollback work
  - Atomic transaction
- Constraints
  - Integrity constraints
  - Domain constraints
  - Unique constraint
  - Check clause
  - Referential integrity
    - Cascading deletes
    - Cascading updates
  - Assertions
- Data types
  - Date and time types
  - Default values
  - Large objects
    - clob
    - blob
  - User-defined types
  - distinct types
  - Domains
  - Type conversions
- Catalogs
- Schemas
- Indices
- Privileges
  - Types of privileges
    - **select**
    - **insert**
    - **update**
  - Granting of privileges
  - Revoking of privileges
  - Privilege to grant privileges
  - Grant option
- Roles
- Authorization on views
- Execute authorization
- Invoker privileges
- Row-level authorization
- Virtual private database (VPD)

5.6 Summary

- Functions and procedures can be defined using SQL procedural extensions that allow iteration and conditional (if-then-else) statements.
- Triggers define actions to be executed automatically when certain events occur and corresponding conditions are satisfied. Triggers have many uses, such as business rule implementation and audit logging. They may carry out actions outside the database system by means of external language routines.



Review Terms