Relational Algebra

The Theory behind Relational Databases

PROFESSIONAL & CONTINUING EDUCATION
UNIVERSITY of WASHINGTON

Relational Algebra: What and Why

- Ted Codd introduced relational algebra to databases and created the relational model

- Relational algebra provides a theoretical foundation for relational databases, and particularly for query languages like SQL

Relational Algebra: What and Why

> Why do you want a theoretical foundation?
  - If you want to optimize a query or a database
  - If you are thinking about using NOSQL, then you should be aware of the limitations and advantages of NOSQL data management.
    > In other words, relational algebra assists in comparing SQL with NOSQL (NOT-SQL, Not-Only-SQL, KNOW-SQL, http://www.youtube.com/watch?v=sh1YACOK_bo)

Relational Algebra: What and Why

- Why is relational algebra important for a data scientist?
  - Even without using SQL?
- What do machine learning algorithms use as their primary structure?
- If ETL & Data Preparation take up the bulk of time,
  - How can you be more efficient?
- If Data comes in tables,
  - How can you manipulate the data?

New Terminology (1)

Term	Comments
Table	Part of a database
Relation	A table where rows are unique Operand in Relational Algebra/Calculus
Tuple	single, double, triple, qudruple, quintuple, sextuple; Like a row in a table
Arity	unary, binary, ternary, quaternary
Closure	Operation on a type produces a value of that same type: Natural Numbers have closure under + and * 3 * 5 = 15 Natural Numbers don't have closure under – or / 3 – 5 = –2

New Terminology (2)

Term	Comments
Procedural	Step-by-step solution to solving problem or achieving goal. I will drive to Bellevue, enter the classroom and listen to the lecture. (Relational Algebra is procedural or imperative)
Declarative	Stating what one wants in non-ambiguous terms without describing how one is to achieve one's goal. Example: I want to know what was said in class last week. I don't care if you use the slide deck, your memory, or the recording to get me that information. (SQL is declarative)
Relational Algebra	The algebra that describes relations as operands and results
Relational Calculus	The calculus that uses relations as operands and results (SQL)

New Terminology (3)

Operation	Symbols	Comments
Selection	σ (sigma); $\sigma_{\varphi}(R)$;	SELECT * FROM <table name> WHERE Column1 = 1
Projection	π (pi); $\pi_{c1, c2, \ldots, cn}(R)$	SELECT Column1, Column 2 FROM <table name>
Rename	Ρ (rho)	as
Union	∪	A∪B; A={1,2,3, 5}; B={0,2}; {1,2,3, 5}∪{0,2}={0,1,2,3,5}
Intersection	∩	A∩B; A={1,2,3, 5}; B={0,2}; {1,2,3, 5}∩{0,2}= {2}
Difference	\, -,	B\A = B-A; {0,2} - {1,2,3,5} = {0}

New Terminology (4)

Operation	Symbols	Comments
Product	X	AXB A={1,2,3,5}; B={0,2}; {1,2,3, 5}X{0,2}= {{1,0}, {2,0}, {3,0}, {5,0}, {1,2}, {2,2}, {3,2}, {5,2}}
Join	$\bowtie_{\varphi}$	$B \bowtie_{\varphi} A$; φ: A > B; A={1,2,3,5}; B={0,2}; {1,2,3,5} $\bowtie_{\varphi}$ {0,2} = {{1,0},{2,0},{3,0},{3,2},{5,0},{5,2}}
Division	÷	A÷B = C; Project to show me the columns in A that are not in B; Select to show me the tuples in A that are a superset of a tuple in B.

Structure of a Relation

Operand

Relational Algebra

Name	**Age**	**Home**
Blackbur	5	None
Kobayas	21	Rent
Menchú	31	Rent
Alvarez	42	Rent
Tagore	50	Own

Relational Algebra: Relation

Name	**Age**	**Home**
Blackbur	5	None
Kobayas	21	Rent
Menchú	31	Rent
Alvarez	42	Rent
Tagore	50	Own

Relation

Relational Algebra: Relation

Relation is like a table except that each row must be unique like in a set

Relation

Name	Age	Home
Blackbur	5	None
Kobayas	21	Rent
Menchú	31	Rent
Alvarez	42	Rent
Tagore	50	Own

Relational Algebra: Attribute

Name	Age	Home
Blackbur	5	None
Kobayas	21	Rent
Menchú	31	Rent
Alvarez	42	Rent
Tagore	50	Own

Attribute

Relational Algebra: Attribute

Attribute:
Must be of the same data type.
Have a name

Name	**Age**	**Home**
Blackbur	5	None
Kobayas	21	Rent
Menchú	31	Rent
Alvarez	42	Rent
Tagore	50	Own

Attribute

Relational Algebra: Tuple

Name	Age	Home
Blackbur	5	None
Kobayas	21	Rent
Menchú	31	Rent
Alvarez	42	Rent
Tagore	50	Own

tuple

Relational Algebra: Tuple

tuple from: sing**le**, doub**le**, tri**ple**, quadr**uple**, quin**tuple**
arity from: un**ary**, bin**ary**, tern**ary**

Name	Age	Home
Blackbur	5	None
Kobayas	21	Rent
Menchú	31	Rent
Alvarez	42	Rent
Tagore	50	Own

tuple with arity of 3

Relational Algebra: Operands and Simple Operations

- Operand
  - Relation (Table)
- Operations
  - UNION
  - INTERSECT
  - PROJECT
  - SELECT
  - PRODUCT
  - DIVISION

Union Operation

Relational Algebra: Union

Combine Relations

Name	Age	Home
Blackbur	5	None
Kobayas	21	Rent

Name	Age	Home
Menchú	31	Rent
Alvarez	42	Rent
Tagore	50	Own

Relational Algebra: Union

Combine Relations

<u>**Name**</u>	<u>**Age**</u>	<u>**Home**</u>
Blackbur	5	None
Kobayas	21	Rent

<u>**Name**</u>	<u>**Age**</u>	<u>**Home**</u>
Menchú	31	Rent
Alvarez	42	Rent
Tagore	50	Own

Relational Algebra Union:
R ∪ S

Relational Algebra: Union

Combine Relations

SQL Statement:
SELECT * FROM MyTableR UNION
SELECT * FROM MyTableS

Name	Age	Home
Blackbur	5	None
Kobayas	21	Rent

Name	Age	Home
Menchú	31	Rent
Alvarez	42	Rent
Tagore	50	Own

Relational Algebra Union:
R ∪ S

Relational Algebra: Union

Combine Relations

Name	Age	Home
Blackbur	5	None
Kobayas	21	Rent

Name	Age	Home
Menchú	31	Rent
Alvarez	42	Rent
Tagore	50	Own

→

Name	Age	Home
Blackbur	5	None
Kobayas	21	Rent
Menchú	31	Rent
Alvarez	42	Rent
Tagore	50	Own

Relational Algebra Union:
R ∪ S

Intersect Operation

Relational Algebra: Intersect

Name	Age	Home
Blackbur	5	None
Kobayas	21	Rent
Menchú	31	Rent
Tagore	50	Own

Same Rows

Name	Age	Home
Menchú	31	Rent
Alvarez	42	Rent
Tagore	50	Own

Relational Algebra: Intersect

Name	Age	Home
Blackbur	5	None
Kobayas	21	Rent
Menchú	31	Rent
Tagore	50	Own

Same Rows

Name	Age	Home
Menchú	31	Rent
Alvarez	42	Rent
Tagore	50	Own

Relational Algebra: Intersect

Name	Age	Home
Blackbur	5	None
Kobayas	21	Rent
Menchú	31	Rent
Tagore	50	Own

Same Rows

Name	Age	Home
Menchú	31	Rent
Alvarez	42	Rent
Tagore	50	Own

Relational Algebra Intersection:
R ∩ S

Relational Algebra: Intersect

Name	**Age**	**Home**
Blackbur	5	None
Kobayas	21	Rent
Menchú	31	Rent
Tagore	50	Own

Same Rows

Name	**Age**	**Home**
Menchú	31	Rent
Alvarez	42	Rent
Tagore	50	Own

SQL Statement:

```
SELECT * FROM MyTableR
INTERSECT
 SELECT * FROM MyTableS
```

Relational Algebra Intersection:

R ∩ S

Relational Algebra: Intersect

Name	Age	Home
Blackbur	5	None
Kobayas	21	Rent
Menchú	31	Rent
Tagore	50	Own

Same Rows

Name	Age	Home
Menchú	31	Rent
Alvarez	42	Rent
Tagore	50	Own

→

Name	Age	Home
Menchú	31	Rent
Tagore	50	Own

Relational Algebra Intersection:
$R \cap S$

Relational Algebra: Examples

- R ∪ S
  - SELECT * FROM MyTableR UNION SELECT * FROM MyTableS
- SELECT * FROM MyTableS UNION SELECT * FROM MyTableR
  - R ∪ S or S ∪ R

- R ∩ S
  - SELECT * FROM MyTableR INTERSECT SELECT * FROM MyTableS
- SELECT * FROM MyTableS INTERSECT SELECT * FROM MyTableR
  - R ∩ S or S ∩ R

Relational Algebra: Examples

– In General:

- An operation with ∪ or ∩ produces a relation
- $R \cup S = S \cup R$
- $R \cap S = S \cap R$
- $(R \cup S) \cap T = (R \cap T) \cup (S \cap T)$
- $(R \cap S) \cup T = (R \cup T) \cap (S \cup T)$

Relational Algebra Operations

So far:

- Union
- Intersect

Coming up:

- Project
- Select
- Product
- Join
- Division

Project Operation

Relational Algebra: Project

Name	**Age**	**Home**
Blackbur	5	None
Kobayas	21	Rent
Menchú	31	Rent
Alvarez	42	Rent
Tagore	50	Own

Vertical partition

Relational Algebra: Project

Name	Age	Home
Blackbur	5	None
Kobayas	21	Rent
Menchú	31	Rent
Alvarez	42	Rent
Tagore	50	Own

Vertical partition

Relational Algebra Project:

$\pi_{c1,\ c2,\ \ldots,\ cn}(R)$

where

c1, c2, …, cn: Age, Home

R: MyTable

Relational Algebra: Project

<u>Name</u>	<u>Age</u>	<u>Home</u>
Blackbur	5	None
Kobayas	21	Rent
Menchú	31	Rent
Alvarez	42	Rent
Tagore	50	Own

SQL Statement:

```
SELECT Age, Home FROM MyTable
```

Vertical partition

Relational Algebra Project:

$\pi_{c1,\, c2,\, \ldots,\, cn}(R)$

where

c1, c2, …, cn: Age, Home

R: MyTable

Relational Algebra: Project

Name	Age	Home
Blackbur	5	None
Kobayas	21	Rent
Menchú	31	Rent
Alvarez	42	Rent
Tagore	50	Own

→

Age	Home
5	None
21	Rent
31	Rent
42	Rent
50	Own

Relational Algebra Project:

$\pi_{c1,\ c2,\ \ldots,\ cn}(R)$

where

c1, c2, …, cn: Age, Home

R: MyTable

Relational Algebra: Project

Name	Age	Home
Blackbur	5	None
Kobayas	21	Rent
Menchú	31	Rent
Alvarez	42	Rent
Tagore	50	Own

→

Age	Home
5	None
21	Rent
31	Rent
42	Rent
50	Own

The result of a projection is a relation with 0 to n attributes where n is the number of attributes in the operand

Relational Algebra Project:

$\pi_{c1,\ c2,\ \ldots,\ cn}(R)$

where

c1, c2, …, cn: Age, Home

R: MyTable

Select Operation

Relational Algebra: Examples

- $\pi_{Age,Home}(R)$

  >SELECT Age, Home FROM MyTable

- $\sigma_{Home=\text{“Rent”}}(R)$

  >SELECT * FROM MyTable WHERE Home = “Rent”

- $\pi_{Age,Home}(\sigma_{Home=\text{“Rent”}}(R))$ or $\sigma_{Home=\text{“Rent”}}(\pi_{Age,Home}(R))$

  >SELECT Age, Home FROM MyTable WHERE Home = “Rent”

Relational Algebra: Examples

– In General:

- > An operation with σ produces a relation
- > An operation with π produces a relation
- > $\sigma_{\varphi 1}(\sigma_{\varphi 2}(R)) = \sigma_{\varphi 2}(\sigma_{\varphi 1}(R))$
- > $\pi_{[c1]}(\pi_{[c2]}(R)) \neq \pi_{[c2]}(\pi_{[c1]}(R))$ (<u>except if</u> c1 = c2 because c1 ⊂ c2 and c2 ⊃ c1)
- > $\pi_{[c]}(\sigma_{\varphi}(R)) = \sigma_{\varphi}(\pi_{[c]}(R))$ (<u>only if</u> columns in φ are also in [c])

Relational Algebra: Select

Name	**Age**	**Home**
Blackbur	5	None
Kobayas	21	Rent
Menchú	31	Rent
Alvarez	42	Rent
Tagore	50	Own

Horizontal partition

Relational Algebra: Select

Name	Age	Home
Blackbur	5	None
Kobayas	21	Rent
Menchú	31	Rent
Alvarez	42	Rent
Tagore	50	Own

Horizontal partition

Relational Algebra Select:
$\sigma_{\varphi}(R)$
where
φ: Home = “Rent”
R: MyTable

Relational Algebra: Select

SQL Statement:
SELECT * FROM MyTable WHERE Home = "Rent"

Name	Age	Home
Blackbur	5	None
Kobayas	21	Rent
Menchú	31	Rent
Alvarez	42	Rent
Tagore	50	Own

Horizontal partition

Relational Algebra Select:
$\sigma_{\varphi}(R)$
where
φ: Home = "Rent"
R: MyTable

Relational Algebra: Select

Name	Age	Home
Blackbur	5	None
Kobayas	21	Rent
Menchú	31	Rent
Alvarez	42	Rent
Tagore	50	Own

→

Name	Age	Home
Kobayas	21	Rent
Menchú	31	Rent
Alvarez	42	Rent

The result of a selection is a relation with 0 to n tuples where n is the number of tuples in the operand

Relational Algebra Select:

$\sigma_{\varphi}(R)$

where

φ: Home = “Rent”

R: MyTable

Product Operation

Relational Algebra: Product

Combine Rows

Name	Age
Blackbur	5
Kobayas	21

Name 2	Home
Menchú	Rent
Alvarez	Rent
Tagore	Own

Relational Algebra Product:
R X S

Relational Algebra: Product

Combine Rows

Name	Age
Blackbur	5
Kobayas	21

Name 2	Home
Menchú	Rent
Alvarez	Rent
Tagore	Own

SQL Statement:
SELECT * FROM TableR, TableS

Relational Algebra Product:
R X S

Relational Algebra: Product

Combine Rows

Name	**Age**
Blackbur	5
Kobayas	21

Name 2	**Home**
Menchú	Rent
Alvarez	Rent
Tagore	Own

→

Name	**Age**	**Name 2**	**Home**
Blackbur	5	Menchú	Rent
		Alvarez	Rent
		Tagore	Own
Kobayas	21	Menchú	Rent
		Alvarez	Rent
		Tagore	Own

Relational Algebra Product:
R X S

Relational Algebra: Product

Combine Rows

Name	Age
Blackbur	5
Kobayas	21

Name 2	Home
Menchú	Rent
Alvarez	Rent
Tagore	Own

→

Name	Age	Name 2	Home
Blackbur	5	Menchú	Rent
Blackbur	5	Alvarez	Rent
Blackbur	5	Tagore	Own
Kobayas	21	Menchú	Rent
Kobayas	21	Alvarez	Rent
Kobayas	21	Tagore	Own

Relational Algebra Product:
R X S

Relational Algebra: Product

Combine Rows

Name	Age
Blackbur	5
Kobayas	21

Name 2	Home
Menchú	Rent
Alvarez	Rent
Tagore	Own

Name	Age	Name 2	Home
Blackbur	5	Menchú	Rent
Blackbur	5	Alvarez	Rent
Blackbur	5	Tagore	Own
Kobayas	21	Menchú	Rent
Kobayas	21	Alvarez	Rent
Kobayas	21	Tagore	Own

Relational Algebra Product: R X S

Relational Algebra: Product

Combine Rows

Name	Age
Blackbur	5
Kobayas	21

Name 2	Home
Menchú	Rent
Alvarez	Rent
Tagore	Own

Name	Age	Name 2	Home
Blackbur	5	Menchú	Rent
Kobayas	21		
Blackbur	5	Alvarez	Rent
Kobayas	21		
Blackbur	5	Tagore	Own
Kobayas	21		

Relational Algebra Product:
R X S

Relational Algebra: Product

Combine Rows

Name	**Age**
Blackbur	5
Kobayas	21

Name 2	**Home**
Menchú	Rent
Alvarez	Rent
Tagore	Own

→

Name	**Age**	**Name 2**	**Home**
Blackbur	5	Menchú	Rent
Kobayas	21	Menchú	Rent
Blackbur	5	Alvarez	Rent
Kobayas	21	Alvarez	Rent
Blackbur	5	Tagore	Own
Kobayas	21	Tagore	Own

Relational Algebra Product:
R X S

Relational Algebra: Product

Combine Rows

Name	Age
Blackbur	5
Kobayas	21

Name 2	Home
Menchú	Rent
Alvarez	Rent
Tagore	Own

→

Name	Age	Name 2	Home
Blackbur	5	Menchú	Rent
Kobayas	21	Menchú	Rent
Blackbur	5	Alvarez	Rent
Kobayas	21	Alvarez	Rent
Blackbur	5	Tagore	Own
Kobayas	21	Tagore	Own

Relational Algebra Product:
R X S

Relational Algebra: Product

The result of a product is a relation with n*m tuples where n and m are the number of tuples in the operands. The arity of the result is i + j where i and j are the arities of the operands.

Combine Rows

Name	Age
Blackbur	5
Kobayas	21

Name 2	Home
Menchú	Rent
Alvarez	Rent
Tagore	Own

→

Name	Age	Name 2	Home
Blackbur	5	Menchú	Rent
Kobayas	21	Menchú	Rent
Blackbur	5	Alvarez	Rent
Kobayas	21	Alvarez	Rent
Blackbur	5	Tagore	Own
Kobayas	21	Tagore	Own

Relational Algebra Product:
R X S

Relational Algebra: Product

The result of a product is a relation with n*m tuples where n and m are the number of tuples in the operands. The arity of the result is i + j where i and j are the arities of the operands.

Combine Rows

Name	**Age**
Blackbur	5
Kobayas	21

Name 2	**Home**
Menchú	Rent
Alvarez	Rent
Tagore	Own

→

Name	**Age**	**Name 2**	**Home**
Blackbur	5	Menchú	Rent
Blackbur	5	Alvarez	Rent
Blackbur	5	Tagore	Own
Kobayas	21	Menchú	Rent
Kobayas	21	Alvarez	Rent
Kobayas	21	Tagore	Own

Relational Algebra Product:
R X S

Join Operation

Relational Algebra: Join

- A Join is a Product with a select statement

- Product followed by Select
  - SELECT * FROM TableR, TableS WHERE Home = "Rent"
  - $\sigma_{\varphi}(R \times S)$ where φ: Home = "Rent"

– JOIN
  - SELECT * FROM TableR JOIN TableS ON Home = "Rent"
  - $R \bowtie_{\varphi} S$ where φ: Home = "Rent"

Relational Algebra: Join

Combine Rows

Name	Age
Blackbur	5
Kobayas	21

Name 2	Home
Menchú	Rent
Alvarez	Rent
Tagore	Own

→

Name	Age	Name 2	Home
Blackbur	5	Menchú	Rent
Kobayas	21	Menchú	Rent
Blackbur	5	Alvarez	Rent
Kobayas	21	Alvarez	Rent
Blackbur	5	Tagore	Own
Kobayas	21	Tagore	Own

Relational Algebra Product with Select:
σ_{φ}(R X S) where φ: Home = “Rent”
Relational Algebra Join:
R $\bowtie_{\varphi}$ S where φ: Home = “Rent”

Relational Algebra: Join

Combine Rows

Name	**Age**
Blackbur	5
Kobayas	21

Name 2	**Home**
Menchú	Rent
Alvarez	Rent
Tagore	Own

→

Name	**Age**	**Name 2**	**Home**
Blackbur	5	Menchú	Rent
Kobayas	21	Menchú	Rent
Blackbur	5	Alvarez	Rent
Kobayas	21	Alvarez	Rent
Blackbur	5	Tagore	Own
Kobayas	21	Tagore	Own

Relational Algebra Product with Select:

σ_φ(R X S) where φ: Home = "Rent"

Relational Algebra Join:

R $\bowtie_\varphi$ S where φ: Home = "Rent"

Relational Algebra: Join

Combine Rows

Name	Age
Blackbur	5
Kobayas	21

Name 2	Home
Menchú	Rent
Alvarez	Rent
Tagore	Own

→

Name	Age	Name 2	Home
Blackbur	5	Menchú	Rent
Kobayas	21	Menchú	Rent
Blackbur	5	Alvarez	Rent
Kobayas	21	Alvarez	Rent

Relational Algebra Product with Select:

$\sigma_{\varphi}(R \times S)$ where φ: Home = "Rent"

Relational Algebra Join:

$R \bowtie_{\varphi} S$ where φ: Home = "Rent"

Relational Algebra Operations

So far:

- Union
- Intersect
- Project
- Select
- Product
- Join

Coming up:

- Division

Division Operation

Relational Algebra: Division

This was a Product Operand

Name	Age
Blackbur	5
Kobayas	21

Name 2	Home
Menchú	Rent
Alvarez	Rent
Tagore	Own

This was a Product Operand

This was the result of a Product

Name	Age	Name 2	Home
Blackbur	5	Menchú	Rent
Blackbur	5	Alvarez	Rent
Blackbur	5	Tagore	Own
Kobayas	21	Menchú	Rent
Kobayas	21	Alvarez	Rent
Kobayas	21	Tagore	Own

Relational Algebra Division:
R ÷ S

Relational Algebra: Division

A Division is sort of like the reverse of a Product

This was a Product Operand

Name	Age
Blackbur	5
Kobayas	21

This was the result of a Product

Name	Age	Name 2	Home
Blackbur	5	Menchú	Rent
Blackbur	5	Alvarez	Rent
Blackbur	5	Tagore	Own
Kobayas	21	Menchú	Rent
Kobayas	21	Alvarez	Rent
Kobayas	21	Tagore	Own

Name 2	Home
Menchú	Rent
Alvarez	Rent
Tagore	Own

This was a Product Operand

Relational Algebra Division:
R ÷ S

Relational Algebra: Division

A Division is sort of like the reverse of a Product

This was a Product Operand

Name	Age
Blackbur	5
Kobayas	21

Name 2	Home
Menchú	Rent
Alvarez	Rent
Tagore	Own

This was a Product Operand

This was the result of a Product

Name	Age	Name 2	Home
Blackbur	5	Menchú	Rent
Blackbur	5	Alvarez	Rent
Blackbur	5	Tagore	Own
Kobayas	21	Menchú	Rent
Kobayas	21	Alvarez	Rent
Kobayas	21	Tagore	Own

Relational Algebra Division:
$R \div S$

Relational Algebra: Division

Name	**Age**
Blackbur	5
Kobayas	21

Name 2	**Home**
Menchú	Rent
Alvarez	Rent
Tagore	Own

Name	**Age**	**Name 2**	**Home**
Blackbur	5	Menchú	Rent
Blackbur	5	Alvarez	Rent
Blackbur	5	Tagore	Own
Kobayas	21	Menchú	Rent
Kobayas	21	Alvarez	Rent
Kobayas	21	Tagore	Own
Sancar	54	Tagore	Own

Add another row to this table that did not result from the product.

Relational Algebra Division:
R ÷ S

Relational Algebra: Division

Name	Age
Blackbur	5
Kobayas	21

Name	Age	Name 2	Home
Blackbur	5	Menchú	Rent
Blackbur	5	Alvarez	Rent
Blackbur	5	Tagore	Own
Kobayas	21	Menchú	Rent
Kobayas	21	Alvarez	Rent
Kobayas	21	Tagore	Own
Sancar	54	Tagore	Own

Relational Algebra Division:
R ÷ S

Relational Algebra: Division

Exclude columns

Project

Name	Age
Blackbur	5
Kobayas	21

Result of Projection

Name 2	Home

Name	Age	Name 2	Home
Blackbur	5	Menchú	Rent
Blackbur	5	Alvarez	Rent
Blackbur	5	Tagore	Own
Kobayas	21	Menchú	Rent
Kobayas	21	Alvarez	Rent
Kobayas	21	Tagore	Own
Sancar	54	Tagore	Own

Relational Algebra Division:
R ÷ S

Relational Algebra: Division

Select

Name	**Age**
Blackbur	5
Kobayas	21

Name	**Age**	**Name 2**	**Home**
Blackbur	5	Menchú	Rent
Blackbur	5	Alvarez	Rent
Blackbur	5	Tagore	Own
Kobayas	21	Menchú	Rent
Kobayas	21	Alvarez	Rent
Kobayas	21	Tagore	Own
Sancar	54	Tagore	Own

Result of Selection

Name 2	**Home**
Menchú	Rent

Relational Algebra Division:
$R \div S$

Relational Algebra: Division

Select

Name	Age
Blackbur	5
Kobayas	21

Name	Age	Name 2	Home
Blackbur	5	Menchú	Rent
Blackbur	5	Alvarez	Rent
Blackbur	5	Tagore	Own
Kobayas	21	Menchú	Rent
Kobayas	21	Alvarez	Rent
Kobayas	21	Tagore	Own
Sancar	54	Tagore	Own

Result of Selection

Name 2	Home
Menchú	Rent
Alvarez	Rent

Relational Algebra Division:
R ÷ S

Relational Algebra: Division

Select

Name	Age
Blackbur	5
Kobayas	21

Name	Age	Name 2	Home
Blackbur	5	Menchú	Rent
Blackbur	5	Alvarez	Rent
Blackbur	5	Tagore	Own
Kobayas	21	Menchú	Rent
Kobayas	21	Alvarez	Rent
Kobayas	21	Tagore	Own
Sancar	54	Tagore	Own

Name 2	Home
Menchú	Rent
Alvarez	Rent
Tagore	Own

Result of Selection

Relational Algebra Division:
R ÷ S

Relational Algebra: Division

[Menchú, Rent] is in the same tuple as [Blackbur, 5] and [Kobayas, 21]

Name	Age
Blackbur	5
Kobayas	21

Name 2	Home
Menchú	Rent
Alvarez	Rent
Tagore	Own

Name	Age	Name 2	Home
Blackbur	5	Menchú	Rent
Blackbur	5	Alvarez	Rent
Blackbur	5	Tagore	Own
Kobayas	21	Menchú	Rent
Kobayas	21	Alvarez	Rent
Kobayas	21	Tagore	Own
Sancar	54	Tagore	Own

Relational Algebra Division: R ÷ S

Relational Algebra: Division

[Alvarez, Rent] is in the same tuple as [Blackbur, 5] and [Kobayas, 21]

Name	Age
Blackbur	5
Kobayas	21

Name 2	Home
Menchú	Rent
Alvarez	Rent
Tagore	Own

Name	Age	Name 2	Home
Blackbur	5	Menchú	Rent
Blackbur	5	Alvarez	Rent
Blackbur	5	Tagore	Own
Kobayas	21	Menchú	Rent
Kobayas	21	Alvarez	Rent
Kobayas	21	Tagore	Own
Sancar	54	Tagore	Own

Relational Algebra Division:
R ÷ S

Relational Algebra: Division

[Tagore, Own] is in the same tuple as
[Blackbur, 5] and [Kobayas, 21]

Name	Age
Blackbur	5
Kobayas	21

Name 2	Home
Menchú	Rent
Alvarez	Rent
Tagore	Own

Name	Age	Name 2	Home
Blackbur	5	Menchú	Rent
Blackbur	5	Alvarez	Rent
Blackbur	5	Tagore	Own
Kobayas	21	Menchú	Rent
Kobayas	21	Alvarez	Rent
Kobayas	21	Tagore	Own
Sancar	54	Tagore	Own

Relational Algebra Division:
R ÷ S

Relational Algebra: Division

The result of a division is a relation with n tuples of arity I where the dividend operand has at least n*m tuples of arity i + j and the divisor operand has exactly m tuples of arity j that are a subset of the of the dividend tuples.

Name	Age
Blackbur	5
Kobayas	21

Name 2	Home
Menchú	Rent
Alvarez	Rent
Tagore	Own

Name	Age	Name 2	Home
Blackbur	5	Menchú	Rent
Blackbur	5	Alvarez	Rent
Blackbur	5	Tagore	Own
Kobayas	21	Menchú	Rent
Kobayas	21	Alvarez	Rent
Kobayas	21	Tagore	Own
Sancar	54	Tagore	Own

Relational Algebra Division:
R ÷ S

Relational Algebra: Resources

Links for definitions and concepts:

- http://en.wikipedia.org/wiki/Cartesian_product
- http://en.wikipedia.org/wiki/Commutative_property
- http://en.wikipedia.org/wiki/Associative_property
- http://en.wikipedia.org/wiki/Closure_(mathematics)
- http://en.wikipedia.org/wiki/Relational_calculus
- http://en.wikipedia.org/wiki/Relational_algebra
- http://en.wikipedia.org/wiki/Edgar_F._Codd
- http://en.wikipedia.org/wiki/Relational_model
- http://en.wikipedia.org/wiki/Relational_database
- http://en.wikipedia.org/wiki/Query_language

Summary

Table = Part of a Database

Relation = Table with unique rows

Attribute = Column in a table relation

- Arity – number of columns

Tuple = Row in the table relation

Math operations on a Relation

- Union, Intersect, Project, Select, Join
- Product, Division

Relational Algebra

The theory behind Relational Databases