Course A7B36DBS: **Database Systems**

Lecture 03:

SQL – Data Definition and Manipulation

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Outline

- **SQL**
  - **Data definition**
    - Definition of tables
    - Data types
    - Integrity constraints
    - Schema modification
  - **Data manipulation**
    - Insertion
    - Updates
    - Deletion

Structured Query Language (SQL)

Structured Query Language

- **SQL**
  - Standard language for accessing relational databases
    - **Data definition** (DDL)
      - Creation of table schemas and integrity constraints
    - **Data manipulation** (DML)
      - Querying
      - Data insertion, deletion, updates
    - Transaction management
    - Modules (programming language)
    - Database administration

Structured Query Language

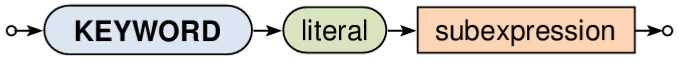
- **SQL standards**
  - Backwards compatible
  - ANSI/ISO
    - **SQL-86** – intersection of IBM SQL implementations
    - SQL-89 – small revision, integrity constraints
    - **SQL-92** – schema modification, transactions, set operators, new data types, cursors, referential integrity actions, …
    - **SQL:1999** – recursive queries, triggers, object-relational features, regular expressions, types for full-text, images, spatial data, …
    - **SQL:2003** – SQL/XML, sequence generators
    - SQL:2006 – other extensions of XML, integration of XQuery
    - SQL:2008
    - SQL:2011 – temporal databases

Structured Query Language

- **Commercial systems**
  - Current implementations at different standard levels
    - Most often SQL:1999, SQL:2003
  - However (and unfortunately)…
    - **Some extra proprietary features supported**
    - **Some standard features not supported**
    - Even syntax may differ
      - And so data migration is usually not straightforward
  - Specific extensions
    - Procedural, transactional and other functionality, e.g., TRANSACT-SQL (Microsoft SQL Server), PL/SQL (Oracle)

SQL Syntax Diagrams

- **Syntax** (railroad) **diagrams**
  - Graphical representation of context-free grammars
    - I.e. a practical approach how to describe languages (such as SQL) in a graphical and user-friendly way
  - Technically…
    - Directed graph representing an automaton accepting SQL
    - Terms in diagrams:
      - Capital letters on blue – keywords
      - Small letters on green – literals
      - Small letters on orange – subexpressions



SQL: Schema Definition

Table Creation

- **CREATE TABLE**
  - Construction of a table schema (and an empty table)
    - **Table name**
    - Definition of **table columns**
      - Together with their column-scope integrity constraints
    - Definition of **table-scope integrity constraints**

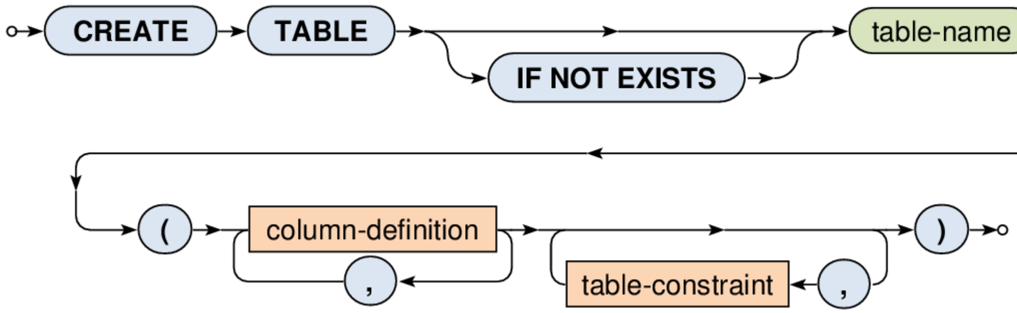


Table Creation

- **CREATE TABLE**
  - Definition of table columns
    - **Column name**
    - **Data type**
    - **Default value**
      - When a new row is about to be inserted and not all its values are specified, then the default values are used (if defined)
    - Definition of column-scope IC

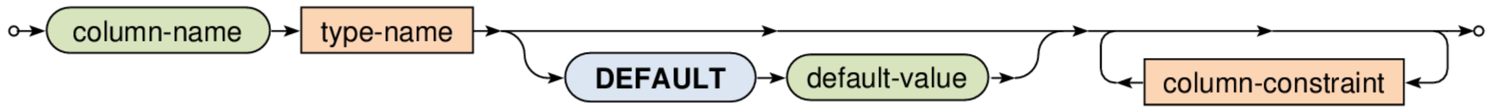


Table Creation

- **Example**
  - Simple table without integrity constraints

```
CREATE TABLE Product (
   Id INTEGER,
   Name VARCHAR(128),
   Price DECIMAL(6,2),
   Produced DATE,
   Available BOOLEAN DEFAULT TRUE,
   Weight FLOAT
);
```

Data Types

- Available data types
  - Precise numeric types
    - **INTEGER**, INT, SMALLINT, BIGINT
    - **DECIMAL**(precision, scale)
      - Precision = number of all digits (including decimal digits)
      - Scale = number of decimal digits
  - Approximate numeric types
    - FLOAT, REAL, DOUBLE PRECISION – real numbers
  - Logical values
    - **BOOLEAN**

Data Types

- Available data types
  - Character strings
    - **CHAR**(length), CHARACTER(length) – fixed-length strings
      - Shorter strings are automatically right-padded with spaces
    - **VARCHAR**(length), CHARACTER VARYING(length)
      - Strings of a variable length
  - Temporal types
    - **DATE**, **TIME**, **TIMESTAMP**
- **Type conversions**
  - Meaningful conversions are defined automatically
    - Otherwise see CAST…

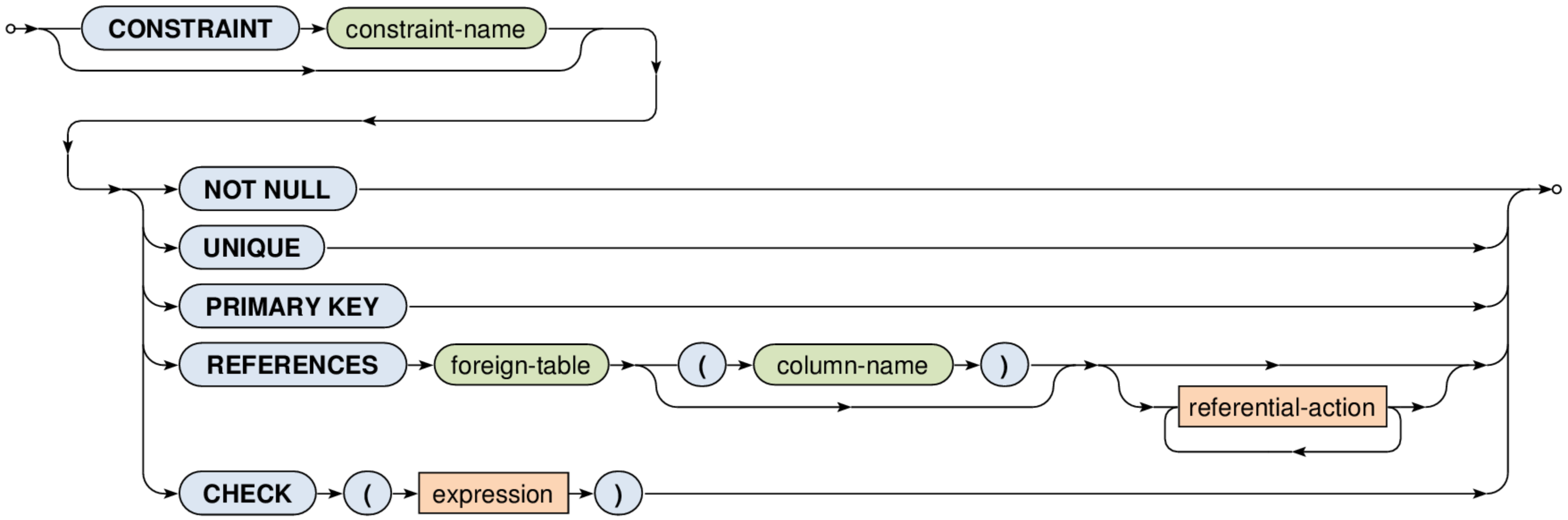
Data Types

- **Example**
  - Simple table without integrity constraints

```
CREATE TABLE Product (
   Id INTEGER,
   Name VARCHAR(128),
   Price DECIMAL(6,2),
   Produced DATE,
   Available BOOLEAN DEFAULT TRUE,
   Weight FLOAT
);
```

Integrity Constraints

- **Column integrity constraints**
  - Allow us to limit domains of the allowed values



Integrity Constraints

- Column integrity constraints
  - **NOT NULL**
    - Values must not be `NULL`
  - **UNIQUE**
    - All values must be distinct
      - But can there be just one or multiple `NULL` values?
  - **PRIMARY KEY**
    - Only one primary key is allowed in a table!
    - Equivalent to NOT NULL + UNIQUE

Integrity Constraints

- Column integrity constraints
  - **FOREIGN KEY**
    - Referential integrity
      - Values from the referencing table must also exist in the referenced table
      - `NULL` values are ignored
      - Only unique / primary keys can be referenced
  - **CHECK**
    - Generic condition that must be satisfied
      - However, only values within a given row may be tested

Integrity Constraints: Example

```
CREATE TABLE Producer (
   Id INTEGER PRIMARY KEY,
   Name VARCHAR(128),
   Country VARCHAR(64)
);

CREATE TABLE Product (
   Id INTEGER CONSTRAINT IC_Product_PK PRIMARY KEY,
   Name VARCHAR(128) UNIQUE,
   Price DECIMAL(6,2) CONSTRAINT IC_Product_Price NOT NULL,
   Produced DATE CHECK (Produced >= '2015-01-01'),
   Available BOOLEAN DEFAULT TRUE NOT NULL,
   Weight FLOAT,
   Producer INTEGER REFERENCES Producer (Id)
);
```

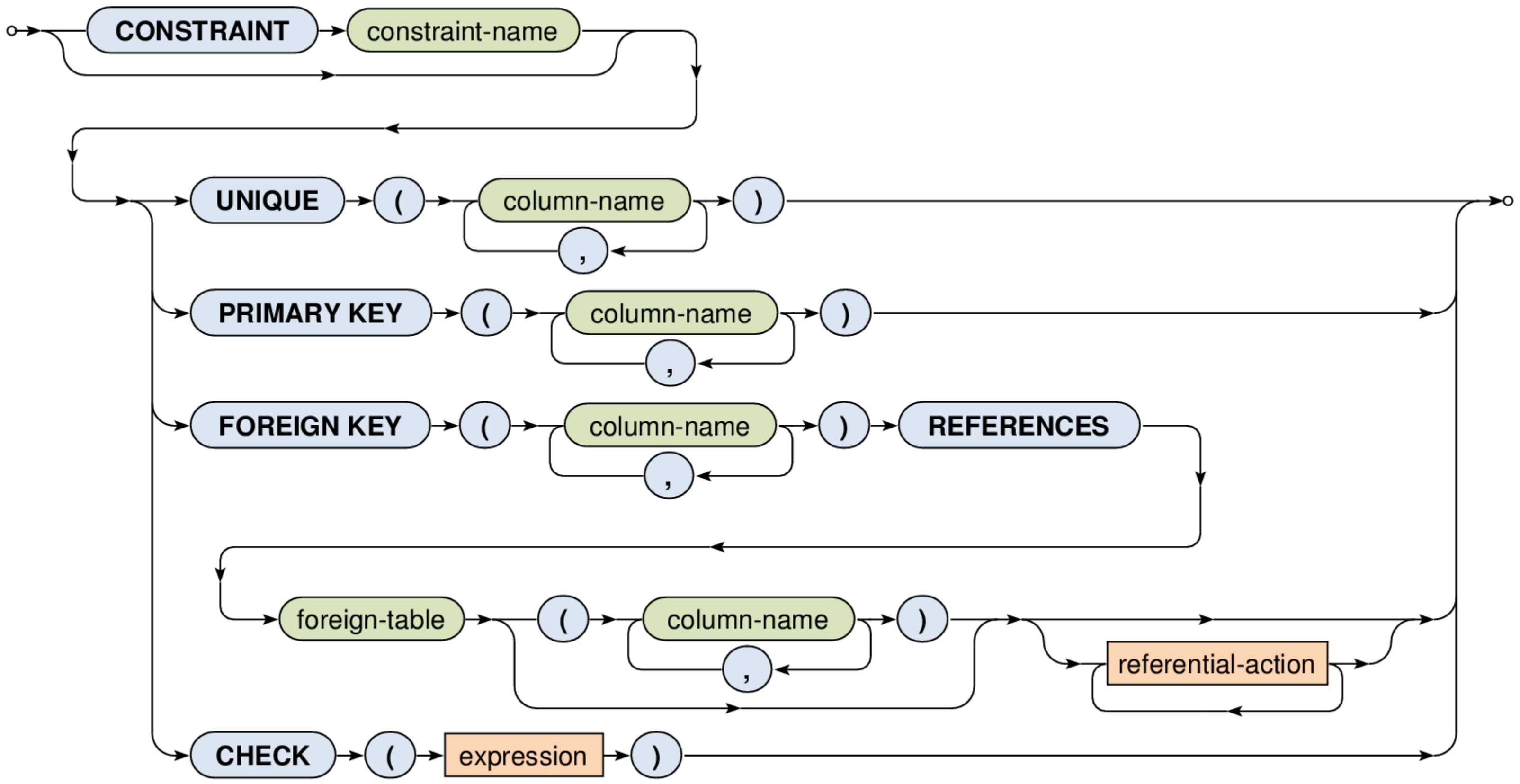
Integrity Constraints: Example

- **Example**
  - Referential integrity within a single table

```
CREATE TABLE Employee (
   Id INTEGER PRIMARY KEY,
   Name VARCHAR(128),
   Boss INTEGER REFERENCES Employee (Id)
);
```

Integrity Constraints

- **Table integrity constraints**



Integrity Constraints

- **Table integrity constraints**
  - Analogous to column IC, just for multiple columns, i.e. for tuples of values
  - **UNIQUE**
  - **PRIMARY KEY**
  - **FOREIGN KEY**
    - Tuples containing at least one `NULL` value are ignored
  - **CHECK**
    - Even with more complex conditions testing the entire tables
      - However, table integrity constraints are considered to be satisfied on empty tables (by definition, without evaluation)
      - See CREATE ASSERTION…

Integrity Constraints: Example

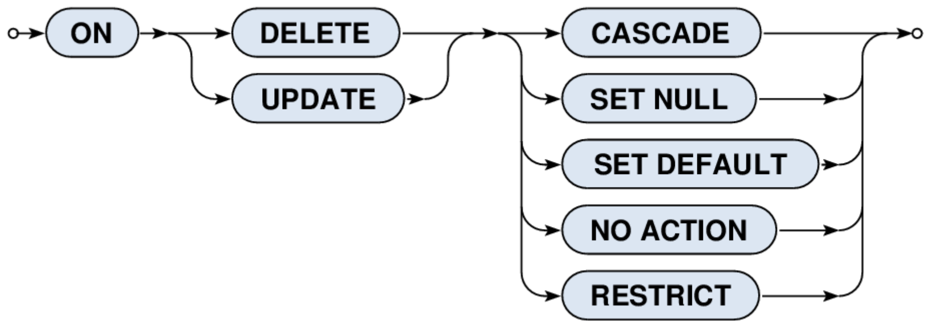
```
CREATE TABLE Producer (
   Name VARCHAR(128),
   Country VARCHAR(3),
   CONSTRAINT IC_Producer_PK PRIMARY KEY (Name, Country)
);

CREATE TABLE Product (
   Id INTEGER PRIMARY KEY,
   …
   ProducerName VARCHAR(128),
   ProducerCountry VARCHAR(3),
   CONSTRAINT IC_Product_Producer_FK
      FOREIGN KEY (ProducerName, ProducerCountry)
      REFERENCES Producer (Name, Country)
);
```

Referential Integrity

- **Referential actions**
  - When an operation on the referenced table would cause violation of the foreign key in the referencing table…
    - I.e. value of the foreign key of at least one row in the referencing table would become invalid as a result
  - … then…
    - this operation is blocked and an error message is generated
    - but if a referential action is defined, it is triggered…

Referential Integrity

- **Referential actions**



  - Triggering situations
    - **ON UPDATE, ON DELETE**
      - When the action is triggered
      - Once again, these are considered to be operations on the referenced table

Referential Integrity

- Referential actions
  - **CASCADE**
    - Row with the referencing value is updated / deleted as well
  - **SET NULL** – referencing value is set to `NULL`
  - **SET DEFAULT** – referencing value is set to its default
  - **NO ACTION** – default – no action takes place
    - I.e. as if no referential action would be defined at all
  - **RESTRICT** – no action takes place as well…
    - However, the integrity check is performed at the beginning, i.e. before the operation is even tried to be executed
      - ... and so triggers or the operation itself have no chance to remedy the situation even if they could be able to achieve such a state (and so RESTRICT is different to NO ACTION)

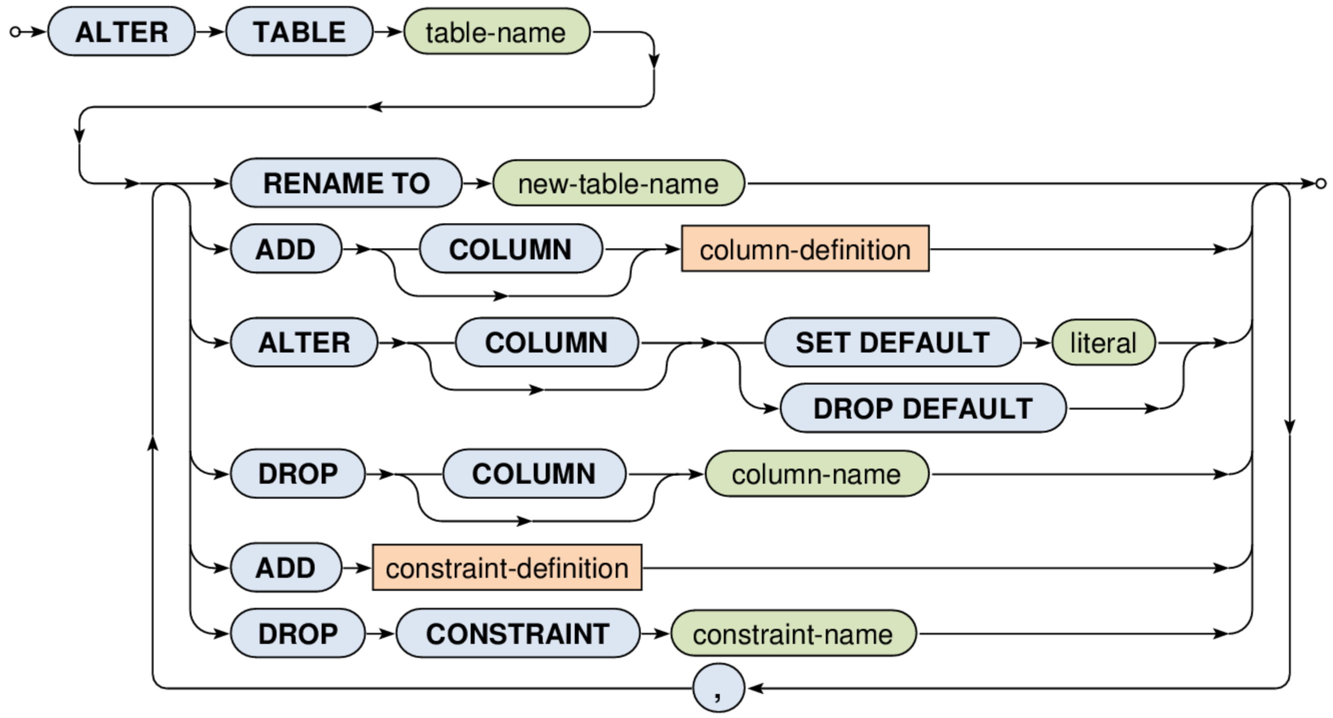
Referential Integrity: Example

```
CREATE TABLE Producer (
   Id INTEGER PRIMARY KEY,
   Name VARCHAR(128),
   Country VARCHAR(64)
);

CREATE TABLE Product (
   Id INTEGER PRIMARY KEY,
   …
   Producer INTEGER
      REFERENCES Producer (Id) ON DELETE CASCADE
);
```

SQL: Schema Modification

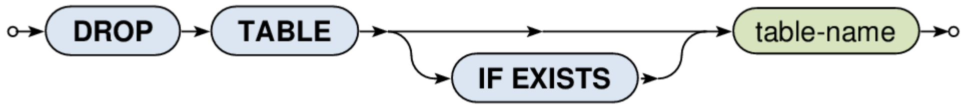
Schema Modification

- **ALTER TABLE**
  - Addition/change/removal of table columns/IC



Schema Modification

- **DROP TABLE**
  - Complementary to the table creation
    - I.e. table definition as well as table content are deleted



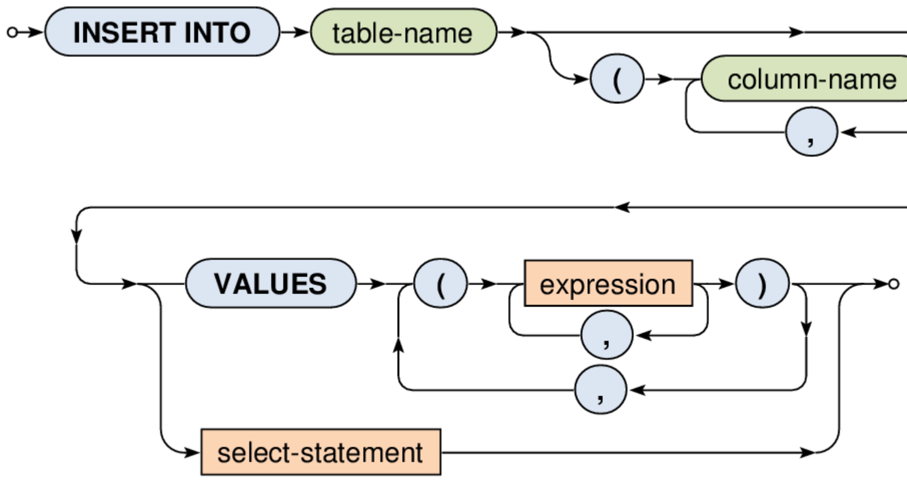
SQL: Data Modification

SQL Data Manipulation

- Data manipulation language
  - Data modification
    - **INSERT INTO** – insertion of rows
    - **DELETE FROM** – deletion of rows
    - **UPDATE** – modification of rows
  - Data querying
    - **SELECT**… *the next lecture*

Data Insertion

- **INSERT INTO**
  - Insertion of new rows into a table
    - …by an explicit enumeration / from a result of a selection
    - Default values are assumed for the omitted columns

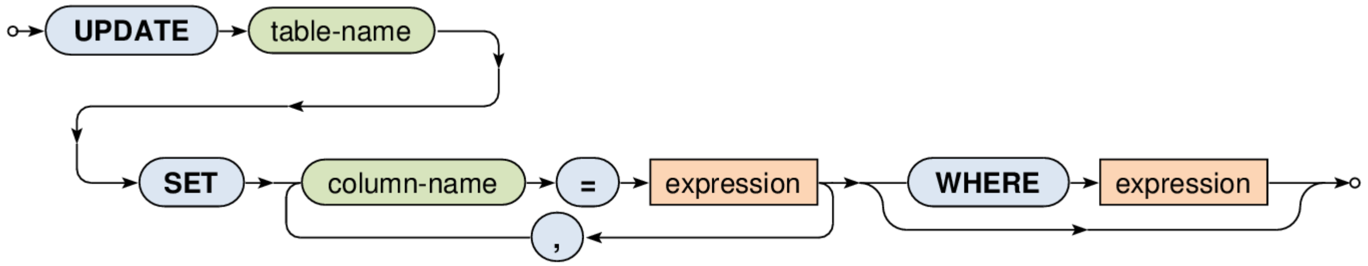


Data Insertion: Example

```
CREATE TABLE Product (
    Id INTEGER PRIMARY KEY,
    Name VARCHAR(128) UNIQUE,
    Price DECIMAL(6,2) NOT NULL,
    Produced DATE,
    Available BOOLEAN DEFAULT TRUE,
    Weight FLOAT,
    Producer INTEGER
);

INSERT INTO Product
    VALUES (0, 'Chair1', 2000, '2015-05-06', TRUE, 3.5, 11);

INSERT INTO Product
    (Id, Name, Price, Produced, Weight, Producer)
    VALUES (1, 'Chair2', 1500, '2015-05-06', 4.5, 11);
```

Data Updates

- **UPDATE**
  - Modification of existing rows in a table
    - Only rows matching the given condition are considered
  - Newly assigned values can be…
    - `NULL`, literal, value given by an expression, result of a scalar subquery



Data Updates: Example

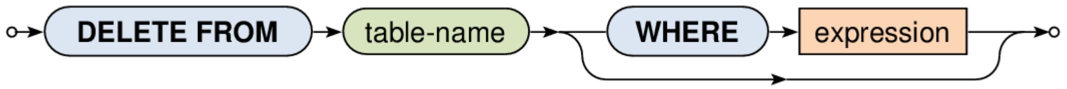
```
CREATE TABLE Product (
    Id INTEGER PRIMARY KEY,
    Name VARCHAR(128) UNIQUE,
    Price DECIMAL(6,2) NOT NULL,
    Produced DATE,
    Available BOOLEAN DEFAULT TRUE,
    Weight FLOAT,
    Producer INTEGER
);
```

```
UPDATE Product
    SET Name = 'Notebook'
    WHERE (Name = 'Laptop');
```

```
UPDATE Product
    SET Price = Price * 0.9
    WHERE (Produced < '2015-01-01');
```

Data Deletion

- **DELETE FROM**
  - Deletion of existing rows from a table
    - Only rows matching the given condition are considered



Data Deletion: Example

```
CREATE TABLE Product (
   Id INTEGER PRIMARY KEY,
   Name VARCHAR(128) UNIQUE,
   Price DECIMAL(6,2) NOT NULL,
   Produced DATE,
   Available BOOLEAN DEFAULT TRUE,
   Weight FLOAT,
   Producer INTEGER
);
```

```
DELETE FROM Product
   WHERE (Price > 2000);

DELETE FROM Product
```