# *The Relational Algebra*

Two groups of SQL

DDL – creating tables, columns
DML – Querying and modifying data

Where did DML SQL come from?

The Relational Algebra !

# *The Relational Algebra*

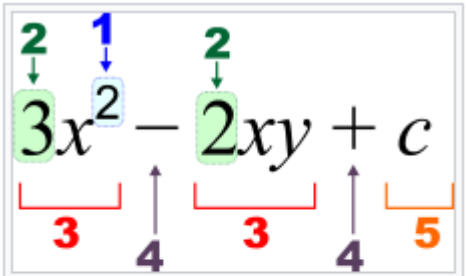
- Write a query in SQL, submit it
- The DBMS engine “parses” the SQL, checks syntax
- Builds an execution plan (based on Relational Algebra)
- Executes the SQL
- Returns an Answer Set (a table)
- Stores the SQL in cache (Oracle Shared Pool)

# *The Relational Algebra*

- Preparing the query for execution
  - It is like algebra

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

  - Variables and Operations
    - The “variables” are relations
    - The operations are
      - Union
      - Intersection
      - Difference
      - Selection
      - Projection
      - Cartesian Product
      - Join




Algebraic expression notation:
1 – power (exponent)
2 – coefficient
3 – term
4 – operator
5 – constant term
*x y c* – variables/constants

# *Set Operations*

Some Operations are “Set” Operations

- **Think of each table as entire “set” of data**
- **Consider two tables:  R and S**
  - Same attributes, same domains

- set operations in Relational Algebra.

| | |
|---|---|
| – R <union> S | all elements in R or S or both |
| – R <intersection> S | the set of elements in R and S |
| – R <difference> S | the set of elements in R but not in S |

# *Example Union*

## Table C

| CustomerID | CustomerName | ContactName | Address | City | PostalCode | Country |
|---|---|---|---|---|---|---|
| 1 | Alfreds Futterkiste | Maria Anders | Obere Str. 57 | Berlin | 12209 | Germany |
| 2 | Ana Trujillo Emparedados y helados | Ana Trujillo | Avda. de la Constitución 2222 | México D.F. | 05021 | Mexico |
| 3 | Antonio Moreno Taquería | Antonio Moreno | Mataderos 2312 | México D.F. | 05023 | Mexico |

## Table S

| SupplierID | SupplierName | ContactName | Address | City | PostalCode | Country |
|---|---|---|---|---|---|---|
| 1 | Exotic Liquid | Charlotte Cooper | 49 Gilbert St. | London | EC1 4SD | UK |
| 2 | New Orleans Cajun Delights | Shelley Burke | P.O. Box 78934 | New Orleans | 70117 | USA |
| 3 | Grandma Kelly's Homestead | Regina Murphy | 707 Oxford Rd. | Ann Arbor | 48104 | USA |

# *Example Union*

C <union> S

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | Alfreds Futterkiste | Maria Anders | Obere Str. 57 | Berlin | 12209 | Germany |
| 2 | Ana Trujillo Emparedados y helados | Ana Trujillo | Avda. de la Constitución 2222 | México D.F. | 5021 | Mexico |
| 3 | Antonio Moreno Taquería | Antonio Moreno | Mataderos 2312 | México D.F. | 5023 | Mexico |
| 1 | Exotic Liquid | Charlotte Cooper | 49 Gilbert St. | London | EC1 4SD | UK |
| 2 | New Orleans Cajun Delights | Shelley Burke | P.O. Box 78934 | New Orleans | 70117 | USA |
| 3 | Grandma Kelly's Homestead | Regina Murphy | 707 Oxford Rd. | Ann Arbor | 48104 | USA |

# *Projection*

Produce a new relation that is a subset of columns

Table C

| CustomerID | CustomerName | ContactName | Address | City | PostalCode | Country |
|---|---|---|---|---|---|---|
| 1 | Alfreds Futterkiste | Maria Anders | Obere Str. 57 | Berlin | 12209 | Germany |
| 2 | Ana Trujillo Emparedados y helados | Ana Trujillo | Avda. de la Constitución 2222 | México D.F. | 05021 | Mexico |
| 3 | Antonio Moreno Taquería | Antonio Moreno | Mataderos 2312 | México D.F. | 05023 | Mexico |

<projection> CustomerID, CustomerName, City (C)

| | | |
|---|---|---|
| 1 | Alfreds Futterkiste | Berlin |
| 2 | Ana Trujillo Emparedados y helados | México D.F. |
| 3 | Antonio Moreno Taquería | México D.F. |

# *Selection*

Produce a new relation that is a subset of tuples

- Based on a condition

Table C

| CustomerID | CustomerName | ContactName | Address | City | PostalCode | Country |
|---|---|---|---|---|---|---|
| 1 | Alfreds Futterkiste | Maria Anders | Obere Str. 57 | Berlin | 12209 | Germany |
| 2 | Ana Trujillo Emparedados y helados | Ana Trujillo | Avda. de la Constitución 2222 | México D.F. | 05021 | Mexico |
| 3 | Antonio Moreno Taquería | Antonio Moreno | Mataderos 2312 | México D.F. | 05023 | Mexico |

<selection> <Country=Mexico> (C)

| | | | | | | |
|---|---|---|---|---|---|---|
| 2 | Ana Trujillo Emparedados y helados | Ana Trujillo | Avda. de la Constitución 2222 | México D.F. | 5021 | Mexico |
| 3 | Antonio Moreno Taquería | Antonio Moreno | Mataderos 2312 | México D.F. | 5023 | Mexico |

# *Cartesian Product*

Produce a new relation that is the combination of every tuple in one table combined with every tuple in the other.

Table C

| CustomerID | CustomerName |
|---|---|
| 1 | Howard Snyder |
| 2 | Yoshi Lattimer |
| 3 | John Steel |
| 4 | Jaime Yorres |
| 5 | Fran Wilson |
| 6 | Rene Phillips |

Table O

| OrderID | CustomerID | OrderTotal |
|---|---|---|
| 10262 | 1 | 10556.22 |
| 10269 | 7 | 124.56 |
| 10278 | 8 | 105938.44 |
| 10304 | 12 | 1034.34 |
| 10307 | 2 | 15679.02 |
| 10322 | 17 | 9305.18 |

# *Cartesian Product*

| CustomerID | CustomerName | OrderID | CustomerID | OrderTotal |
|---|---|---|---|---|
| 1 | Howard Snyder | 10262 | 1 | 10556.22 |
| 1 | Howard Snyder | 10269 | 7 | 124.56 |
| 1 | Howard Snyder | 10278 | 8 | 105938.44 |
| 1 | Howard Snyder | 10304 | 12 | 1034.34 |
| 1 | Howard Snyder | 10307 | 2 | 15679.02 |
| 1 | Howard Snyder | 10322 | 17 | 9305.18 |
| 2 | Yoshi Lattimer | 10262 | 1 | 10556.22 |
| 2 | Yoshi Lattimer | 10269 | 7 | 124.56 |
| 2 | Yoshi Lattimer | 10278 | 8 | 105938.44 |
| 2 | Yoshi Lattimer | 10304 | 12 | 1034.34 |
| 2 | Yoshi Lattimer | 10307 | 2 | 15679.02 |
| 2 | Yoshi Lattimer | 10322 | 17 | 9305.18 |
| 3 | John Steel | 10262 | 1 | 10556.22 |
| 3 | John Steel | 10269 | 7 | 124.56 |
| 3 | John Steel | 10278 | 8 | 105938.44 |
| 3 | John Steel | 10304 | 12 | 1034.34 |
| 3 | John Steel | 10307 | 2 | 15679.02 |
| 3 | John Steel | 10322 | 17 | 9305.18 |
| 4 | Jaime Yorres | 10262 | 1 | 10556.22 |
| 4 | Jaime Yorres | 10269 | 7 | 124.56 |
| 4 | Jaime Yorres | 10278 | 8 | 105938.44 |
| 4 | Jaime Yorres | 10304 | 12 | 1034.34 |
| 4 | Jaime Yorres | 10307 | 2 | 15679.02 |
| 4 | Jaime Yorres | 10322 | 17 | 9305.18 |
| 5 | Fran Wilson | 10262 | 1 | 10556.22 |
| 5 | Fran Wilson | 10269 | 7 | 124.56 |
| 5 | Fran Wilson | 10278 | 8 | 105938.44 |
| 5 | Fran Wilson | 10304 | 12 | 1034.34 |
| 5 | Fran Wilson | 10307 | 2 | 15679.02 |
| 5 | Fran Wilson | 10322 | 17 | 9305.18 |
| 6 | Rene Phillips | 10262 | 1 | 10556.22 |
| 6 | Rene Phillips | 10269 | 7 | 124.56 |
| 6 | Rene Phillips | 10278 | 8 | 105938.44 |
| 6 | Rene Phillips | 10304 | 12 | 1034.34 |
| 6 | Rene Phillips | 10307 | 2 | 15679.02 |
| 6 | Rene Phillips | 10322 | 17 | 9305.18 |

← Product

# *Natural Joins*

| CustomerID | CustomerName | OrderID | CustomerID | OrderTotal |
|---|---|---|---|---|
| 1 | Howard Snyder | 10262 | 1 | 10556.22 |
| 1 | Howard Snyder | 10269 | 7 | 124.56 |
| 1 | Howard Snyder | 10278 | 8 | 105938.44 |
| 1 | Howard Snyder | 10304 | 12 | 1034.34 |
| 1 | Howard Snyder | 10307 | 2 | 15679.02 |
| 1 | Howard Snyder | 10322 | 17 | 9305.18 |
| 2 | Yoshi Lattimer | 10262 | 1 | 10556.22 |
| 2 | Yoshi Lattimer | 10269 | 7 | 124.56 |
| 2 | Yoshi Lattimer | 10278 | 8 | 105938.44 |
| 2 | Yoshi Lattimer | 10304 | 12 | 1034.34 |
| 2 | Yoshi Lattimer | 10307 | 2 | 15679.02 |
| 2 | Yoshi Lattimer | 10322 | 17 | 9305.18 |
| 3 | John Steel | 10262 | 1 | 10556.22 |
| 3 | John Steel | 10269 | 7 | 124.56 |
| 3 | John Steel | 10278 | 8 | 105938.44 |
| 3 | John Steel | 10304 | 12 | 1034.34 |
| 3 | John Steel | 10307 | 2 | 15679.02 |
| 3 | John Steel | 10322 | 17 | 9305.18 |
| 4 | Jaime Yorres | 10262 | 1 | 10556.22 |
| 4 | Jaime Yorres | 10269 | 7 | 124.56 |
| 4 | Jaime Yorres | 10278 | 8 | 105938.44 |
| 4 | Jaime Yorres | 10304 | 12 | 1034.34 |
| 4 | Jaime Yorres | 10307 | 2 | 15679.02 |
| 4 | Jaime Yorres | 10322 | 17 | 9305.18 |
| 5 | Fran Wilson | 10262 | 1 | 10556.22 |
| 5 | Fran Wilson | 10269 | 7 | 124.56 |
| 5 | Fran Wilson | 10278 | 8 | 105938.44 |
| 5 | Fran Wilson | 10304 | 12 | 1034.34 |
| 5 | Fran Wilson | 10307 | 2 | 15679.02 |
| 5 | Fran Wilson | 10322 | 17 | 9305.18 |
| 6 | Rene Phillips | 10262 | 1 | 10556.22 |
| 6 | Rene Phillips | 10269 | 7 | 124.56 |
| 6 | Rene Phillips | 10278 | 8 | 105938.44 |
| 6 | Rene Phillips | 10304 | 12 | 1034.34 |
| 6 | Rene Phillips | 10307 | 2 | 15679.02 |
| 6 | Rene Phillips | 10322 | 17 | 9305.18 |

Useless?

# *Natural Join*

Produce a new relation that combines matching tuples on a common attribute.

Table C

| CustomerID | CustomerName |
|---|---|
| 1 | Howard Snyder |
| 2 | Yoshi Lattimer |
| 3 | John Steel |
| 4 | Jaime Yorres |
| 5 | Fran Wilson |
| 6 | Rene Phillips |

Table O

| OrderID | CustomerID | OrderTotal |
|---|---|---|
| 10262 | 1 | 10556.22 |
| 10269 | 7 | 124.56 |
| 10278 | 8 | 105938.44 |
| 10304 | 12 | 1034.34 |
| 10307 | 2 | 15679.02 |
| 10322 | 17 | 9305.18 |

# *Natural Join*

C <join> O

| CustomerID | CustomerName | OrderID | CustomerID | OrderTotal |
|---|---|---|---|---|
| 1 | Howard Snyder | 10262 | 1 | 10556.22 |
| 2 | Yoshi Lattimer | 10307 | 2 | 15679.02 |

# *Example Union*

Some more examples of Set Operations:

**Graduates**

| Number | Surname | Age |
|---|---|---|
| 7274 | Robinson | 37 |
| 7432 | O'Malley | 39 |
| 9824 | Darkes | 38 |

**Managers**

| Number | Surname | Age |
|---|---|---|
| 9297 | O'Malley | 56 |
| 7432 | O'Malley | 39 |
| 9824 | Darkes | 38 |

# *Example Union*

**Graduates ∪ Managers**

| Number | Surname | Age |
|---|---|---|
| 7274 | Robinson | 37 |
| 7432 | O'Malley | 39 |
| 9824 | Darkes | 38 |
| 9297 | O'Malley | 56 |

# *Example Intersection*

**Graduates**

| Number | Surname | Age |
|---|---|---|
| 7274 | Robinson | 37 |
| 7432 | O'Malley | 39 |
| 9824 | Darkes | 38 |

**Managers**

| Number | Surname | Age |
|---|---|---|
| 9297 | O'Malley | 56 |
| 7432 | O'Malley | 39 |
| 9824 | Darkes | 38 |

# *Example Intersection*

**Graduates ∩ Managers**

| Number | Sumame | Age |
|---|---|---|
| 7432 | O'Malley | 39 |
| 9824 | Darkes | 38 |

# *Example Difference*

**Graduates**

| Number | Surname | Age |
|---|---|---|
| 7274 | Robinson | 37 |
| 7432 | O'Malley | 39 |
| 9824 | Darkes | 38 |

**Managers**

| Number | Surname | Age |
|---|---|---|
| 9297 | O'Malley | 56 |
| 7432 | O'Malley | 39 |
| 9824 | Darkes | 38 |

# *Example Difference*

**Graduates - Managers**

| Number | Surname | Age |
|---|---|---|
| 7274 | Robinson | 37 |