Lancaster University

SCC.201 Databases

2024 - Week 4 – Relational Algebra

Uraz C Turker

Last week Functional Dependencies and Normal Forms

Lancaster University

- Prove that the ACEF is a key for R(A,B,C,D,E,F,G,H) where we are given a set of FDs F:{A->BDGH}.
-
-
-

Last week Functional Dependencies and Normal Forms

Lancaster University

- Prove that the ACEF is a key for R(A,B,C,D,E,F,G,H) where we are given a set of FDs F:{A->BDGH}.
- A->A
-
-

Last week Functional Dependencies and Normal Forms

Lancaster University

- Prove that the ACEF is a key for R(A,B,C,D,E,F,G,H) where we are given a set of FDs F:{A->BDGH}.
- A->A
- We know A->BDHG, AA->ABDGH (by Augmentation), so A->ABDGH.
-

Last week Functional Dependencies and Normal Forms

Lancaster University

- Prove that the ACEF is a key for R(A,B,C,D,E,F,G,H) where we are given a set of FDs F:{A->BDGH}.
- A->A
- We know A->BDHG, AA->ABDGH (by Augmentation), so A->ABDGH.
- ACEF -> ABCDEFGH (by Augmentation) so ACEF->ABCDEFGH as required.

Last week Functional Dependencies and Normal Forms

Lancaster University

- Prove that the ACEF is a key for R(A,B,C,D,E,F,G,H) where we are given a set of FDs F:{A->BDGH, ACEF->ABCDEFGH}
- What is the Normalisation Level?
-
-
-
-

Last week Functional Dependencies and Normal Forms

Lancaster University

- Prove that the ACEF is a key for R(A,B,C,D,E,F,G,H) where we are given a set of FDs F:{A->BDGH, ACEF->ABCDEFGH}
- What is the Normalisation Level?
- 1NF (No set-valued/multivalued attribute)
-
-
-

Last week Functional Dependencies and Normal Forms

Lancaster University

- Prove that the ACEF is a key for R(A,B,C,D,E,F,G,H) where we are given a set of FDs F:{A->BDGH, ACEF->ABCDEFGH}
- What is the Normalisation Level?
- 1NF (No set-valued/multivalued attribute)
- 2NF (No part of a key determines a non-prime attribute)
-
-

Last week Functional Dependencies and Normal Forms

Lancaster University

- Prove that the ACEF is a key for R(A,B,C,D,E,F,G,H) where we are given a set of FDs F:{A->BDGH, ACEF->ABCDEFGH}
- What is the Normalisation Level?
- 1NF (No set-valued/multivalued attribute)
- 2NF (No part of a key determines a non-prime attribute)
- {A,C,E,F} are prime attributes and {B,D,G,H} are non-prime attributes.
-

Last week Functional Dependencies and Normal Forms

Lancaster University

- Prove that the ACEF is a key for R(A,B,C,D,E,F,G,H) where we are given a set of FDs F:{A->BDGH, ACEF->ABCDEFGH}
- What is the Normalisation Level?
- 1NF (No set-valued/multivalued attribute)
- 2NF (No part of a key determines a non-prime attribute)
- {A,C,E,F} are prime attributes and {B,D,G,H} are non-prime attributes.
- A->BDGH so it is not in 2NF. It is in 1NF.

Last week Functional Dependencies and Normal Forms

Lancaster University

- Prove that the ACEF is a key for R(A,B,C,D,E,F,G,H) where we are given a set of FDs F:{A->BDGH, ACEF->ABCDEFGH}
- Make it in 2NF.
-
-
    -
-

Last week Functional Dependencies and Normal Forms

Lancaster University

- Prove that the ACEF is a key for R(A,B,C,D,E,F,G,H) where we are given a set of FDs F:{A->BDGH, ACEF->ABCDEFGH}
- Make it in 2NF.
- The problematic functional dependency is A->BDGH, so I must move this FD out of the relation.
-
  -
-

Last week Functional Dependencies and Normal Forms

Lancaster University

- Prove that the ACEF is a key for R(A,B,C,D,E,F,G,H) where we are given a set of FDs F:{A->BDGH, ACEF->ABCDEFGH}
- Make it in 2NF.
- The problematic functional dependency is A->BDGH, so I must move this FD out of the relation.
- How?
  -
-

Last week Functional Dependencies and Normal Forms

Lancaster University

- Prove that the ACEF is a key for R(A,B,C,D,E,F,G,H) where we are given a set of FDs F:{A->BDGH, ACEF->ABCDEFGH}
- Make it in 2NF.
- The problematic functional dependency is A->BDGH, so I must move this FD out of the relation.
- How?
  - BY DECOMPOSITION!
-

Last week Functional Dependencies and Normal Forms

Lancaster University

- Prove that the ACEF is a key for R(A,B,C,D,E,F,G,H) where we are given a set of FDs F:{A->BDGH, ACEF->ABCDEFGH}
- Make it in 2NF.
- The problematic functional dependency is A->BDGH, so I must move this FD out of the relation.
- How?
  - BY DECOMPOSITION!
- I will have two tables R1(ABDGH) and R2(ACEF) instead of R(ABCDEFGH)

Let’s work on a table given in the Uraz Language!

Lancaster University

QERS	EHHVIWW	TLSRI RYQFIV	EKI
YVEC	Pgersxiw	07234954355	42
NSLR	Pshsr	07463523562	19
YVEC	Pgersxiw	07234466224	42
NSLR	Pshsr	07314523621	20

What is the CK set?

Lancaster University

QERS	EHHVIWW	TLSRI RYQFIV	EKI
YVEC	Pgersxiw	07234954355	42
NSLR	Pshsr	07463523562	19
YVEC	Pgersxiw	07234466224	42
NSLR	Pshsr	07314523621	20

What is the CK set: {TLSRI RYQFIV}

Lancaster University

QERS	EHHVIWW	TLSRI RYQFIV	EKI
YVEC	Pgersxiw	07234954355	42
NSLR	Pshsr	07463523562	19
YVEC	Pgersxiw	07234466224	42
NSLR	Pshsr	07314523621	20

What are the NPAs:

Lancaster University

QERS	EHHVIWW	TLSRI RYQFIV	EKI
YVEC	Pgersxiw	07234954355	42
NSLR	Pshsr	07463523562	19
YVEC	Pgersxiw	07234466224	42
NSLR	Pshsr	07314523621	20

What are the NPAs: {QERS,EHHVIWW,EKI}

Lancaster University

QERS	EHHVIWW	TLSRI RYQFIV	EKI
YVEC	Pgersxiw	07234954355	42
NSLR	Pshsr	07463523562	19
YVEC	Pgersxiw	07234466224	42
NSLR	Pshsr	07314523621	20

What are the FDs?

Lancaster University

QERS	EHHVIWW	TLSRI RYQFIV	EKI
YVEC	Pgersxiw	07234954355	42
NSLR	Pshsr	07463523562	19
YVEC	Pgersxiw	07234466224	42
NSLR	Pshsr	07314523621	20

What are the FDs: QERS->EHHVIWW(or vice versa)

Lancaster University

QERS	EHHVIWW	TLSRI RYQFIV	EKI
YVEC	Pgersxiw	07234954355	42
NSLR	Pshsr	07463523562	19
YVEC	Pgersxiw	07234466224	42
NSLR	Pshsr	07314523621	20

What are the FDs: EKI->{EHHVIWW,QERS}

Lancaster University

QERS	EHHVIWW	TLSRI RYQFIV	EKI
YVEC	Pgersxiw	07234954355	42
NSLR	Pshsr	07463523562	19
YVEC	Pgersxiw	07234466224	42
NSLR	Pshsr	07314523621	20

Hidden Words ☺

Lancaster University

QERS (NAME)	EHHVIWW (Address)	TLSRI RYQFIV(Phone Nu.)	EKI (Age)
YVEC (Uraz)	Pgersxiw (Lancaster)	07234954355	42
NSLR (John)	Pshsr (London)	07463523562	19
YVEC (Uraz)	Pgersxiw (Lancaster)	07234466224	42
NSLR (John)	Pshsr (London)	07314523621	20

From you…

How did you found the module as a whole?	What aspect of the module did you find most useful?	What aspect of the module did you find most difficult?	What can be improved to help with the module?	How was the support offered by module convenor?	What more support can be provided?	Any other comments
Manageable	Interaction with student's during lectures	Looking at small details to notice why something might be wrong or right	Having a more challenging activity during labs which is meant to challenge you and can perhaps have many interpretations	Extra	NOT NESSESARY YET BUT drop in sessions especially when closer to exams	None

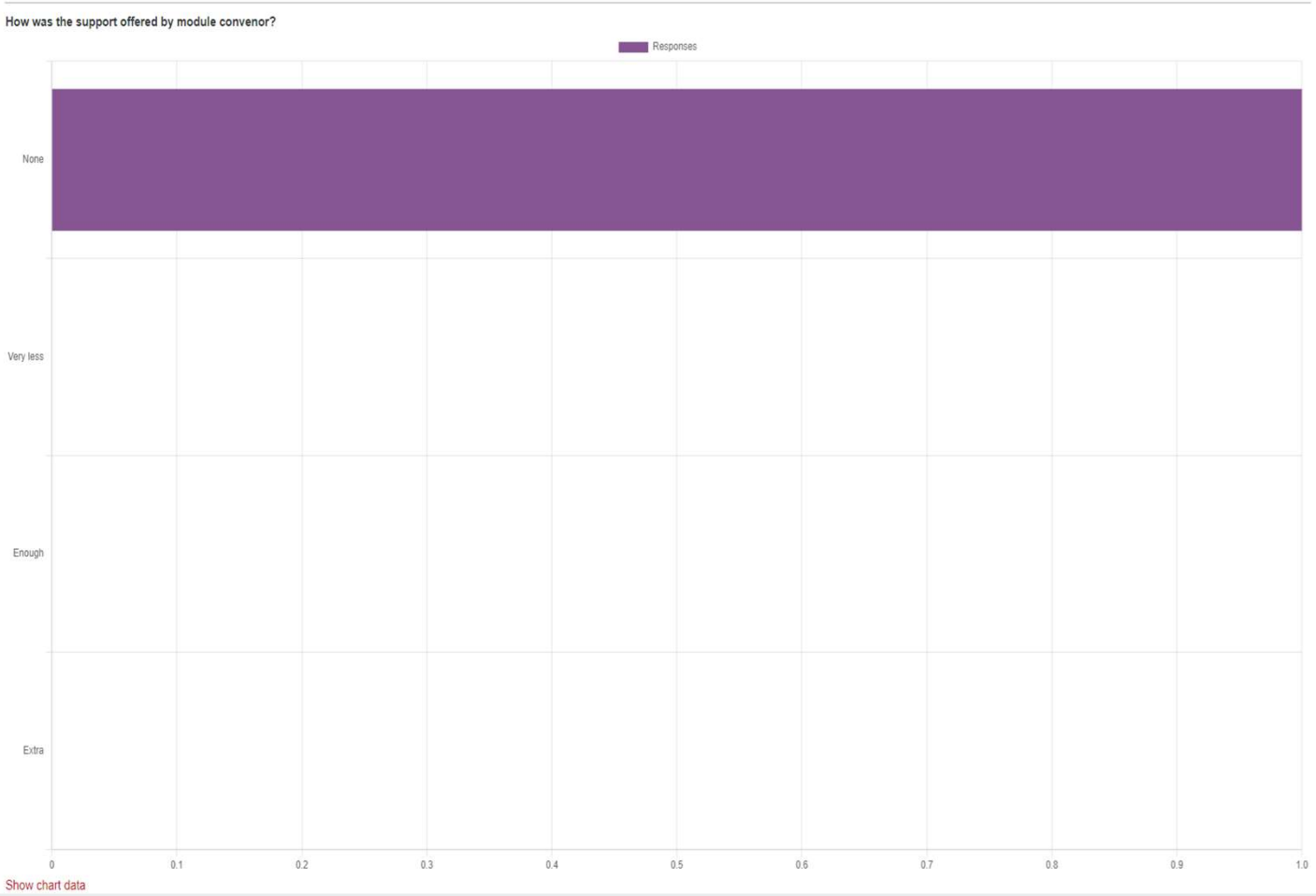
From you

Lancaster University

What can be improved to help with the module?

- I think that it would be useful to release the worked solutions with the lab worksheets so that we can go through and check our answers in the lab while it is fresh and so that should we get stuck, we can check we are on the right track

From you


How was the support offered by module convenor?
Responses
None
Very less
Enough
Extra
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Show chart data

Week 1	Lecture 1	Introduction to the module, Why do we need Databases? Entity Relationship Model
	Lecture 2	Entity Relationship Model (ERM)
	Lab	NO LAB
Week2	Lecture 1	Relational Model (RM)
	Lecture 2	ER to RM
	Lab	ER diagrams.
Week 3	Lecture 1	Functional Dependencies
	Lecture 2	1st, 2nd, 3rd and Boyce-Cott Normal Forms
	Lab	ER to Relational Model.
Week 4	Lecture 1	Relational Algebra
	Lecture 2	Relational Algebra
	Lab	Functional dependencies and Normal forms
Week 5	Lecture 1	SQL Scripts
	Lecture 2	Advanced SQL Scripts
	Lab	Relational algebra
Week 6	Lecture 1	JDBC
	Lecture 2	Review
	Lab	Advanced SQL Scripting
Week 7	Lecture 1	Coursework, Record Search - B-Trees
	Lecture 2	Record Search - B-Trees (Cont.)
	Lab	Project
Week 8	Lecture 1	Search - Hashing
	Lecture 2	Physical Storage - record files, Storage - secondary files
	Lab	Project
Week 9	Lecture 1	Concurrency - Transaction Processing (cont)
	Lecture 2	Durability of Transactions and Crash Recovery
	Lab	Project
Week 10	Lecture 1	Advanced SQL - schemas, views, access control
	Lecture 2	Review
	Lab	Project

Lancaster University

Learning outcomes

Lancaster University

- You will learn basic concepts regarding to relational algebra such as
  - Selection
  - Projection
  - Cross-product
  - Union
  - Set difference.
- After this week, you will be able to
  - Analyse different query formulas with respect to the number of operations they will lead.
  - Devise optimum query structures for modern relational databases.

Reading Materials

Lancaster University

- Chapter 5 of the book
  - Database Systems: a practical approach to design, implementation, and management.
- Chapter 6 of the book
  - Fundamentals of Database Systems.

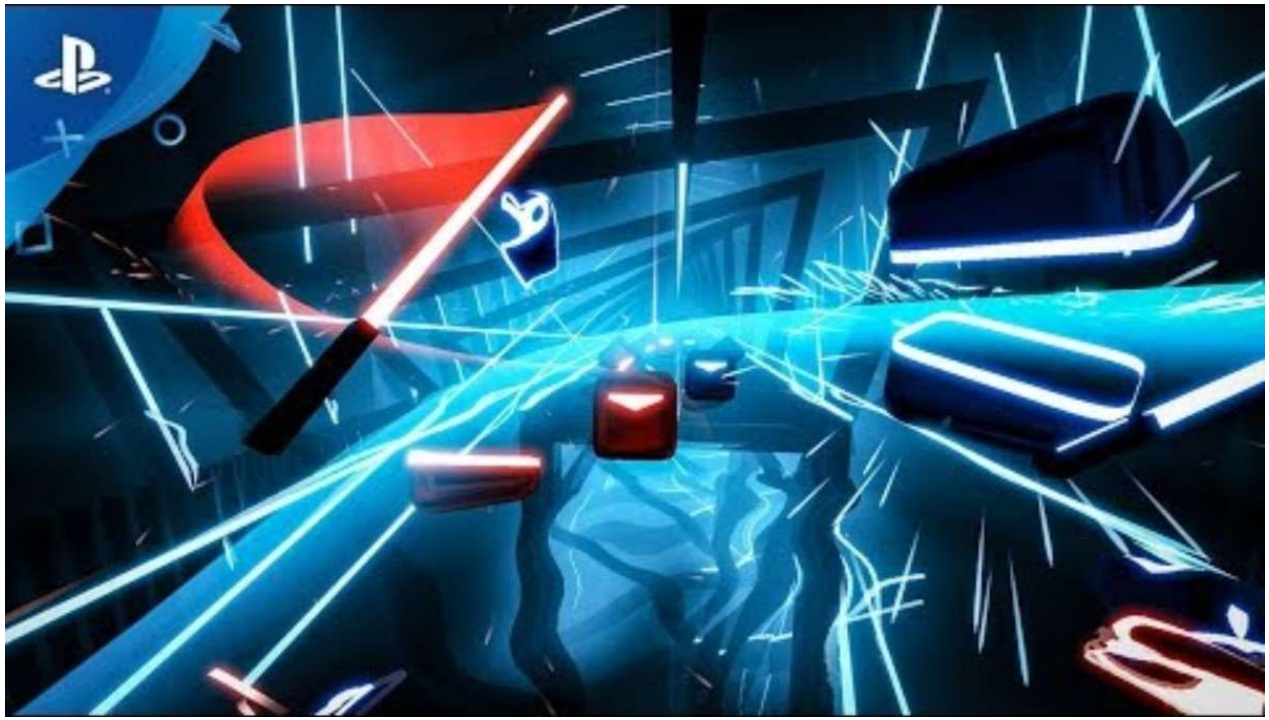
Query Languages

Lancaster University

- For manipulation and retrieval of stored data
- Relational model supports simple yet powerful query languages
- Query languages are not as complex as programming languages
- They are specialized for data manipulation and retrieval

NEW TOPIC – Warning!

Lancaster University



Relational Algebra

Lancaster University

- It is a mathematical query language
- Forms the basis of the SQL query language
- Relational Calculus is another mathematical query language but it is declarative rather than operational
- We will concentrate on relational algebra in this course

Basics of Querying

Lancaster University

- A query is applied to relation instances, and the result of a query is also a relation instance.

eid	ename	Salary	age
28	Eric	90K	35
58	Kyle	100K	33

ename	Salary
Eric	90K
Kyle	100K

Relational Algebra Operations

Lancaster University

- Basic operations:
  - *Selection* (σ) Selects a subset of rows from relation.
  - *Projection* (π) Deletes unwanted columns from relation.
  - *Cross-product* ($\times$) Combines two relations.
  - *Set-difference* ($-$) Tuples in relation 1, but not in relation 2.
  - *Union* ($\cup$) Tuples in relation 1 and in relation 2.

Relational Algebra

Lancaster University

- Additional operations:
  - Intersection,
  - *Join*
  - division,
  - Renaming
- Each operation returns a relation therefore operations can be *composed*

Projection

- Input is a single relation instance
- Deletes attributes that are not in *projection list*.
- *Schema* of result contains exactly the fields in the projection list, with the same names that they had in the input relation.
-
  -

$S2$

sid	sname	rating	age
28	yuppy	9	35.0
31	lubber	8	55.5
44	guppy	5	35.0
58	rusty	10	35.0

$$\pi_{sname,rating}(S2)$$

sname	rating
yuppy	9
lubber	8
guppy	5
rusty	10

Projection

- Input is a single relation instance
- Deletes attributes that are not in *projection list*.
- *Schema* of result contains exactly the fields in the projection list, with the same names that they had in the input relation.
- Projection operator has to eliminate *duplicates* (Why??)
  - Note: real systems typically don't do duplicate elimination unless the user explicitly asks for it. (Why not?)

$S2$

sid	sname	rating	age
28	yuppy	9	35.0
31	lubber	8	55.5
44	guppy	5	35.0
58	rusty	10	35.0

$$\pi_{sname,rating}(S2)$$

sname	rating
yuppy	9
lubber	8
guppy	5
rusty	10

Projection

- Input is a single relation instance
- Deletes attributes that are not in *projection list*.
- *Schema* of result contains exactly the fields in the projection list, with the same names that they had in the input relation.
- Projection operator has to eliminate *duplicates* (Why??)
  - Note: real systems typically don't do duplicate elimination unless the user explicitly asks for it. (Why not?)

S2

sid	sname	rating	age
28	yuppy	9	35.0
31	lubber	8	55.5
44	guppy	5	35.0
58	rusty	10	35.0

$$\pi_{age}(S2)$$

age
35.0
55.5

Selection

- Input is a single relation instance
- Selects rows that satisfy *selection condition*.
- No duplicates in result! (Why?)
- *Schema* of result identical to schema of input relation.

S2

sid	sname	rating	age
28	yuppy	9	35.0
31	lubber	8	55.5
44	guppy	5	35.0
58	rusty	10	35.0

$$\sigma_{rating>8}(S2)$$

sid	sname	rating	age
28	yuppy	9	35.0
58	rusty	10	35.0

Selection

- Input is a single relation instance
- Selects rows that satisfy *selection condition*.
- No duplicates in result! (Why?)
- *Schema* of result identical to schema of input relation.
- *Result* relation can be the *input* for another relational algebra operation!

S2

sid	sname	rating	age
28	yuppy	9	35.0
31	lubber	8	55.5
44	guppy	5	35.0
58	rusty	10	35.0

$$\pi_{sname,rating}(\sigma_{rating>8}(S2))$$

Selection

- Input is a single relation instance
- Selects rows that satisfy *selection condition*.
- No duplicates in result! (Why?)
- *Schema* of result identical to schema of input relation.
- *Result* relation can be the *input* for another relational algebra operation!

S2

sid	sname	rating	age
28	yuppy	9	35.0
31	lubber	8	55.5
44	guppy	5	35.0
58	rusty	10	35.0

$$\pi_{sname,rating}(\sigma_{rating>8}(S2))$$

$\pi_{sname,rating}$ (

sid	sname	rating	age
28	yuppy	9	35.0
58	rusty	10	35.0

)

Selection

- Input is a single relation instance
- Selects rows that satisfy *selection condition*.
- No duplicates in result! (Why?)
- *Schema* of result identical to schema of input relation.
- *Result* relation can be the *input* for another relational algebra operation!

$S2$

sid	sname	rating	age
28	yuppy	9	35.0
31	lubber	8	55.5
44	guppy	5	35.0
58	rusty	10	35.0

$$\pi_{sname,rating}(\sigma_{rating>8}(S2))$$

$\pi_{sname,rating}$(

sid	sname	rating	age
28	yuppy	9	35.0
58	rusty	10	35.0

)

sname	rating
yuppy	9
rusty	10

Example

Lancaster University

Question

- Find the sid of the player where (rating * age) <400.
-
-
-

Players table

sid	sname	rating	age
28	yuppy	9	35.0
31	lubber	8	55.5
44	guppy	5	35.0
58	rusty	10	35.0

Example

Lancaster University

Question

- Find the sid of the player where (rating * age) <400.
- i) Drop columns that are not related to the query.
-
-

Players table

sid	sname	rating	age
28	yuppy	9	35.0
31	lubber	8	55.5
44	guppy	5	35.0
58	rusty	10	35.0

Example

Lancaster University

Question

- Find the sid of the player where (rating * age) <400.
- i) Drop columns that are not related to the query.

$$R1 = \pi_{sid,rating,age}(Players)$$

-
-

Players table

sid	sname	rating	age
28	yuppy	9	35.0
31	lubber	8	55.5
44	guppy	5	35.0
58	rusty	10	35.0

Example

Lancaster University

Question

- Find the sid of the player where (rating * age) <400.
- i) Drop columns that are not related to the query.

$$R1 = \pi_{sid,rating,age}(Players)$$

- ii)Select the rows that obey the condition
-

Players table

sid	sname	rating	age
28	yuppy	9	35.0
31	lubber	8	55.5
44	guppy	5	35.0
58	rusty	10	35.0

Example

Lancaster University

Question

- Find the sid of the player where (rating * age) <400.
- i) Drop columns that are not related to the query.

$$R1 = \pi_{sid,rating,age}(Players)$$

- ii)Select the rows that obey the condition

$$R2 = \sigma_{rating*age<400}(R1)$$

-

Players table

sid	sname	rating	age
28	yuppy	9	35.0
31	lubber	8	55.5
44	guppy	5	35.0
58	rusty	10	35.0

Example

Lancaster University

Question

- Find the sid of the player where (rating * age) <400.
- i) Drop columns that are not related to the query.

$$R1 = \pi_{sid,rating,age}(Players)$$

- ii)Select the rows that obey the condition

$$R2 = \sigma_{rating*age<400}(R1)$$

- iii)Return your result

Players table

sid	sname	rating	age
28	yuppy	9	35.0
31	lubber	8	55.5
44	guppy	5	35.0
58	rusty	10	35.0

Example

Lancaster University

Question

- Find the sid of the player where (rating * age) <400.
- i) Drop columns that are not related to the query.

$$R1 = \pi_{sid,rating,age}(Players)$$

- ii)Select the rows that obey the condition

$$R2 = \sigma_{rating*age<400}(R1)$$

- iii)Return your result

$$\pi_{sid}(R2)$$

Players table

sid	sname	rating	age
28	yuppy	9	35.0
31	lubber	8	55.5
44	guppy	5	35.0
58	rusty	10	35.0

Example

Lancaster University

Question

- Find the sid of the player where (rating * age) <400.
-
-

Players table

sid	sname	rating	age
28	yuppy	9	35.0
31	lubber	8	55.5
44	guppy	5	35.0
58	rusty	10	35.0

Example

Lancaster University

Question

- Find the sid of the player where (rating * age) <400.
- i) Select the rows that obey the condition
-

Players table

sid	sname	rating	age
28	yuppy	9	35.0
31	lubber	8	55.5
44	guppy	5	35.0
58	rusty	10	35.0

Example

Lancaster University

Question

- Find the sid of the player where (rating * age) <400.
- i) Select the rows that obey the condition

$$R1 = \sigma_{rating*age<400}(Players)$$

-

Players table

sid	sname	rating	age
28	yuppy	9	35.0
31	lubber	8	55.5
44	guppy	5	35.0
58	rusty	10	35.0

Example

Lancaster University

Question

- Find the sid of the player where (rating * age) <400.
- i) Select the rows that obey the condition

$$R1 = \sigma_{rating*age<400}(Players)$$

- ii)Return your result

Players table

sid	sname	rating	age
28	yuppy	9	35.0
31	lubber	8	55.5
44	guppy	5	35.0
58	rusty	10	35.0

Example

Lancaster University

Question

- Find the sid of the player where (rating * age) <400.
- i) Select the rows that obey the condition

$$R1 = \sigma_{rating*age<400}(Players)$$

- ii)Return your result

$$\pi_{sid}(R1)$$

Players table

sid	sname	rating	age
28	yuppy	9	35.0
31	lubber	8	55.5
44	guppy	5	35.0
58	rusty	10	35.0

Different solutions. # of operations is important!

Lancaster University

2 operations

- Find the sid of the player where (rating * age) <400.
- i) Select the rows that obey the condition

$$R1 = \sigma_{rating*age<400}(Players)$$

- ii)Return your result

$$\pi_{sid}(R1)$$

3 operations

- Find the sid of the player where (rating * age) <400.
- i) Drop columns that are not related to the query.

$$R1 = \pi_{sid,rating,age}(Players)$$

- ii)Select the rows that obey the condition

$$R2 = \sigma_{rating*age<400}(R1)$$

- iii)Return your result

$$\pi_{sid}(R2)$$

Union, Intersection, Set-Difference

- All of these operations take two input relations, which must be *union-compatible*:
  - Same number of fields.
  - `Corresponding' fields have the same type.

Union

S1

sid	sname	rating	age
22	dustin	7	45.0
31	lubber	8	55.5
58	rusty	10	35.0

S2

sid	sname	rating	age
28	yuppy	9	35.0
31	lubber	8	55.5
44	guppy	5	35.0
58	rusty	10	35.0

$S1 \cup S2$

sid	sname	rating	age
22	dustin	7	45.0
31	lubber	8	55.5
58	rusty	10	35.0
44	guppy	5	35.0
28	yuppy	9	35.0

Intersection

S1

sid	sname	rating	age
22	dustin	7	45.0
31	lubber	8	55.5
58	rusty	10	35.0

S2

sid	sname	rating	age
28	yuppy	9	35.0
31	lubber	8	55.5
44	guppy	5	35.0
58	rusty	10	35.0

$S1 \cap S2$

sid	sname	rating	age
31	lubber	8	55.5
58	rusty	10	35.0

Set Difference

S1

sid	sname	rating	age
22	dustin	7	45.0
31	lubber	8	55.5
58	rusty	10	35.0

S2

sid	sname	rating	age
28	yuppy	9	35.0
31	lubber	8	55.5
44	guppy	5	35.0
58	rusty	10	35.0

$S1 - S2$

sid	sname	rating	age
22	dustin	7	45.0

Find the locations of suppliers having Part# 1

Lancaster University

- Select all the rows where Part# is 1

Sps

Supplier	Part#	Stock
Acme	1	17
Acme	2	25
Acme	3	17
Ajax	1	25
Ajax	3	18
Amco	1	3
Amco	2	22
Jamco	1	3

Locs

Supplier	Location
Acme	London
Ajax	Bristol
Amco	Glasgow
Jamco	Glasgow

Find the locations of suppliers having Part# 1

Lancaster University

- Select all the rows where Part# is 1

$$R1 = \sigma_{rpart\#=1}(Sps)$$

Sps

Supplier	Part#	Stock
Acme	1	17
Acme	2	25
Acme	3	17
Ajax	1	25
Ajax	3	18
Amco	1	3
Amco	2	22
Jamco	1	3

$Locs$

Supplier	Location
Acme	London
Ajax	Bristol
Amco	Glasgow
Jamco	Glasgow

Find the locations of suppliers having Part# 1

Lancaster University

- Select all the rows where Part# is 1

$$R1 = \sigma_{rpart\#=1}(Sps)$$

- Find their Supplier names
-
-

Sps

Supplier	Part#	Stock
Acme	1	17
Acme	2	25
Acme	3	17
Ajax	1	25
Ajax	3	18
Amco	1	3
Amco	2	22
Jamco	1	3

$Locs$

Supplier	Location
Acme	London
Ajax	Bristol
Amco	Glasgow
Jamco	Glasgow

Find the locations of suppliers having Part# 1

Lancaster University

- Select all the rows where Part# is 1

$$R1 = \sigma_{part\#=1}(Sps)$$

- Find their Supplier names

$$R2 = \pi_{Supplier}(R1)$$

-
-

Sps

Supplier	Part#	Stock
Acme	1	17
Acme	2	25
Acme	3	17
Ajax	1	25
Ajax	3	18
Amco	1	3
Amco	2	22
Jamco	1	3

$Locs$

Supplier	Location
Acme	London
Ajax	Bristol
Amco	Glasgow
Jamco	Glasgow

Find the locations of suppliers having Part# 1

Lancaster University

- Select all the rows where Part# is 1

$$R1 = \sigma_{part\#=1}(Sps)$$

- Find their Supplier names

$$R2 = \pi_{Supplier}(R1)$$

- Then what?
-

Sps

Supplier	Part#	Stock
Acme	1	17
Acme	2	25
Acme	3	17
Ajax	1	25
Ajax	3	18
Amco	1	3
Amco	2	22
Jamco	1	3

$Locs$

Supplier	Location
Acme	London
Ajax	Bristol
Amco	Glasgow
Jamco	Glasgow

Find the locations of suppliers having Part# 1

Lancaster University

- Select all the rows where Part# is 1

$$R1 = \sigma_{part\#=1}(Sps)$$

- Find their Supplier names

$$R2 = \pi_{Supplier}(R1)$$

- Then what?
- We need to find a way of combining relations for such queries.

Sps

Supplier	Part#	Stock
Acme	1	17
Acme	2	25
Acme	3	17
Ajax	1	25
Ajax	3	18
Amco	1	3
Amco	2	22
Jamco	1	3

$Locs$

Supplier	Location
Acme	London
Ajax	Bristol
Amco	Glasgow
Jamco	Glasgow

Cross-Product

- S1 X R1
- Each row of S1 is paired with each row of R1.
- *Result schema* has one field per field of S1 and R1, with field names `inherited' if possible.

S1

sid	sname	rating	age
22	dustin	7	45.0
31	lubber	8	55.5
58	rusty	10	35.0

R1

sid	bid	day
22	101	10/10/96
58	103	11/12/96

Cross-Product

S1

sid	sname	rating	age
22	dustin	7	45.0
31	lubber	8	55.5
58	rusty	10	35.0

R1

sid	bid	day
22	101	10/10/96
58	103	11/12/96

S1 **X** *R1*

(sid)	sname	rating	age	(sid)	bid	day

Cross-Product

S1

sid	sname	rating	age
22	dustin	7	45.0
31	lubber	8	55.5
58	rusty	10	35.0

R1

sid	bid	day
22	101	10/10/96
58	103	11/12/96

S1 **X** *R1*

(sid)	sname	rating	age	(sid)	bid	day

Cross-Product

S1

sid	sname	rating	age
22	dustin	7	45.0
31	lubber	8	55.5
58	rusty	10	35.0

R1

sid	bid	day
22	101	10/10/96
58	103	11/12/96

S1 **X** *R1*

(sid)	sname	rating	age	(sid)	bid	day
22	dustin	7	45.0	22	101	10/10/96

Cross-Product

S1

sid	sname	rating	age
22	dustin	7	45.0
31	lubber	8	55.5
58	rusty	10	35.0

R1

sid	bid	day
22	101	10/10/96
58	103	11/12/96

S1 X R1

(sid)	sname	rating	age	(sid)	bid	day
22	dustin	7	45.0	22	101	10/10/96
22	dustin	7	45.0	58	103	11/12/96

Cross-Product

S1

sid	sname	rating	age
22	dustin	7	45.0
31	lubber	8	55.5
58	rusty	10	35.0

R1

sid	bid	day
22	101	10/10/96
58	103	11/12/96

S1 **X** *R1*

(sid)	sname	rating	age	(sid)	bid	day
22	dustin	7	45.0	22	101	10/10/96
22	dustin	7	45.0	58	103	11/12/96
31	lubber	8	55.5	22	101	10/10/96

Cross-Product

S1

sid	sname	rating	age
22	dustin	7	45.0
31	lubber	8	55.5
58	rusty	10	35.0

R1

sid	bid	day
22	101	10/10/96
58	103	11/12/96

S1 **X** *R1*

(sid)	sname	rating	age	(sid)	bid	day
22	dustin	7	45.0	22	101	10/10/96
22	dustin	7	45.0	58	103	11/12/96
31	lubber	8	55.5	22	101	10/10/96
31	lubber	8	55.5	58	103	11/12/96

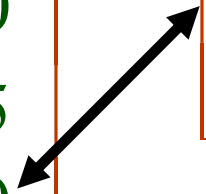
Cross-Product

S1

sid	sname	rating	age
22	dustin	7	45.0
31	lubber	8	55.5
58	rusty	10	35.0

R1

sid	bid	day
22	101	10/10/96
58	103	11/12/96



S1 **X** *R1*

(sid)	sname	rating	age	(sid)	bid	day
22	dustin	7	45.0	22	101	10/10/96
22	dustin	7	45.0	58	103	11/12/96
31	lubber	8	55.5	22	101	10/10/96
31	lubber	8	55.5	58	103	11/12/96
58	rusty	10	35.0	22	101	10/10/96

Cross-Product

S1

sid	sname	rating	age
22	dustin	7	45.0
31	lubber	8	55.5
58	rusty	10	35.0

R1

sid	bid	day
22	101	10/10/96
58	103	11/12/96

S1 **X** *R1*

(sid)	sname	rating	age	(sid)	bid	day
22	dustin	7	45.0	22	101	10/10/96
22	dustin	7	45.0	58	103	11/12/96
31	lubber	8	55.5	22	101	10/10/96
31	lubber	8	55.5	58	103	11/12/96
58	rusty	10	35.0	22	101	10/10/96
58	rusty	10	35.0	58	103	11/12/96

Both S1 and R1 have a field called *sid*. Which may cause a conflict when referring to columns

S1 X R1

(sid)	sname	rating	age	(sid)	bid	day
22	dustin	7	45.0	22	101	10/10/96
22	dustin	7	45.0	58	103	11/12/96
31	lubber	8	55.5	22	101	10/10/96
31	lubber	8	55.5	58	103	11/12/96
58	rusty	10	35.0	22	101	10/10/96
58	rusty	10	35.0	58	103	11/12/96

Renaming Operator

Takes a relation schema and gives a new name to the schema and the columns

$$\rho\,(C(1 \to sid1, 5 \to sid2),\ S1 \times R1)$$

C

1	2	3	4	5	6	7
sid1	sname	rating	age	sid2	bid	day
22	dustin	7	45.0	22	101	10/10/96
22	dustin	7	45.0	58	103	11/12/96
31	lubber	8	55.5	22	101	10/10/96
31	lubber	8	55.5	58	103	11/12/96
58	rusty	10	35.0	22	101	10/10/96
58	rusty	10	35.0	58	103	11/12/96

Find the locations of suppliers having Part# 1

Lancaster University

- Select all the rows where Part# is 1

$$R1 = \sigma_{part\#=1}(Sps)$$

- Find their Supplier names

$$R2 = \pi_{Supplier}(R1)$$

- Take cross product with Locs

Supplier	Part#	Stock
Acme	1	17
Acme	2	25
Acme	3	17
Ajax	1	25
Ajax	3	18
Amco	1	3
Amco	2	22
Jamco	1	3

Supplier	Location
Acme	London
Ajax	Bristol
Amco	Glasgow
Jamco	Glasgow

Find the locations of suppliers having Part# 1

Lancaster University

- Select all the rows where Part# is 1

$$R1 = \sigma_{part\#=1}(Sps)$$

- Find their Supplier names

$$R2 = \pi_{Supplier}(R1)$$

- Take cross product with Locs

$$R3 = (R2 \times Locs)$$

-

Sps

Supplier	Part#	Stock
Acme	1	17
Acme	2	25
Acme	3	17
Ajax	1	25
Ajax	3	18
Amco	1	3
Amco	2	22
Jamco	1	3

$Locs$

Supplier	Location
Acme	London
Ajax	Bristol
Amco	Glasgow
Jamco	Glasgow

Find the locations of suppliers having Part# 1

Lancaster University

- Select all the rows where Part# is 1

$$R1 = \sigma_{part\#=1}(Sps)$$

- Find their Supplier names

$$R2 = \pi_{Supplier}(R1)$$

- Take cross product with Locs

$$R3 = (R2 \times Locs)$$

- Return the result

Sps

Supplier	Part#	Stock
Acme	1	17
Acme	2	25
Acme	3	17
Ajax	1	25
Ajax	3	18
Amco	1	3
Amco	2	22
Jamco	1	3

$Locs$

Supplier	Location
Acme	London
Ajax	Bristol
Amco	Glasgow
Jamco	Glasgow

Find the locations of suppliers having Part# 1

Lancaster University

- Select all the rows where Part# is 1

$$R1 = \sigma_{part\#=1}(Sps)$$

- Find their Supplier names

$$R2 = \pi_{Supplier}(R1)$$

- Take cross product with Locs

$$R3 = (R2 \times Locs)$$

- Return the result

$$\sigma_{Location}(R3)$$

Sps

Supplier	Part#	Stock
Acme	1	17
Acme	2	25
Acme	3	17
Ajax	1	25
Ajax	3	18
Amco	1	3
Amco	2	22
Jamco	1	3

$Locs$

Supplier	Location
Acme	London
Ajax	Bristol
Amco	Glasgow
Jamco	Glasgow

Joins

- *Condition Join* : $R \bowtie_c S = \sigma_c(R \times S)$

  - *Result schema* same as that of cross-product.
  - Fewer tuples than cross-product, might be able to compute more efficiently
  - Sometimes called a *theta-join*.

Joins

S1

sid	sname	rating	age
22	dustin	7	45.0
31	lubber	8	55.5
58	rusty	10	35.0

R1

sid	bid	day
22	101	10/10/96
58	103	11/12/96

$$S1 \bowtie_{S1.sid < R1.sid} R1$$

(sid)	sname	rating	age	(sid)	bid	day
22	dustin	7	45.0	58	103	11/12/96
31	lubber	8	55.5	58	103	11/12/96

S1

sid	sname	rating	age
22	dustin	7	45.0
31	lubber	8	55.5
58	rusty	10	35.0

R1

sid	bid	day
22	101	10/10/96
58	103	11/12/96

S1 **X** *R1*

(sid)	sname	rating	age	(sid)	bid	day
22	dustin	7	45.0	22	101	10/10/96
22	dustin	7	45.0	58	103	11/12/96
31	lubber	8	55.5	22	101	10/10/96
31	lubber	8	55.5	58	103	11/12/96
58	rusty	10	35.0	22	101	10/10/96
58	rusty	10	35.0	58	103	11/12/96

S1

sid	sname	rating	age
22	dustin	7	45.0
31	lubber	8	55.5
58	rusty	10	35.0

R1

sid	bid	day
22	101	10/10/96
58	103	11/12/96

$$\sigma_{S1.sid<R1.sid}(S1\times R1)$$

(sid)	sname	rating	age	(sid)	bid	day
22	dustin	7	45.0	22	101	10/10/96
22	dustin	7	45.0	58	103	11/12/96
31	lubber	8	55.5	22	101	10/10/96
31	lubber	8	55.5	58	103	11/12/96
58	rusty	10	35.0	22	101	10/10/96
58	rusty	10	35.0	58	103	11/12/96

S1

sid	sname	rating	age
22	dustin	7	45.0
31	lubber	8	55.5
58	rusty	10	35.0

R1

sid	bid	day
22	101	10/10/96
58	103	11/12/96

$$\sigma_{S1.sid < R1.sid}(S1 \times R1)$$

(sid)	sname	rating	age	(sid)	bid	day
22	dustin	7	45.0	58	103	11/12/96
31	lubber	8	55.5	58	103	11/12/96

Equi-Join: A special case of condition join where the condition *c* contains only ***equalities*.**

S1

sid	sname	rating	age
22	dustin	7	45.0
31	lubber	8	55.5
58	rusty	10	35.0

R1

sid	bid	day
22	101	10/10/96
58	103	11/12/96

$$S1 \bowtie_{sid} R1$$

sid	sname	rating	age	bid	day

Equi-Join: A special case of condition join where the condition *c* contains only ***equalities*.**

S1

sid	sname	rating	age
22	dustin	7	45.0
31	lubber	8	55.5
58	rusty	10	35.0

R1

sid	bid	day
22	101	10/10/96
58	103	11/12/96

$$S1 \bowtie_{sid} R1$$

sid	sname	rating	age	bid	day
22	dustin	7	45.0	101	10/10/96
[redacted]					

Equi-Join: A special case of condition join where the condition *c* contains only ***equalities*.**

S1

sid	sname	rating	age
22	dustin	7	45.0
31	lubber	8	55.5
58	rusty	10	35.0

R1

sid	bid	day
22	101	10/10/96
58	103	11/12/96

$$S1 \bowtie_{sid} R1$$

sid	sname	rating	age	bid	day
22	dustin	7	45.0	101	10/10/96

Equi-Join: A special case of condition join where the condition *c* contains only ***equalities*.**

S1

sid	sname	rating	age
22	dustin	7	45.0
31	lubber	8	55.5
58	rusty	10	35.0

R1

sid	bid	day
22	101	10/10/96
58	103	11/12/96

$$S1 \bowtie_{sid} R1$$

sid	sname	rating	age	bid	day
22	dustin	7	45.0	101	10/10/96
58	rusty	10	35.0	103	11/12/96

Joins

- *Equi-Join*: A special case of condition join where the condition *c* contains only ***equalities*.**

$$S1 \bowtie_{sid} R1$$

sid	sname	rating	age	bid	day
22	dustin	7	45.0	101	10/10/96
58	rusty	10	35.0	103	11/12/96

- *Result schema* similar to cross-product, but only one copy of fields for which equality is specified.
- *Natural Join*: Equijoin on ***all* common** fields.

$$S1 \bowtie R1$$

Find the sids of sailors who've reserved all boats

Reserves

sid	*bid*	*day*
22	101	10/10/98
22	102	10/10/98
22	103	10/8/98
22	104	10/7/98
31	102	11/10/98
31	103	11/6/98
31	104	11/12/98
64	101	9/5/98
64	102	9/8/98
74	103	9/8/98

Boats

bid	*bname*	*color*
101	Interlake	blue
102	Interlake	red
103	Clipper	green
104	Marine	red

Find the sids of sailors who've reserved all boats

Reserves

sid	*bid*	*day*
22	101	10/10/98
22	102	10/10/98
22	103	10/8/98
22	104	10/7/98
31	102	11/10/98
31	103	11/6/98
31	104	11/12/98
64	101	9/5/98
64	102	9/8/98
74	103	9/8/98

Boats

bid	*bname*	*color*
101	Interlake	blue
102	Interlake	red
103	Clipper	green
104	Marine	red

- I want the set of <sid> values where for every <bid> of B, <sid,bid> is in A.

Find the sids of sailors who've reserved all boats

Reserves

sid	*bid*	*day*
22	101	10/10/98
22	102	10/10/98
22	103	10/8/98
22	104	10/7/98
31	102	11/10/98
31	103	11/6/98
31	104	11/12/98
64	101	9/5/98
64	102	9/8/98
74	103	9/8/98

Boats

bid	*bname*	*color*
101	Interlake	blue
102	Interlake	red
103	Clipper	green
104	Marine	red

B

- I want the set of <sid> values where for every <bid> of B, <sid,bid> is in A.

Find the sids of sailors who've reserved all boats

Reserves

sid	*bid*	*day*
22	101	10/10/98
22	102	10/10/98
22	103	10/8/98
22	104	10/7/98
31	102	11/10/98
31	103	11/6/98
31	104	11/12/98
64	101	9/5/98
64	102	9/8/98
74	103	9/8/98

A

Boats

bid	*bname*	*color*
101	Interlake	blue
102	Interlake	red
103	Clipper	green
104	Marine	red

B

- I want the set of <sid> values where for every <bid> of B, <sid,bid> is in A.

Find the sids of sailors who've reserved all boats

Reserves

sid	*bid*	*day*
22	101	10/10/98
22	102	10/10/98
22	103	10/8/98
22	104	10/7/98
31	102	11/10/98
31	103	11/6/98
31	104	11/12/98
64	101	9/5/98
64	102	9/8/98
74	103	9/8/98

A

Boats

bid	*bname*	*color*
101	Interlake	blue
102	Interlake	red
103	Clipper	green
104	Marine	red

B

- I want the set of <sid> values where for every <bid> of B, <sid,bid> is in A.

Now what?

Division

- Not supported as a primitive operator, but useful for expressing queries like:
  *Find sailors who have reserved **all** boats*.
- Let *A* have 2 fields, *x* and *y*; *B* have only field *y*:
  - *A/B* = $\left\{ \langle x \rangle \mid \exists \langle x, y \rangle \in A \ \ \forall \langle y \rangle \in B \right\}$
    - i.e., ***A/B is a set of values, where {A/B} X {B} is in set A*.**
    - *Or*: It is the set of <x> values where for every <y> of B, <xy> is in A.
- In general, *x* and *y* can be any lists of fields; *y* is the list of fields in *B*, and *x U y* is the list of fields of *A*.

Examples of Division A/B

- It is the set of <x> values where for every <y> of B, <xy> is in A. OR

sno	pno
s1	p1
s1	p2
s1	p3
s1	p4
s2	p1
s2	p2
s3	p2
s4	p2
s4	p4

A

pno
p2

B1

pno
p2
p4

B2

pno
p1
p2
p4

B3

sno
s1
s2
s3
s4

A/B1

sno
s1
s4

A/B2

sno
s1

A/B3

Find the sids of sailors who've reserved all boats

Reserves

sid	*bid*	*day*
22	101	10/10/98
22	102	10/10/98
22	103	10/8/98
22	104	10/7/98
31	102	11/10/98
31	103	11/6/98
31	104	11/12/98
64	101	9/5/98
64	102	9/8/98
74	103	9/8/98

A

Boats

bid	*bname*	*color*
101	Interlake	blue
102	Interlake	red
103	Clipper	green
104	Marine	red

B

- I want the set of <sid> values where for every <bid> of B, <sid,bid> is in A.

Find the sids of sailors who've reserved all boats

Reserves

sid	*bid*	*day*
22	101	10/10/98
22	102	10/10/98
22	103	10/8/98
22	104	10/7/98
31	102	11/10/98
31	103	11/6/98
31	104	11/12/98
64	101	9/5/98
64	102	9/8/98
74	103	9/8/98

A

Boats

bid	*bname*	*color*
101	Interlake	blue
102	Interlake	red
103	Clipper	green
104	Marine	red

B

- I want the set of <sid> values where for every <bid> of B, <sid,bid> is in A.

$$(\pi_{sid,bid}\text{Reserves})/(\pi_{bid}Boats)$$

Find the sids of sailors who've reserved all boats

Reserves

sid	*bid*	*day*
22	101	10/10/98
22	102	10/10/98
22	103	10/8/98
22	104	10/7/98
31	102	11/10/98
31	103	11/6/98
31	104	11/12/98
64	101	9/5/98
64	102	9/8/98
74	103	9/8/98

A

Boats

bid	*bname*	*color*
101	Interlake	blue
102	Interlake	red
103	Clipper	green
104	Marine	red

B

sid
22

- I want the set of <sid> values where for every <bid> of B, <sid,bid> is in A.

$$(\pi_{sid,bid}\text{Reserves})/(\pi_{bid}Boats)$$

Find names of sailors who've reserved boat #103

sid	*sname*	*rating*	*age*
22	Dustin	7	45.0
29	Brutus	1	33.0
31	Lubber	8	55.5
32	Andy	8	25.5
58	Rusty	10	35.0
64	Horatio	7	35.0
71	Zorba	10	16.0
74	Horatio	9	35.0
85	Art	3	25.5
95	Bob	3	63.5

Figure 4.15 An Instance $S3$ of Sailors

sid	*bid*	*day*
22	101	10/10/98
22	102	10/10/98
22	103	10/8/98
22	104	10/7/98
31	102	11/10/98
31	103	11/6/98
31	104	11/12/98
64	101	9/5/98
64	102	9/8/98
74	103	9/8/98

Figure 4.16 An Instance $R2$ of Reserves

Find names of sailors who've reserved boat #103

- Solution 1: $\pi_{sname}((\sigma_{bid=103} \text{Reserves}) \bowtie Sailors)$

sid	*sname*	*rating*	*age*
22	Dustin	7	45.0
29	Brutus	1	33.0
31	Lubber	8	55.5
32	Andy	8	25.5
58	Rusty	10	35.0
64	Horatio	7	35.0
71	Zorba	10	16.0
74	Horatio	9	35.0
85	Art	3	25.5
95	Bob	3	63.5

Figure 4.15 An Instance $S3$ of Sailors

sid	*bid*	*day*
22	101	10/10/98
22	102	10/10/98
22	103	10/8/98
22	104	10/7/98
31	102	11/10/98
31	103	11/6/98
31	104	11/12/98
64	101	9/5/98
64	102	9/8/98
74	103	9/8/98

Figure 4.16 An Instance $R2$ of Reserves

Find names of sailors who've reserved boat #103

- Solution 1: $\pi_{sname}((\sigma_{bid=103} \text{Reserves}) \bowtie Sailors)$

sid	*sname*	*rating*	*age*
22	Dustin	7	45.0
29	Brutus	1	33.0
31	Lubber	8	55.5
32	Andy	8	25.5
58	Rusty	10	35.0
64	Horatio	7	35.0
71	Zorba	10	16.0
74	Horatio	9	35.0
85	Art	3	25.5
95	Bob	3	63.5

Figure 4.15 An Instance $S3$ of Sailors

sid	*bid*	*day*
22	101	10/10/98
22	102	10/10/98
22	103	10/8/98
22	104	10/7/98
31	102	11/10/98
31	103	11/6/98
31	104	11/12/98
64	101	9/5/98
64	102	9/8/98
74	103	9/8/98

Figure 4.16 An Instance $R2$ of Reserves

Find names of sailors who've reserved boat #103

- Solution 1: $\pi_{sname}((\sigma_{bid=103} \text{Reserves}) \bowtie Sailors)$

sid	*sname*	*rating*	*age*
22	Dustin	7	45.0
29	Brutus	1	33.0
31	Lubber	8	55.5
32	Andy	8	25.5
58	Rusty	10	35.0
64	Horatio	7	35.0
71	Zorba	10	16.0
74	Horatio	9	35.0
85	Art	3	25.5
95	Bob	3	63.5

Figure 4.15 An Instance $S3$ of Sailors

sid	*bid*	*day*
22	101	10/10/98
22	102	10/10/98
22	103	10/8/98
22	104	10/7/98
31	102	11/10/98
31	103	11/6/98
31	104	11/12/98
64	101	9/5/98
64	102	9/8/98
74	103	9/8/98

Figure 4.16 An Instance $R2$ of Reserves

Find names of sailors who've reserved boat #103

- Solution 1: $\pi_{sname}((\sigma_{bid=103} Reserves) \bowtie Sailors)$

sid	sname	rating	age
22	Dustin	7	45.0
29	Brutus	1	33.0
31	Lubber	8	55.5
32	Andy	8	25.5
58	Rusty	10	35.0
64	Horatio	7	35.0
71	Zorba	10	16.0
74	Horatio	9	35.0
85	Art	3	25.5
95	Bob	3	63.5

Figure 4.15 An Instance $S3$ of Sailors

sid	bid	day
22	101	10/10/98
22	102	10/10/98
22	103	10/8/98
22	104	10/7/98
31	102	11/10/98
31	103	11/6/98
31	104	11/12/98
64	101	9/5/98
64	102	9/8/98
74	103	9/8/98

Figure 4.16 An Instance $R2$ of Reserves

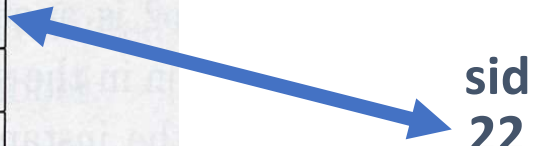
sid
22
31
74

Find names of sailors who've reserved boat #103

- Solution 1: $\pi_{sname}((\sigma_{bid=103} Reserves) \bowtie Sailors)$

sid	*sname*	*rating*	*age*
22	Dustin	7	45.0
29	Brutus	1	33.0
31	Lubber	8	55.5
32	Andy	8	25.5
58	Rusty	10	35.0
64	Horatio	7	35.0
71	Zorba	10	16.0
74	Horatio	9	35.0
85	Art	3	25.5
95	Bob	3	63.5

Figure 4.15 An Instance $S3$ of Sailors



sid
22
31
74

Find names of sailors who've reserved boat #103

- Solution 1: $\pi_{sname}((\sigma_{bid=103} Reserves) \bowtie Sailors)$

sid	*sname*	*rating*	*age*
22	Dustin	7	45.0
29	Brutus	1	33.0
31	Lubber	8	55.5
32	Andy	8	25.5
58	Rusty	10	35.0
64	Horatio	7	35.0
71	Zorba	10	16.0
74	Horatio	9	35.0
85	Art	3	25.5
95	Bob	3	63.5

Figure 4.15 An Instance $S3$ of Sailors

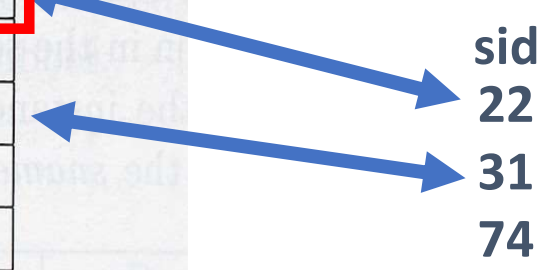
sid
22
31
74

Find names of sailors who've reserved boat #103

- Solution 1: $\pi_{sname}((\sigma_{bid=103} Reserves) \bowtie Sailors)$

sid	*sname*	*rating*	*age*
22	Dustin	7	45.0
29	Brutus	1	33.0
31	Lubber	8	55.5
32	Andy	8	25.5
58	Rusty	10	35.0
64	Horatio	7	35.0
71	Zorba	10	16.0
74	Horatio	9	35.0
85	Art	3	25.5
95	Bob	3	63.5

Figure 4.15 An Instance $S3$ of Sailors

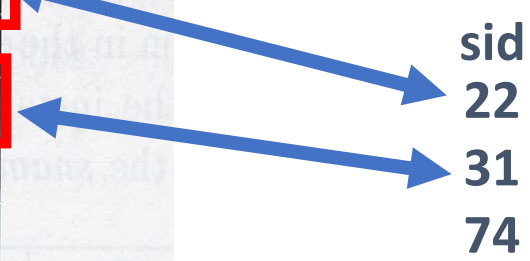


Find names of sailors who've reserved boat #103

- Solution 1: $\pi_{sname}((\sigma_{bid=103} Reserves) \bowtie Sailors)$

sid	*sname*	*rating*	*age*
22	Dustin	7	45.0
29	Brutus	1	33.0
31	Lubber	8	55.5
32	Andy	8	25.5
58	Rusty	10	35.0
64	Horatio	7	35.0
71	Zorba	10	16.0
74	Horatio	9	35.0
85	Art	3	25.5
95	Bob	3	63.5

Figure 4.15 An Instance $S3$ of Sailors

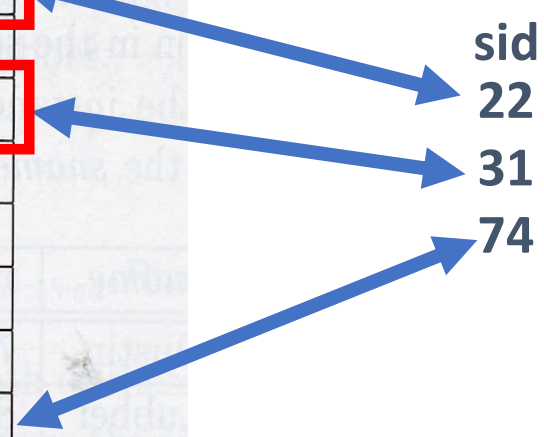


Find names of sailors who've reserved boat #103

- Solution 1: $\pi_{sname}((\sigma_{bid=103} Reserves) \bowtie Sailors)$

sid	*sname*	*rating*	*age*
22	Dustin	7	45.0
29	Brutus	1	33.0
31	Lubber	8	55.5
32	Andy	8	25.5
58	Rusty	10	35.0
64	Horatio	7	35.0
71	Zorba	10	16.0
74	Horatio	9	35.0
85	Art	3	25.5
95	Bob	3	63.5

Figure 4.15 An Instance $S3$ of Sailors



Find names of sailors who've reserved boat #103

- Solution 1: $\pi_{sname}((\sigma_{bid=103} \text{Reserves}) \bowtie Sailors)$

sid	*sname*	*rating*	*age*
22	Dustin	7	45.0
29	Brutus	1	33.0
31	Lubber	8	55.5
32	Andy	8	25.5
58	Rusty	10	35.0
64	Horatio	7	35.0
71	Zorba	10	16.0
74	Horatio	9	35.0
85	Art	3	25.5
95	Bob	3	63.5

Figure 4.15 An Instance $S3$ of Sailors

Find names of sailors who've reserved boat #103

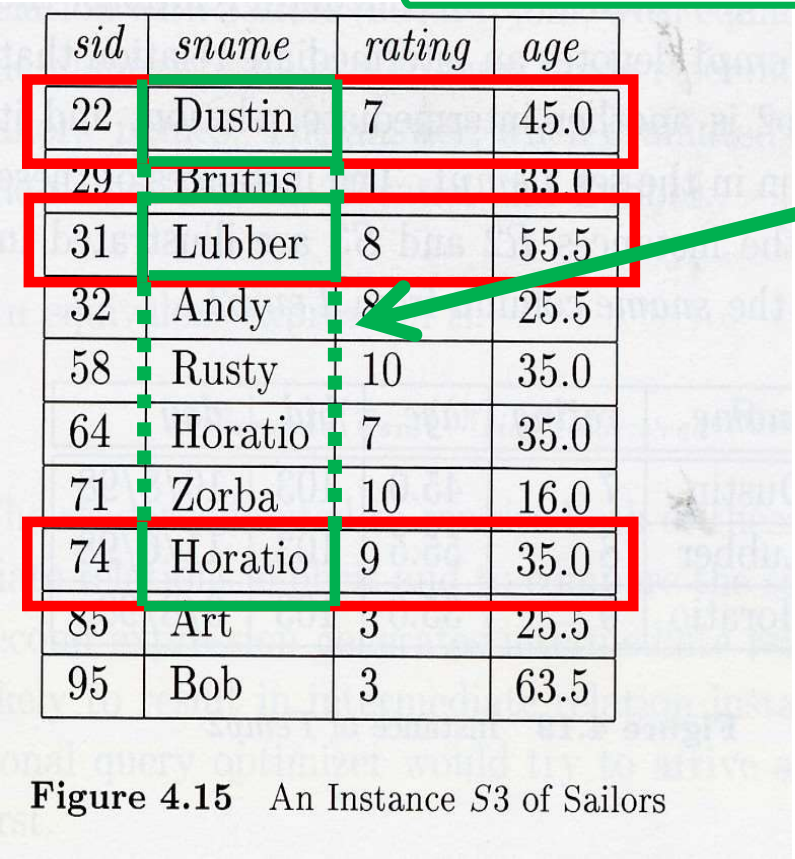
- Solution 1: $\pi_{sname}((\sigma_{bid=103} Reserves) \bowtie Sailors)$

sid	sname	rating	age
22	Dustin	7	45.0
29	Brutus	1	33.0
31	Lubber	8	55.5
32	Andy	8	25.5
58	Rusty	10	35.0
64	Horatio	7	35.0
71	Zorba	10	16.0
74	Horatio	9	35.0
85	Art	3	25.5
95	Bob	3	63.5

Figure 4.15 An Instance $S3$ of Sailors

Find names of sailors who've reserved boat #103

- Solution 1: $\pi_{sname}((\sigma_{bid=103} \text{Reserves}) \bowtie Sailors)$



sid	*sname*	*rating*	*age*
22	Dustin	7	45.0
29	Brutus	1	33.0
31	Lubber	8	55.5
32	Andy	8	25.5
58	Rusty	10	35.0
64	Horatio	7	35.0
71	Zorba	10	16.0
74	Horatio	9	35.0
85	Art	3	25.5
95	Bob	3	63.5

Figure 4.15 An Instance $S3$ of Sailors

Find names of sailors who've reserved boat #103

sid	*sname*	*rating*	*age*
22	Dustin	7	45.0
29	Brutus	1	33.0
31	Lubber	8	55.5
32	Andy	8	25.5
58	Rusty	10	35.0
64	Horatio	7	35.0
71	Zorba	10	16.0
74	Horatio	9	35.0
85	Art	3	25.5
95	Bob	3	63.5

Figure 4.15 An Instance $S3$ of Sailors

sid	*bid*	*day*
22	101	10/10/98
22	102	10/10/98
22	103	10/8/98
22	104	10/7/98
31	102	11/10/98
31	103	11/6/98
31	104	11/12/98
64	101	9/5/98
64	102	9/8/98
74	103	9/8/98

Figure 4.16 An Instance $R2$ of Reserves

Find names of sailors who've reserved boat #103

$$\pi_{sname}(\sigma_{bid=103}(\text{Re}serves \bowtie Sailors))$$

sid	*sname*	*rating*	*age*
22	Dustin	7	45.0
29	Brutus	1	33.0
31	Lubber	8	55.5
32	Andy	8	25.5
58	Rusty	10	35.0
64	Horatio	7	35.0
71	Zorba	10	16.0
74	Horatio	9	35.0
85	Art	3	25.5
95	Bob	3	63.5

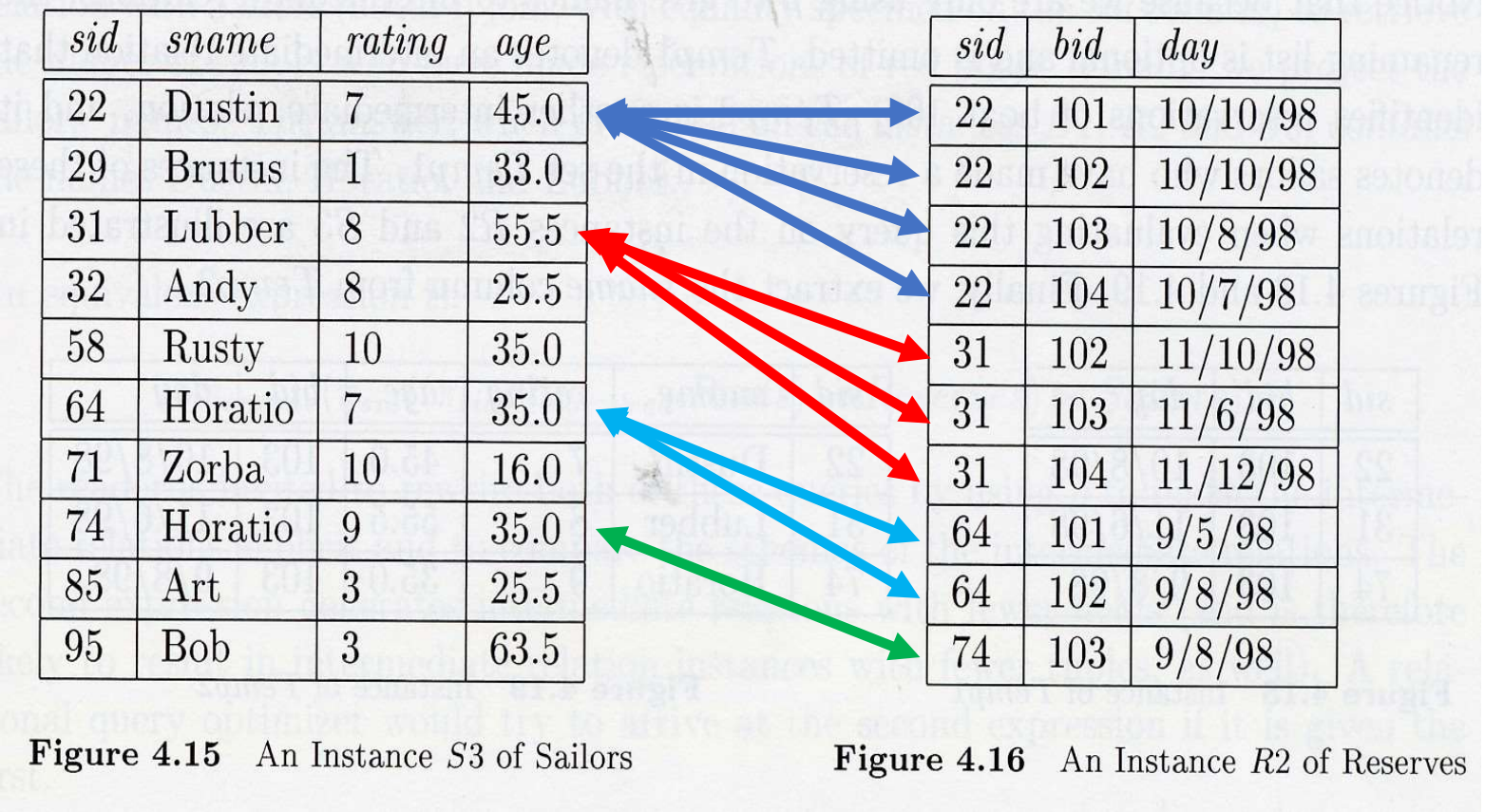
Figure 4.15 An Instance $S3$ of Sailors

sid	*bid*	*day*
22	101	10/10/98
22	102	10/10/98
22	103	10/8/98
22	104	10/7/98
31	102	11/10/98
31	103	11/6/98
31	104	11/12/98
64	101	9/5/98
64	102	9/8/98
74	103	9/8/98

Figure 4.16 An Instance $R2$ of Reserves

Find names of sailors who've reserved boat #103

$$\pi_{sname}(\sigma_{bid=103}(Reserves \bowtie Sailors))$$



sid	sname	rating	age
22	Dustin	7	45.0
29	Brutus	1	33.0
31	Lubber	8	55.5
32	Andy	8	25.5
58	Rusty	10	35.0
64	Horatio	7	35.0
71	Zorba	10	16.0
74	Horatio	9	35.0
85	Art	3	25.5
95	Bob	3	63.5

Figure 4.15 An Instance $S3$ of Sailors

sid	bid	day
22	101	10/10/98
22	102	10/10/98
22	103	10/8/98
22	104	10/7/98
31	102	11/10/98
31	103	11/6/98
31	104	11/12/98
64	101	9/5/98
64	102	9/8/98
74	103	9/8/98

Figure 4.16 An Instance $R2$ of Reserves

Find names of sailors who've reserved boat #103

$$\pi_{sname}(\sigma_{bid=103}(Reserves \bowtie Sailors))$$

sid	sname	rating	age	bid	day
22	Dustin	7	45.0	101	10/10/98
22	Dustin	7	45.0	102	10/10/98
22	Dustin	7	45.0	103	10/8/98
22	Dustin	7	45.0	104	10/7/98
31	Lubber	8	55.5	102	11/10/98
31	Lubber	8	55.5	103	11/6/98
31	Lubber	8	55.5	104	11/12/98
64	Horatio	7	35.0	101	9/5/98
64	Horatio	7	35.0	102	9/8/98
74	Horatio	9	35.0	103	9/8/98

Result of Natural Join

Find names of sailors who've reserved boat #103

$$\pi_{sname}(\sigma_{bid=103}(Reserves \bowtie Sailors))$$

Result of Selection bid=103

sid	*sname*	*rating*	*age*	*bid*	*day*
22	Dustin	7	45.0	101	10/10/98
22	Dustin	7	45.0	102	10/10/98
22	Dustin	7	45.0	103	10/8/98
22	Dustin	7	45.0	104	10/7/98
31	Lubber	8	55.5	102	11/10/98
31	Lubber	8	55.5	103	11/6/98
31	Lubber	8	55.5	104	11/12/98
64	Horatio	7	35.0	101	9/5/98
64	Horatio	7	35.0	102	9/8/98
74	Horatio	9	35.0	103	9/8/98

Find names of sailors who've reserved boat #103

$$\pi_{sname}(\sigma_{bid=103}(Reserves \bowtie Sailors))$$

Result of Projection on sname

sid	*sname*	*rating*	*age*	*bid*	*day*
22	Dustin	7	45.0	101	10/10/98
22	Dustin	7	45.0	102	10/10/98
22	Dustin	7	45.0	103	10/8/98
22	Dustin	7	45.0	104	10/7/98
31	Lubber	8	55.5	102	11/10/98
31	Lubber	8	55.5	103	11/6/98
31	Lubber	8	55.5	104	11/12/98
64	Horatio	7	35.0	101	9/5/98
64	Horatio	7	35.0	102	9/8/98
74	Horatio	9	35.0	103	9/8/98

Find names of sailors who've reserved boat #103

- Solution 1: $\pi_{sname}((\sigma_{bid=103}\text{Re}serves) \bowtie Sailors)$

- Solution 2: $\rho\ (Temp1,\ \sigma_{bid=103}\ \text{Re}serves)$

  $\rho\ (Temp2,\ Temp1 \bowtie Sailors)$

  $\pi_{sname}\ (Temp2)$

- Solution 3: $\pi_{sname}(\sigma_{bid=103}(\text{Re}serves \bowtie Sailors))$

Lancaster University

Lecture 4

Continue

Find names of sailors who've reserved a red boat

sid	*sname*	*rating*	*age*
22	Dustin	7	45.0
29	Brutus	1	33.0
31	Lubber	8	55.5
32	Andy	8	25.5
58	Rusty	10	35.0
64	Horatio	7	35.0
71	Zorba	10	16.0
74	Horatio	9	35.0
85	Art	3	25.5
95	Bob	3	63.5

Figure 4.15 An Instance $S3$ of Sailors

sid	*bid*	*day*
22	101	10/10/98
22	102	10/10/98
22	103	10/8/98
22	104	10/7/98
31	102	11/10/98
31	103	11/6/98
31	104	11/12/98
64	101	9/5/98
64	102	9/8/98
74	103	9/8/98

Figure 4.16 An Instance $R2$ of Reserves

bid	*bname*	*color*
101	Interlake	blue
102	Interlake	red
103	Clipper	green
104	Marine	red

Figure 4.17 An Instance $B1$ of Boats

Find names of sailors who've reserved a red boat

- NOTE: Information about boat colour is only available in Boats; so need an extra join:

$$\pi_{sname}((\sigma_{color='red'} Boats) \bowtie Reserves \bowtie Sailors)$$

- A more efficient solution:

$$\pi_{sname}(\pi_{sid}((\pi_{bid}\sigma_{color='red'} Boats) \bowtie Res) \bowtie Sailors)$$

Find names of sailors who've reserved a red boat

sid	*sname*	*rating*	*age*
22	Dustin	7	45.0
29	Brutus	1	33.0
31	Lubber	8	55.5
32	Andy	8	25.5
58	Rusty	10	35.0
64	Horatio	7	35.0
71	Zorba	10	16.0
74	Horatio	9	35.0
85	Art	3	25.5
95	Bob	3	63.5

Figure 4.15 An Instance $S3$ of Sailors

sid	*bid*	*day*
22	101	10/10/98
22	102	10/10/98
22	103	10/8/98
22	104	10/7/98
31	102	11/10/98
31	103	11/6/98
31	104	11/12/98
64	101	9/5/98
64	102	9/8/98
74	103	9/8/98

Figure 4.16 An Instance $R2$ of Reserves

bid	*bname*	*color*
101	Interlake	blue
102	Interlake	red
103	Clipper	green
104	Marine	red

Figure 4.17 An Instance $B1$ of Boats

Find names of sailors who've reserved a red boat

sid	*sname*	*rating*	*age*
22	Dustin	7	45.0
29	Brutus	1	33.0
31	Lubber	8	55.5
32	Andy	8	25.5
58	Rusty	10	35.0
64	Horatio	7	35.0
71	Zorba	10	16.0
74	Horatio	9	35.0
85	Art	3	25.5
95	Bob	3	63.5

Figure 4.15 An Instance $S3$ of Sailors

sid	*bid*	*day*
22	101	10/10/98
22	102	10/10/98
22	103	10/8/98
22	104	10/7/98
31	102	11/10/98
31	103	11/6/98
31	104	11/12/98
64	101	9/5/98
64	102	9/8/98
74	103	9/8/98

Figure 4.16 An Instance $R2$ of Reserves

bid	*bname*	*color*
101	Interlake	blue
102	Interlake	red
103	Clipper	green
104	Marine	red

Figure 4.17 An Instance $B1$ of Boats

Find names of sailors who've reserved a red boat

sid	*sname*	*rating*	*age*
22	Dustin	7	45.0
29	Brutus	1	33.0
31	Lubber	8	55.5
32	Andy	8	25.5
58	Rusty	10	35.0
64	Horatio	7	35.0
71	Zorba	10	16.0
74	Horatio	9	35.0
85	Art	3	25.5
95	Bob	3	63.5

Figure 4.15 An Instance $S3$ of Sailors

sid	*bid*	*day*
22	101	10/10/98
22	102	10/10/98
22	103	10/8/98
22	104	10/7/98
31	102	11/10/98
31	103	11/6/98
31	104	11/12/98
64	101	9/5/98
64	102	9/8/98
74	103	9/8/98

Figure 4.16 An Instance $R2$ of Reserves

bid	*bname*	*color*
101	Interlake	blue
102	Interlake	red
103	Clipper	green
104	Marine	red

Figure 4.17 An Instance $B1$ of Boats

Find names of sailors who've reserved a red boat

sid	*sname*	*rating*	*age*
22	Dustin	7	45.0
29	Brutus	1	33.0
31	Lubber	8	55.5
32	Andy	8	25.5
58	Rusty	10	35.0
64	Horatio	7	35.0
71	Zorba	10	16.0
74	Horatio	9	35.0
85	Art	3	25.5
95	Bob	3	63.5

Figure 4.15 An Instance $S3$ of Sailors

sid	*bid*	*day*
22	101	10/10/98
22	102	10/10/98
22	103	10/8/98
22	104	10/7/98
31	102	11/10/98
31	103	11/6/98
31	104	11/12/98
64	101	9/5/98
64	102	9/8/98
74	103	9/8/98

Figure 4.16 An Instance $R2$ of Reserves

bid	*bname*	*color*
101	Interlake	blue
102	Interlake	red
103	Clipper	green
104	Marine	red

Figure 4.17 An Instance $B1$ of Boats

Find names of sailors who've reserved a red boat

22
31
64

sid	*sname*	*rating*	*age*
22	Dustin	7	45.0
29	Brutus	1	33.0
31	Lubber	8	55.5
32	Andy	8	25.5
58	Rusty	10	35.0
64	Horatio	7	35.0
71	Zorba	10	16.0
74	Horatio	9	35.0
85	Art	3	25.5
95	Bob	3	63.5

Figure 4.15 An Instance $S3$ of Sailors

sid	*bid*	*day*
22	101	10/10/98
22	102	10/10/98
22	103	10/8/98
22	104	10/7/98
31	102	11/10/98
31	103	11/6/98
31	104	11/12/98
64	101	9/5/98
64	102	9/8/98
74	103	9/8/98

Figure 4.16 An Instance $R2$ of Reserves

bid	*bname*	*color*
101	Interlake	blue
102	Interlake	red
103	Clipper	green
104	Marine	red

Figure 4.17 An Instance $B1$ of Boats

Find names of sailors who've reserved a red boat

22
31
64

sid	*sname*	*rating*	*age*
22	Dustin	7	45.0
29	Brutus	1	33.0
31	Lubber	8	55.5
32	Andy	8	25.5
58	Rusty	10	35.0
64	Horatio	7	35.0
71	Zorba	10	16.0
74	Horatio	9	35.0
85	Art	3	25.5
95	Bob	3	63.5

Figure 4.15 An Instance $S3$ of Sailors

sid	*bid*	*day*
22	101	10/10/98
22	102	10/10/98
22	103	10/8/98
22	104	10/7/98
31	102	11/10/98
31	103	11/6/98
31	104	11/12/98
64	101	9/5/98
64	102	9/8/98
74	103	9/8/98

Figure 4.16 An Instance $R2$ of Reserves

bid	*bname*	*color*
101	Interlake	blue
102	Interlake	red
103	Clipper	green
104	Marine	red

Figure 4.17 An Instance $B1$ of Boats

Find names of sailors who've reserved a red and a green boat.

HOW ABOUT THIS ANSWER?

sid	sname	rating	age
22	Dustin	7	45.0
29	Brutus	1	33.0
31	Lubber	8	55.5
32	Andy	8	25.5
58	Rusty	10	35.0
64	Horatio	7	35.0
71	Zorba	10	16.0
74	Horatio	9	35.0
85	Art	3	25.5
95	Bob	3	63.5

Figure 4.15 An Instance $S3$ of Sailors

sid	bid	day
22	101	10/10/98
22	102	10/10/98
22	103	10/8/98
22	104	10/7/98
31	102	11/10/98
31	103	11/6/98
31	104	11/12/98
64	101	9/5/98
64	102	9/8/98
74	103	9/8/98

Figure 4.16 An Instance $R2$ of Reserves

bid	bname	color
101	Interlake	blue
102	Interlake	red
103	Clipper	green
104	Marine	red

Figure 4.17 An Instance $B1$ of Boats

$$\rho(Tempred, \pi_{sid}((\sigma_{color='red'} Boats) \bowtie Reserves))$$

$$\rho\ (Tempgreen, \pi_{sid}((\sigma_{color='green'} Boats) \bowtie Reserves))$$

$$\pi_{sname}((Tempred \cap Tempgreen) \bowtie Sailors)$$

Find names of sailors who've reserved a red and a green boat.

HOW ABOUT THIS ONE?

sid	sname	rating	age
22	Dustin	7	45.0
29	Brutus	1	33.0
31	Lubber	8	55.5
32	Andy	8	25.5
58	Rusty	10	35.0
64	Horatio	7	35.0
71	Zorba	10	16.0
74	Horatio	9	35.0
85	Art	3	25.5
95	Bob	3	63.5

Figure 4.15 An Instance $S3$ of Sailors

sid	bid	day
22	101	10/10/98
22	102	10/10/98
22	103	10/8/98
22	104	10/7/98
31	102	11/10/98
31	103	11/6/98
31	104	11/12/98
64	101	9/5/98
64	102	9/8/98
74	103	9/8/98

Figure 4.16 An Instance $R2$ of Reserves

bid	bname	color
101	Interlake	blue
102	Interlake	red
103	Clipper	green
104	Marine	red

Figure 4.17 An Instance $B1$ of Boats

$$\rho(Tmp1,\pi_{sid}((\sigma_{color='red'}Boats)\bowtie Reserves))$$

$$\rho(Tmp2,\pi_{sid}((\sigma_{color='green'}Boats)\bowtie Reserves))$$

$$\pi_{sname}(Tmp1\bowtie Sailors)\cap\pi_{sname}(Tmp2\bowtie Sailors)$$

Find the names of sailors who've reserved all boats

Division

$\pi_{sid,bid}\text{Reserves}$

sid	bid
22	101
22	102
22	103
22	104
31	102
31	104
64	101
64	102
74	103

$(\pi_{sid,bid}\text{Reserves})/(\pi_{bid}Boats)$

$\pi_{sname}(Division \rhd\!\lhd Sailors)$

sid
22

$\pi_{bid}Boats$

bid
101
102
103
104

sid	*sname*	*rating*	*age*
22	Dustin	7	45.0
29	Brutus	1	33.0
31	Lubber	8	55.5
32	Andy	8	25.5
58	Rusty	10	35.0
64	Horatio	7	35.0
71	Zorba	10	16.0
74	Horatio	9	35.0
85	Art	3	25.5
95	Bob	3	63.5

Figure 4.15 An Instance $S3$ of Sailors

sid	*bid*	*day*
22	101	10/10/98
22	102	10/10/98
22	103	10/8/98
22	104	10/7/98
31	102	11/10/98
31	103	11/6/98
31	104	11/12/98
64	101	9/5/98
64	102	9/8/98
74	103	9/8/98

Figure 4.16 An Instance $R2$ of Reserves

bid	*bname*	*color*
101	Interlake	blue
102	Interlake	red
103	Clipper	green
104	Marine	red

Figure 4.17 An Instance $B1$ of Boats

Find the names of sailors who've reserved all boats

- Uses division; schemas of the input relations must be carefully chosen:

$$\rho\ (Tempsids, (\pi_{sid,bid} \text{Re}serves) / (\pi_{bid} Boats))$$

$$\pi_{sname}(Tempsids \bowtie Sailors)$$

- To find sailors who've reserved all 'Interlake' boats:

$$..... \quad / \ \pi_{bid}(\sigma_{bname='Interlake'} Boats)$$

Review and Summary (will be long ☺)

Lancaster University

Relational Algebra forms the foundation of querying for modern DBMSs

Review and Summary (will be long ☺)

Lancaster University

Relational Algebra forms the foundation of querying for modern DBMSs

There are operators (we will see again) that allow us to create complex query formulas.

Review and Summary (will be long ☺)

Lancaster University

Relational Algebra forms the foundation of querying for modern DBMSs

There are operators (we will see again) that allow us to create complex query formulas.

Two important optimisation points

- Number of operations
- Size of the data used while computing the query.

Review and Summary (will be long ☺)

Lancaster University

- **Selection**
-

Review and Summary (will be long ☺)

Lancaster University

- **Selection**

$$\sigma_{conditions}(RelationName)$$

-

Review and Summary (will be long ☺)

Lancaster University

- **Selection**

$$\sigma_{conditions}(RelationName)$$

- This operator selects ROWS that are satisfying the condition.
-

Review and Summary (will be long ☺)

Lancaster University

- **Selection**

$$\sigma_{conditions}(RelationName)$$

- This operator selects ROWS that are satisfying the condition.
- Result is another relation with no duplicates

Example on Selection

Lancaster University

MECHANIC

SSI	Name	Phone_Number
87542702	Tom	75315567, 75315264
68201937	Uraz	75335521, 75334567
23139827	Nick	75315544, 75315237

CAR

Model	Weight	Length (mm)	Max_Speed
BMW 3.21	1400	2501	200
Toyota_Corolla	1300	3321	200
Hyundai E.GLS	1400	3895	210

Example on Selection

Lancaster University

- List the cars that are heavier than 1350.

MECHANIC

SSI	Name	Phone_Number
87542702	Tom	75315567, 75315264
68201937	Uraz	75335521, 75334567
23139827	Nick	75315544, 75315237

CAR

Model	Weight	Length (mm)	Max_Speed
BMW 3.21	1400	2501	200
Toyota_Corolla	1300	3321	200
Hyundai E.GLS	1400	3895	210

Example on Selection

Lancaster University

- List the cars that are heavier than 1350.

$$\sigma_{weight>1350}(CAR)$$

MECHANIC

SSI	Name	Phone_Number
87542702	Tom	75315567, 75315264
68201937	Uraz	75335521, 75334567
23139827	Nick	75315544, 75315237

CAR

Model	Weight	Length (mm)	Max_Speed
BMW 3.21	1400	2501	200
Toyota_Corolla	1300	3321	200
Hyundai E.GLS	1400	3895	210

Example on Selection

Lancaster University

- List the cars that are heavier than 1350.

$$\sigma_{weight>1350}(CAR)$$

$$R1 = \sigma_{weight>1350}(CAR)$$

MECHANIC

SSI	Name	Phone_Number
87542702	Tom	75315567, 75315264
68201937	Uraz	75335521, 75334567
23139827	Nick	75315544, 75315237

CAR

Model	Weight	Length (mm)	Max_Speed
BMW 3.21	1400	2501	200
Toyota_Corolla	1300	3321	200
Hyundai E.GLS	1400	3895	210

Example on Selection

Lancaster University

- List the cars that are heavier than 1350.

$$\sigma_{weight>135}\ (CAR)$$

$$R1 = \sigma_{weight>13}\ \ (CAR)$$

R1

MECHANIC

SSI	Name	Phone_Number
87542702	Tom	75315567, 75315264
68201937	Uraz	75335521, 75334567
23139827	Nick	75315544, 75315237

CAR

Model	Weight	Length (mm)	Max_Speed
BMW 3.21	1400	2501	200
Toyota_Corolla	1300	3321	200
Hyundai E.GLS	1400	3895	210

Example on Selection

Lancaster University

- List the cars that are heavier than 1350.

$$\sigma_{weight>1350}(CAR)$$

$$R1 = \sigma_{weight>1350}(CAR)$$

R1

Model	Weight	Length (mm)	Max_Speed
BMW 3.21	1400	2501	200
Hyundai E.GLS	1400	3895	210

MECHANIC

SSI	Name	Phone_Number
87542702	Tom	75315567, 75315264
68201937	Uraz	75335521, 75334567
23139827	Nick	75315544, 75315237

CAR

Model	Weight	Length (mm)	Max_Speed
BMW 3.21	1400	2501	200
Toyota_Corolla	1300	3321	200
Hyundai E.GLS	1400	3895	210

Review and Summary (will be long ☺)

Lancaster University

- **Projection**

$$\pi_{attributes}(RelationName)$$

-

-

Review and Summary (will be long ☺)

Lancaster University

- **Projection**

$$\pi_{attributes}(RelationName)$$

- This operator receives a single relation as an input and a list of attributes/fields.
-

Review and Summary (will be long ☺)

Lancaster University

- **Projection**

$$\pi_{attributes}(RelationName)$$

- This operator receives a single relation as an input and a list of attributes/fields.
- Returns a new relation having specified fields only.

Example on Projection

Lancaster University

- Retrieve the SSI's from mechanic table.

MECHANIC

SSI	Name	Phone_Number
87542702	Tom	75315567, 75315264
68201937	Uraz	75335521, 75334567
23139827	Nick	75315544, 75315237

CAR

Model	Weight	Length (mm)	Max_Speed
BMW 3.21	1400	2501	200
Toyota_Corolla	1300	3321	200
Hyundai E.GLS	1400	3895	210

Example on Projection

Lancaster University

- Retrieve the SSI's from mechanic table.

$$\pi_{SSI}(Mechanic)$$

MECHANIC

SSI	Name	Phone_Number
87542702	Tom	75315567, 75315264
68201937	Uraz	75335521, 75334567
23139827	Nick	75315544, 75315237

CAR

Model	Weight	Length (mm)	Max_Speed
BMW 3.21	1400	2501	200
Toyota_Corolla	1300	3321	200
Hyundai E.GLS	1400	3895	210

Example on Projection

Lancaster University

- Retrieve the SSI's from mechanic table.

$$\pi_{SSI}(Mechanic)$$

$$R2 = \pi_{SSI}(Mechanic)$$

MECHANIC

SSI	Name	Phone_Number
87542702	Tom	75315567, 75315264
68201937	Uraz	75335521, 75334567
23139827	Nick	75315544, 75315237

CAR

Model	Weight	Length (mm)	Max_Speed
BMW 3.21	1400	2501	200
Toyota_Corolla	1300	3321	200
Hyundai E.GLS	1400	3895	210

Example on Projection

Lancaster University

- Retrieve the SSI's from mechanic table.

$$\pi_{SSI}(Mechanic)$$

$$R2 = \pi_{SSI}(Mechanic)$$

R2

MECHANIC

SSI	Name	Phone_Number
87542702	Tom	75315567, 75315264
68201937	Uraz	75335521, 75334567
23139827	Nick	75315544, 75315237

CAR

Model	Weight	Length (mm)	Max_Speed
BMW 3.21	1400	2501	200
Toyota_Corolla	1300	3321	200
Hyundai E.GLS	1400	3895	210

Example on Projection

Lancaster University

- Retrieve the SSI's from mechanic table.

$$\pi_{SSI}(Mechanic)$$

$$R2 = \pi_{SSI}(Mechanic)$$

R2

SSI
87542702
68201937
23139827

MECHANIC

SSI	Name	Phone_Number
87542702	Tom	75315567, 75315264
68201937	Uraz	75335521, 75334567
23139827	Nick	75315544, 75315237

CAR

Model	Weight	Length (mm)	Max_Speed
BMW 3.21	1400	2501	200
Toyota_Corolla	1300	3321	200
Hyundai E.GLS	1400	3895	210

Review and Summary (will be long ☺)

Lancaster University

- **Cross-Product**

$$R3 = (R1 \times R2)$$

Review and Summary (will be long ☺)

Lancaster University

- **Cross-Product**

$$R3 = (R1 \times R2)$$

- This is a binary operator and receives two relations.
-

Review and Summary (will be long ☺)

Lancaster University

- **Cross-Product**

$$R3 = (R1 \times R2)$$

- This is a binary operator and receives two relations.
- It returns the cartesian product of relations as a new relation and removes duplicates.
-

Review and Summary (will be long ☺)

Lancaster University

- **Cross-Product**

$$R3 = (R1 \times R2)$$

- This is a binary operator and receives two relations.
- It returns the cartesian product of relations as a new relation and removes duplicates.
- The cross-product operator is used when we want to consider all possible associations between the two relations.

Example on Cross Product

Lancaster University

$$R3 = (Mechanic \times Car)$$

MECHANIC

SSI	Name	Phone_Number
87542702	Tom	75315567, 75315264
68201937	Uraz	75335521, 75334567
23139827	Nick	75315544, 75315237

CAR

Model	Weight	Length (mm)	Max_Speed
BMW 3.21	1400	2501	200
Toyota_Corolla	1300	3321	200
Hyundai E.GLS	1400	3895	210

Example on Cross Product

Lancaster University

$$R3 = (Mechanic \times Car)$$

Model	Weight	Length (mm)	Max_Speed	SSI	Name	Phone_Number
BMW 3.21	1400	2501	200	87542702	Tom	75315567, 75315264
BMW 3.21	1400	2501	200	68201937	Uraz	75335521, 75334567
BMW 3.21	1400	2501	200	23139827	Nick	75315544, 75315237
Toyota_Corolla	1300	3321	200	87542702	Tom	75315567, 75315264
Toyota_Corolla	1300	3321	200	68201937	Uraz	75335521, 75334567
Toyota_Corolla	1300	3321	200	23139827	Nick	75315544, 75315237
Hyundai E.GLS	1400	3895	210	87542702	Tom	75315567, 75315264
Hyundai E.GLS	1400	3895	210	68201937	Uraz	75335521, 75334567
Hyundai E.GLS	1400	3895	210	23139827	Nick	75315544, 75315237

MECHANIC

SSI	Name	Phone_Number
87542702	Tom	75315567, 75315264
68201937	Uraz	75335521, 75334567
23139827	Nick	75315544, 75315237

CAR

Model	Weight	Length (mm)	Max_Speed
BMW 3.21	1400	2501	200
Toyota_Corolla	1300	3321	200
Hyundai E.GLS	1400	3895	210

Review and Summary (will be long ☺)

Lancaster University

- **Condition-Join**

Review and Summary (will be long ☺)

Lancaster University

- **Condition-Join:** Make the Cross-Product on R1 and R2 and get the rows satisfying the condition C

Review and Summary (will be long ☺)

Lancaster University

- **Condition-Join:** Make the Cross-Product on R1 and R2 and get the rows satisfying the condition C

$$R1 \bowtie_C R2$$

Example on Cross Product

Lancaster University

$$R3 = (Mechanic \bowtie_{weight!=140 \ \wedge Name!=Uraz} Car)$$

Model	Weight	Length (mm)	Max_Speed	SSI	Name	Phone_Number
BMW 3.21	1400	2501	200	87542702	Tom	75315567, 75315264
BMW 3.21	1400	2501	200	68201937	Uraz	75335521, 75334567
BMW 3.21	1400	2501	200	23139827	Nick	75315544, 75315237
Toyota_Corolla	1300	3321	200	87542702	Tom	75315567, 75315264
Toyota_Corolla	1300	3321	200	68201937	Uraz	75335521, 75334567
Toyota_Corolla	1300	3321	200	23139827	Nick	75315544, 75315237
Hyundai E.GLS	1400	3895	210	87542702	Tom	75315567, 75315264
Hyundai E.GLS	1400	3895	210	68201937	Uraz	75335521, 75334567
Hyundai E.GLS	1400	3895	210	23139827	Nick	75315544, 75315237

MECHANIC

SSI	Name	Phone_Number
87542702	Tom	75315567, 75315264
68201937	Uraz	75335521, 75334567
23139827	Nick	75315544, 75315237

CAR

Model	Weight	Length (mm)	Max_Speed
BMW 3.21	1400	2501	200
Toyota_Corolla	1300	3321	200
Hyundai E.GLS	1400	3895	210

Example on Cross Product

Lancaster University

$$R3 = (Mechanic \bowtie_{weight!=1400 \wedge Name!=Uraz} Car)$$

Model	Weight	Length (mm)	Max_Speed	SSI	Name	Phone_Number
BMW 3.21	1400	2501	200	87542702	Tom	75315567, 75315264
BMW 3.21	1400	2501	200	68201937	Uraz	75335521, 75334567
BMW 3.21	1400	2501	200	23139827	Nick	75315544, 75315237
Toyota_Corolla	1300	3321	200	87542702	Tom	75315567, 75315264
Toyota_Corolla	1300	3321	200	68201937	Uraz	75335521, 75334567
Toyota_Corolla	1300	3321	200	23139827	Nick	75315544, 75315237
Hyundai E.GLS	1400	3895	210	87542702	Tom	75315567, 75315264
Hyundai E.GLS	1400	3895	210	68201937	Uraz	75335521, 75334567
Hyundai E.GLS	1400	3895	210	23139827	Nick	75315544, 75315237

MECHANIC

SSI	Name	Phone_Number
87542702	Tom	75315567, 75315264
68201937	Uraz	75335521, 75334567
23139827	Nick	75315544, 75315237

CAR

Model	Weight	Length (mm)	Max_Speed
BMW 3.21	1400	2501	200
Toyota_Corolla	1300	3321	200
Hyundai E.GLS	1400	3895	210

Example on Cross Product

Lancaster University

$$R3 = (Mechanic \bowtie_{weight!=1400 \wedge Name!=Ur} Car)$$

Model	Weight	Length (mm)	Max_Speed	SSI	Name	Phone_Number
BMW 3.21	1400	2501	200	87542702	Tom	75315567, 75315264
BMW 3.21	1400	2501	200	68201937	Uraz	75335521, 75334567
BMW 3.21	1400	2501	200	23139827	Nick	75315544, 75315237
Toyota_Corolla	1300	3321	200	87542702	Tom	75315567, 75315264
Toyota_Corolla	1300	3321	200	68201937	Uraz	75335521, 75334567
Toyota_Corolla	1300	3321	200	23139827	Nick	75315544, 75315237
Hyundai E.GLS	1400	3895	210	87542702	Tom	75315567, 75315264
Hyundai E.GLS	1400	3895	210	68201937	Uraz	75335521, 75334567
Hyundai E.GLS	1400	3895	210	23139827	Nick	75315544, 75315237

MECHANIC

SSI	Name	Phone_Number
87542702	Tom	75315567, 75315264
68201937	Uraz	75335521, 75334567
23139827	Nick	75315544, 75315237

CAR

Model	Weight	Length (mm)	Max_Speed
BMW 3.21	1400	2501	200
Toyota_Corolla	1300	3321	200
Hyundai E.GLS	1400	3895	210

Example on Cross Product

Lancaster University

$$R3 = (Mechanic \bowtie_{weight!=1400 \wedge Name!=Uraz} Car)$$

Model	Weight	Length (mm)	Max_Speed	SSI	Name	Phone_Number
BMW 3.21	1400	2501	200	87542702	Tom	75315567, 75315264
BMW 3.21	1400	2501	200	68201937	Uraz	75335521, 75334567
BMW 3.21	1400	2501	200	23139827	Nick	75315544, 75315237
Toyota_Corolla	1300	3321	200	87542702	Tom	75315567, 75315264
Toyota_Corolla	1300	3321	200	68201937	Uraz	75335521, 75334567
Toyota_Corolla	1300	3321	200	23139827	Nick	75315544, 75315237
Hyundai E.GLS	1400	3895	210	87542702	Tom	75315567, 75315264
Hyundai E.GLS	1400	3895	210	68201937	Uraz	75335521, 75334567
Hyundai E.GLS	1400	3895	210	23139827	Nick	75315544, 75315237

MECHANIC

SSI	Name	Phone_Number
87542702	Tom	75315567, 75315264
68201937	Uraz	75335521, 75334567
23139827	Nick	75315544, 75315237

CAR

Model	Weight	Length (mm)	Max_Speed
BMW 3.21	1400	2501	200
Toyota_Corolla	1300	3321	200
Hyundai E.GLS	1400	3895	210

Review and Summary (will be long ☺)

Lancaster University

- **Equi-Join:** Make the Cross-Product on R1 and R2 and get the rows where the selected attributes have the same value

$$R1 \bowtie_{attributes} R2$$

EquiJoin

agtAgents

agentID	divisionID	corporationID	locationID	level	quality	agentTypeID	isLocator
3008416	22	1000002	60000004	1	None	2	0
3003869	22	1000002	60000259	1	None	2	0
3008418	24	1000002	60000262	1	None	2	0

agtResearchAgent

agentID	typeID
3003869	3363
3003869	3368
3003873	3363

agtAgentTypes

agentTypeID	agentType
1	NonAgent
2	BasicAgent
3	TutorialAgent

EquiJoin

agtAgents$\bowtie_{agentID}$ agtResearchAgent

agtAgents

agentID	divisionID	corporationID	locationID	level	quality	agentTypeID	isLocator
3008416	22	1000002	60000004	1	None	2	0
3003869	22	1000002	60000259	1	None	2	0
3008418	24	1000002	60000262	1	None	2	0

agtResearchAgent

agentID	typeID
3003869	3363
3003869	3368
3003873	3363

agtAgentTypes

agentTypeID	agentType
1	NonAgent
2	BasicAgent
3	TutorialAgent

EquiJoin

agtAgents$\bowtie_{agentID}$ $agtResearchAgent$

$agtAgents \times agtResearchAgent$

agentID	divisionID	corporationID	locationID	level	quality	agentTypeID	isLocator	agentID	typeID
3008416	22	1000002	60000004	1	None	2	0	3003869	3363
3003869	22	1000002	60000259	1	None	2	0	3003869	3363
3008418	24	1000002	60000262	1	None	2	0	3003869	3363
3008416	22	1000002	60000004	1	None	2	0	3003869	3368
3003869	22	1000002	60000259	1	None	2	0	3003869	3368
3008418	24	1000002	60000262	1	None	2	0	3003869	3368
3008416	22	1000002	60000004	1	None	2	0	3003873	3363
3003869	22	1000002	60000259	1	None	2	0	3003873	3363
3008418	24	1000002	60000262	1	None	2	0	3003873	3363

EquiJoin

agtAgents$\bowtie_{agentID}$ $agtResearchAgent$

$agtAgents \times agtResearchAgent$

agentID	divisionID	corporationID	locationID	level	quality	agentTypeID	isLocator	agentID	typeID
3008416	22	1000002	60000004	1	None	2	0	3003869	3363
3003869	22	1000002	60000259	1	None	2	0	3003869	3363
3008418	24	1000002	60000262	1	None	2	0	3003869	3363
3008416	22	1000002	60000004	1	None	2	0	3003869	3368
3003869	22	1000002	60000259	1	None	2	0	3003869	3368
3008418	24	1000002	60000262	1	None	2	0	3003869	3368
3008416	22	1000002	60000004	1	None	2	0	3003873	3363
3003869	22	1000002	60000259	1	None	2	0	3003873	3363
3008418	24	1000002	60000262	1	None	2	0	3003873	3363

EquiJoin

agtAgents$\bowtie_{agentID}$ $agtResearchAgent$

$agtAgents \times agtResearchAgent$

agentID	divisionID	corporationID	locationID	level	quality	agentTypeID	isLocator	agentID	typeID
3008416	22	1000002	60000004	1	None	2	0	3003869	3363
3003869	22	1000002	60000259	1	None	2	0	3003869	3363
3008418	24	1000002	60000262	1	None	2	0	3003869	3363
3008416	22	1000002	60000004	1	None	2	0	3003869	3368
3003869	22	1000002	60000259	1	None	2	0	3003869	3368
3008418	24	1000002	60000262	1	None	2	0	3003869	3368
3008416	22	1000002	60000004	1	None	2	0	3003873	3363
3003869	22	1000002	60000259	1	None	2	0	3003873	3363
3008418	24	1000002	60000262	1	None	2	0	3003873	3363

EquiJoin

agtAgents$\bowtie_{agentID}$ $agtResearchAgent$

$agtAgents \times agtResearchAgent$

agentID	divisionID	corporationID	locationID	level	quality	agentTypeID	isLocator	agentID	typeID
3008416	22	1000002	60000004	1	None	2	0	3003869	3363
3003869	22	1000002	60000259	1	None	2	0	3003869	3363
3008418	24	1000002	60000262	1	None	2	0	3003869	3363
3008416	22	1000002	60000004	1	None	2	0	3003869	3368
3003869	22	1000002	60000259	1	None	2	0	3003869	3368
3008418	24	1000002	60000262	1	None	2	0	3003869	3368
3008416	22	1000002	60000004	1	None	2	0	3003873	3363
3003869	22	1000002	60000259	1	None	2	0	3003873	3363
3008418	24	1000002	60000262	1	None	2	0	3003873	3363

EquiJoin

$$\text{agtAgents} \bowtie_{agentID} agtResearchAgent$$

agentID	divisionID	corporationID	locationID	level	quality	agentTypeID	isLocator	typeID
3003869	22	1000002	60000259	1	None	2	0	3363
3003869	22	1000002	60000259	1	None	2	0	3368

Review and Summary (will be long ☺)

Lancaster University

- **Natural Join:** Make the Cross-Product on R1 and R2 and get the rows where all common attributes have the same value

$$R1 \bowtie R2$$

Natural Join

agtAgentTypes$\bowtie$*agtResearchAgents*

agtAgents

agentID	divisionID	corporationID	locationID	level	quality	agentTypeID	isLocator
3008416	22	1000002	60000004	1	None	2	0
3003869	22	1000002	60000259	1	None	2	0
3008418	24	1000002	60000262	1	None	2	0

agtResearchAgent

agentID	typeID
3003869	3363
3003869	3368
3003873	3363

agtAgentTypes

agentTypeID	agentType
1	NonAgent
2	BasicAgent
3	TutorialAgent

Natural Join

agtAgentTypes$\bowtie$ $agtResearchAgent$

$agtAgentTypes \times agtResearchAgent$

agentID	divisionID	corporationID	locationID	level	quality	agentTypeID	isLocator	agentTypeID	agentType
3008416	22	1000002	60000004	1	None	2	0	1	NonAgent
3003869	22	1000002	60000259	1	None	2	0	1	NonAgent
3008418	24	1000002	60000262	1	None	2	0	1	NonAgent
3008416	22	1000002	60000004	1	None	2	0	2	BasicAgent
3003869	22	1000002	60000259	1	None	2	0	2	BasicAgent
3008418	24	1000002	60000262	1	None	2	0	2	BasicAgent
3008416	22	1000002	60000004	1	None	2	0	3	TutorialAgent
3003869	22	1000002	60000259	1	None	2	0	3	TutorialAgent
3008418	24	1000002	60000262	1	None	2	0	3	TutorialAgent

Natural Join

agtAgentTypes⋈ $agtResearchAgent$

$agtAgentTypes \times agtResearchAgent$

agentID	divisionID	corporationID	locationID	level	quality	agentTypeID	isLocator	agentTypeID	agentType
3008416	22	1000002	60000004	1	None	2	0	1	NonAgent
3003869	22	1000002	60000259	1	None	2	0	1	NonAgent
3008418	24	1000002	60000262	1	None	2	0	1	NonAgent
3008416	22	1000002	60000004	1	None	2	0	2	BasicAgent
3003869	22	1000002	60000259	1	None	2	0	2	BasicAgent
3008418	24	1000002	60000262	1	None	2	0	2	BasicAgent
3008416	22	1000002	60000004	1	None	2	0	3	TutorialAgent
3003869	22	1000002	60000259	1	None	2	0	3	TutorialAgent
3008418	24	1000002	60000262	1	None	2	0	3	TutorialAgent

Natural Join

agtAgentTypes⋈ $agtResearchAgent$

$agtAgentTypes \times agtResearchAgent$

agentID	divisionID	corporationID	locationID	level	quality	agentTypeID	isLocator	agentTypeID	agentType
3008416	22	1000002	60000004	1	None	2	0	1	NonAgent
3003869	22	1000002	60000259	1	None	2	0	1	NonAgent
3008418	24	1000002	60000262	1	None	2	0	1	NonAgent
3008416	22	1000002	60000004	1	None	2	0	2	BasicAgent
3003869	22	1000002	60000259	1	None	2	0	2	BasicAgent
3008418	24	1000002	60000262	1	None	2	0	2	BasicAgent
3008416	22	1000002	60000004	1	None	2	0	3	TutorialAgent
3003869	22	1000002	60000259	1	None	2	0	3	TutorialAgent
3008418	24	1000002	60000262	1	None	2	0	3	TutorialAgent

Natural Join

agtAgentTypes$\bowtie$ $agtResearchAgent$

agentID	divisionID	corporationID	locationID	level	quality	agentTypeID	isLocator	agentType
3008416	22	1000002	60000004	1	None	2	0	BasicAgent
3003869	22	1000002	60000259	1	None	2	0	BasicAgent
3008418	24	1000002	60000262	1	None	2	0	BasicAgent

Review and Summary (will be long ☺)

Lancaster University

- **Division**
- A special operation that is used for queries like
  - "Find the ssi's of Mechanics who repair all cars"
  - "Find the Model's of Cars which all Mechanics can repair"

Review and Summary (will be long ☺)

Lancaster University

- **Division**
- A special operation that is used for queries like
  - "Find the ssi's of Mechanics who repair all cars"
  - "Find the Model's of Cars which all Mechanics can repair"

Review and Summary (will be long ☺)

Lancaster University

- Division
- A special operation that is used for queries like
  - "Find the ssi's of Mechanics who repair all cars"
  - "Find the Model's of Cars which all Mechanics can repair"
- The division operator R1/R2 is used for queries which involve "ALL". We are looking for tuples of R1 associated with all tuples of R2.

Review and Summary (will be long ☺)

Lancaster University

Player

Weapon	PlayerID	PlayerName
Axe	221	Uraz
Super Shotgun	56	Jonathan
Nailgun	9	Madison
Grenade Launcher	221	Uraz
Super Nailgun	18	Paulina
Grenade Launcher	120	Cherry
Grenade Launcher	54	Teressa
Nailgun	221	Uraz
Nailgun	120	Cherry
Super Nailgun	221	Uraz
Grenade Launcher	18	Paulina
Super Nailgun	41	Nad
Shotgun	221	Uraz

- Division
- A special operation that is used for queries like
  - "Find the names of Players who use all Weapons"

Weapon

Weapon	Damage	Ammo Type	Maximum Ammo	Fire Mode	Rate of Fire (rpm)	Muzzle Velocity (m/s)	Maximum Range (m)
Axe	20	None	∞	Single	120	-	-
Shotgun	24	Shells	100	Pump-action	120	380	78
Super Shotgun	56	Shells	100	Pump-action	85	380	78
Nailgun	9	Nails	200	Automatic	600	110	229
Super Nailgun	18	Nails	200	Automatic	600	158	229
Grenade Launcher	120	Rockets	100	Semi-auto	100	22.8	-

Review and Summary (will be long ☺)

Lancaster University

Player

Weapon	PlayerID	PlayerName
Axe	221	Uraz
Super Shotgun	56	Jonathan
Nailgun	9	Madison
Grenade Launcher	221	Uraz
Super Nailgun	18	Paulina
Grenade Launcher	120	Cherry
Grenade Launcher	54	Teressa
Nailgun	221	Uraz
Nailgun	120	Cherry
Super Nailgun	221	Uraz
Grenade Launcher	18	Paulina
Super Nailgun	41	Nad
Shotgun	221	Uraz

- Division
- A special operation that is used for queries like
  - "Find the names of Players who use all Weapons"

Weapon

Weapon	Damage	Ammo Type	Maximum Ammo	Fire Mode	Rate of Fire (rpm)	Muzzle Velocity (m/s)	Maximum Range (m)
Axe	20	None	∞	Single	120	-	-
Shotgun	24	Shells	100	Pump-action	120	380	78
Super Shotgun	56	Shells	100	Pump-action	85	380	78
Nailgun	9	Nails	200	Automatic	600	110	229
Super Nailgun	18	Nails	200	Automatic	600	158	229
Grenade Launcher	120	Rockets	100	Semi-auto	100	22.8	-

Review and Summary (will be long ☺)

Lancaster University

Player

Weapon	PlayerID	PlayerName
Axe	221	Uraz
Super Shotgun	56	Jonathan
Nailgun	9	Madison
Grenade Launcher	221	Uraz
Super Nailgun	18	Paulina
Grenade Launcher	120	Cherry
Grenade Launcher	54	Teressa
Nailgun	221	Uraz
Nailgun	120	Cherry
Super Nailgun	221	Uraz
Grenade Launcher	18	Paulina
Super Nailgun	41	Nad
Shotgun	221	Uraz

- Division
- A special operation that is used for queries like
  - "Find the names of Players who use all Weapons"

Weapon

Weapon
Axe
Shotgun
Super Shotgun
Nailgun
Super Nailgun
Grenade Launcher

Review and Summary (will be long ☺)

Lancaster University

Player

Weapon	PlayerID	PlayerName
Axe	221	Uraz
Super Shotgun	56	Jonathan
Nailgun	9	Madison
Grenade Launcher	221	Uraz
Super Nailgun	18	Paulina
Grenade Launcher	120	Cherry
Grenade Launcher	54	Teressa
Nailgun	221	Uraz
Nailgun	120	Cherry
Super Nailgun	221	Uraz
Grenade Launcher	18	Paulina
Super Nailgun	41	Nad
Shotgun	221	Uraz

- Division
- A special operation that is used for queries like
  - "Find the names of Players who use all Weapons"

Weapon

Weapon
Axe
Shotgun
Super Shotgun
Nailgun
Super Nailgun
Grenade Launcher

Review and Summary (will be long ☺)

Lancaster University

Weapon	PlayerName
Axe	Uraz
Super Shotgun	Jonathan
Nailgun	Madison
Grenade Launcher	Uraz
Super Nailgun	Paulina
Grenade Launcher	Cherry
Grenade Launcher	Teressa
Nailgun	Uraz
Nailgun	Cherry
Super Nailgun	Uraz
Grenade Launcher	Paulina
Super Nailgun	Nad
Shotgun	Uraz

- Division
- A special operation that is used for queries like
  - "Find the names of Players who use all Weapons"

Weapon
Axe
Shotgun
Super Shotgun
Nailgun
Super Nailgun
Grenade Launcher

Review and Summary (will be long ☺)

Lancaster University

- Division
- A special operation that is used for queries like
  - "Find the names of Players who use all Weapons"

Weapon	PlayerName
Axe	Uraz
Super Shotgun	Jonathan
Nailgun	Madison
Grenade Launcher	Uraz
Super Nailgun	Paulina
Grenade Launcher	Cherry
Grenade Launcher	Teressa
Nailgun	Uraz
Nailgun	Cherry
Super Nailgun	Uraz
Grenade Launcher	Paulina
Super Nailgun	Nad
Shotgun	Uraz

$$(\pi_{Weapon,PlayerName} Players)/(\pi_{Weapon} Weapons)$$

Weapon
Axe
Shotgun
Super Shotgun
Nailgun
Super Nailgun
Grenade Launcher

Review and Summary (will be long ☺)

Lancaster University

- Division
- A special operation that is used for queries like
  - "Find the names of Players who use all Weapons"

Weapon	PlayerName
Axe	Uraz
Super Shotgun	Jonathan
Nailgun	Madison
Grenade Launcher	Uraz
Super Nailgun	Paulina
Grenade Launcher	Cherry
Grenade Launcher	Teressa
Nailgun	Uraz
Nailgun	Cherry
Super Nailgun	Uraz
Grenade Launcher	Paulina
Super Nailgun	Nad
Shotgun	Uraz

$(\pi_{Weapon,PlayerName}Players)/(\pi_{Weapon}Weapons)$

Weapon
Axe
Shotgun
Super Shotgun
Nailgun
Super Nailgun
Grenade Launcher

$\pi_{Weapon,PlayerName}Players$ is the dividend and

$\pi_{Weapon}Weapons$ is the divider.

Review and Summary (will be long ☺)

Lancaster University

- Division
- A special operation that is used for queries like
  - "Find the names of Players who use all Weapons"

Weapon	PlayerName
Axe	Uraz
Super Shotgun	Jonathan
Nailgun	Madison
Grenade Launcher	Uraz
Super Nailgun	Paulina
Grenade Launcher	Cherry
Grenade Launcher	Teressa
Nailgun	Uraz
Nailgun	Cherry
Super Nailgun	Uraz
Grenade Launcher	Paulina
Super Nailgun	Nad
Shotgun	Uraz

$$(\pi_{Weapon,PlayerName} Players)/(\pi_{Weapon} Weapons)$$

Weapon
Axe
Shotgun
Super Shotgun
Nailgun
Super Nailgun
Grenade Launcher

We are looking for tuples from the Dividend relation associated with all tuples of the Divider relation.

Review and Summary (will be long ☺)

Lancaster University

- Division
- A special operation that is used for queries like
  - "Find the names of Players who use all Weapons"

Weapon	PlayerName
Axe	Uraz
Super Shotgun	Jonathan
Nailgun	Madison
Grenade Launcher	Uraz
Super Nailgun	Paulina
Grenade Launcher	Cherry
Grenade Launcher	Teressa
Nailgun	Uraz
Nailgun	Cherry
Super Nailgun	Uraz
Grenade Launcher	Paulina
Super Nailgun	Nad
Shotgun	Uraz

$$(\pi_{Weapon,PlayerName} Players)/(\pi_{Weapon} Weapons)$$

Weapon
Axe
Shotgun
Super Shotgun
Nailgun
Super Nailgun
Grenade Launcher

We are looking for tuples from the Dividend relation associated with all tuples of the Divider relation.

PlayerName
Uraz

Review and Summary (will be long ☺)

Lancaster University

- Division
- A special operation that is used for queries like
  - "Find the names of Players who use all Weapons"

$$(\pi_{Weapon,PlayerName} Players)/(\pi_{Weapon} Weapons)$$

We are looking for tuples from the Dividend relation associated with all tuples of the Divider relation.

HOW COULD WE COMPUTE THE RESULT WITHOUT '/'?

Review and Summary (will be long ☺)

Lancaster University

Weapon	PlayerName
Axe	Uraz
Pen	Newton
Pen	Uraz

Weapon
Axe
Pen

- Division
- A special operation that is used for queries like
  - "Find the names of Players who use all Weapons"

Review and Summary (will be long ☺)

Lancaster University

Weapon	PlayerName
Axe	Uraz
Pen	Newton
Pen	Uraz

Weapon
Axe
Pen

"Find the names of Players who use all Weapons"
1) Since I am looking for Names, first let me get what we have…

Review and Summary (will be long ☺)

Lancaster University

Weapon	PlayerName
Axe	Uraz
Pen	Newton
Pen	Uraz

Weapon
Axe
Pen

PlayerName
Uraz
Newton

"Find the names of Players who use all Weapons"
1) Since I am looking for Names, first let me get what we have…

Review and Summary (will be long ☺)

Lancaster University

Weapon	PlayerName
Axe	Uraz
Pen	Newton
Pen	Uraz

PlayerName
Uraz
Newton

Weapon
Axe
Pen

1) Since I am looking for Names, first let me get what we have…
2) Next.. What would it look like if all the names used all weapons? (“total association”)

Review and Summary (will be long ☺)

Lancaster University

1) Since I am looking for Names, first let me get what we have…
2) Next.. What would it look like if all the names used all weapons? (“total association”)

Weapon	PlayerName
Axe	Uraz
Pen	Newton
Pen	Uraz

Weapon
Axe
Pen

$$PlayerName \times Weapon$$

PlayerName
Uraz
Newton

×

Weapon
Axe
Pen

=

Weapon	PlayerName
Pen	Uraz
Axe	Uraz
Pen	Newton
Axe	Newton

Review and Summary (will be long ☺)

Lancaster University

1) Since I am looking for Names, first let me get what we have…
2) Next.. What would it look like if all the names used all weapons? (“total association”)
3) Next.. Which tuples are missing from this “total association”?

Weapon	PlayerName
Axe	Uraz
Pen	Newton
Pen	Uraz

Weapon
Axe
Pen

$$PlayerName \times Weapon$$

PlayerName
Uraz
Newton

×

Weapon
Axe
Pen

=

Weapon	PlayerName
Pen	Uraz
Axe	Uraz
Pen	Newton
Axe	Newton

Review and Summary (will be long ☺)

Lancaster University

1) Since I am looking for Names, first let me get what we have…
2) Next.. What would it look like if all the names used all weapons? (“total association”)
3) Next.. Which tuples are missing from this “total association”?

Weapon	PlayerName
Axe	Uraz
Pen	Newton
Pen	Uraz

Weapon
Axe
Pen

$PlayerName \times Weapon$

PlayerName
Uraz
Newton

×

Weapon
Axe
Pen

=

Weapon	PlayerName
Pen	Uraz
Axe	Uraz
Pen	Newton
Axe	Newton

SET DIFFERENCE

Weapon	PlayerName
Axe	Uraz
Pen	Newton
Pen	Uraz

=

Weapon	PlayerName
Axe	Newton

Review and Summary (will be long ☺)

Lancaster University

1) Since I am looking for Names, first let me get what we have…
2) Next.. What would it look like if all the names used all weapons? (“total association”)
3) Next.. Which tuples are missing from this “total association”?
4) Next.. So, which names are causing the trouble, i.e., do not use all weapons?

Weapon	PlayerName
Axe	Uraz
Pen	Newton
Pen	Uraz

Weapon
Axe
Pen

$PlayerName \times Weapon$

PlayerName
Uraz
Newton

×

Weapon
Axe
Pen

=

Weapon	PlayerName
Pen	Uraz
Axe	Uraz
Pen	Newton
Axe	Newton

SET DIFFERENCE

Weapon	PlayerName
Axe	Uraz
Pen	Newton
Pen	Uraz

=

Weapon	PlayerName
Axe	Newton

Review and Summary (will be long ☺)

Lancaster University

1) Since I am looking for Names, first let me get what we have…
2) Next.. What would it look like if all the names used all weapons? (“total association”)
3) Next.. Which tuples are missing from this “total association”?
4) Next.. So, which names are causing the trouble, i.e., do not use all weapons?

Weapon	PlayerName
Axe	Uraz
Pen	Newton
Pen	Uraz

Weapon
Axe
Pen

$PlayerName \times Weapon$

PlayerName
Uraz
Newton

×

Weapon
Axe
Pen

=

Weapon	PlayerName
Pen	Uraz
Axe	Uraz
Pen	Newton
Axe	Newton

SET DIFFERENCE

Weapon	PlayerName
Axe	Uraz
Pen	Newton
Pen	Uraz

=

Weapon	PlayerName
Axe	Newton

Review and Summary (will be long ☺)

Lancaster University

1) Since I am looking for Names, first let me get what we have…
2) Next.. What would it look like if all the names used all weapons? (“total association”)
3) Next.. Which tuples are missing from this “total association”?
4) Next.. So, which names are causing the trouble, i.e., do not use all weapons?

Weapon	PlayerName
Axe	Uraz
Pen	Newton
Pen	Uraz

Weapon
Axe
Pen

$PlayerName \times Weapon$

PlayerName
Uraz
Newton

×

Weapon
Axe
Pen

=

Weapon	PlayerName
Pen	Uraz
Axe	Uraz
Pen	Newton
Axe	Newton

SET DIFFERENCE

Weapon	PlayerName
Axe	Uraz
Pen	Newton
Pen	Uraz

=

Weapon	PlayerName
Axe	Newton

PlayerName
Newton

Review and Summary (will be long ☺)

Lancaster University

Weapon	PlayerName
Axe	Uraz
Pen	Newton
Pen	Uraz

Weapon
Axe
Pen

1) Since I am looking for Names, first let me get what we have…
2) Next.. What would it look like if all the names used all weapons? (“total association”)
3) Next.. Which tuples are missing from this “total association”?
4) Next.. So, which names are causing the trouble, i.e., do not use all weapons?
5) Next.. So, if we find the names that are not using all weapons, we can find the names that use all the weapons..

$$PlayerName \times Weapon$$

PlayerName
Uraz
Newton

×

Weapon
Axe
Pen

=

Weapon	PlayerName
Pen	Uraz
Axe	Uraz
Pen	Newton
Axe	Newton

SET DIFFERENCE

Weapon	PlayerName
Axe	Uraz
Pen	Newton
Pen	Uraz

=

Weapon	PlayerName
Axe	Newton

PlayerName
Newton

Review and Summary (will be long ☺)

Lancaster University

Weapon	PlayerName
Axe	Uraz
Pen	Newton
Pen	Uraz

Weapon
Axe
Pen

1) Since I am looking for Names, first let me get what we have…
2) Next.. What would it look like if all the names used all weapons? (“total association”)
3) Next.. Which tuples are missing from this “total association”?
4) Next.. So, which names are causing the trouble, i.e., do not use all weapons?
5) Next.. So, if we find the names that are not using all weapons, we can find the names that use all the weapons..

$$PlayerName \times Weapon$$

PlayerName
Uraz
Newton

×

Weapon
Axe
Pen

=

Weapon	PlayerName
Pen	Uraz
Axe	Uraz
Pen	Newton
Axe	Newton

SET DIFFERENCE −

Weapon	PlayerName
Axe	Uraz
Pen	Newton
Pen	Uraz

=

Weapon	PlayerName
Axe	Newton

SET DIFFERENCE

PlayerName
Uraz
Newton

−

PlayerName
Newton

=

PlayerName
Uraz

PlayerName
Newton

Review and Summary (will be long ☺)

Lancaster University

$R1$

Weapon	PlayerName
Axe	Uraz
Pen	Newton
Pen	Uraz

$R2$

Weapon
Axe
Pen

1) Since I am looking for Names, first let me get what we have…
2) Next.. What would it look like if all the names used all weapons? (“total association”)
3) Next.. Which tuples are missing from this “total association”?
4) Next.. So, which names are causing the trouble, i.e., do not use all weapons?
5) Next.. So, if we find the names that are not using all weapons, we can find the names that use all the weapons..

$$\pi_{PlayerName}(R1) - (\pi_{PlayerName}(\ (\pi_{PlayerName}(R1)\ \times R2) - R1)\ )$$

Example

Lancaster University

EMPLOYEE(NAME, SSN, BDATE, ADDRESS, SALARY)

DEPARTMENT(DNAME, DNUMBER, MGRSSN)

(IC: MGRSSN references SSN in EMPLOYEE table)

WORKSIN(SSN, DNUMBER, HOURS)

(IC:DNUMBER references DNUMBER in DEPARTMENT table)

(ESSN reference SSN in EMPLOYEE table)

Write the relational algebra expressions for the following queries:

1) List the names of employees whose salary is greater than 30000

2) List the names of employees who work in “shoes” department

3) List the names of employees who work in all departments

Example

Lancaster University

EMPLOYEE(NAME, SSN, BDATE, ADDRESS, SALARY)

DEPARTMENT(DNAME, DNUMBER, MGRSSN)

(IC: MGRSSN references SSN in EMPLOYEE table)

WORKSIN(SSN, DNUMBER, HOURS)

(IC:DNUMBER references DNUMBER in DEPARTMENT table)

(ESSN reference SSN in EMPLOYEE table)

Write the relational algebra expressions for the following queries:

1) List the names of employees whose salary is greater than 30000 $\pi_{Name}(\sigma_{Salary>30000}(Employee))$

2) List the names of employees who work in “shoes” department

3) List the names of employees who work in all departments

Example

Lancaster University

EMPLOYEE(NAME, SSN, BDATE, ADDRESS, SALARY)

DEPARTMENT(DNAME, DNUMBER, MGRSSN)

(IC: MGRSSN references SSN in EMPLOYEE table)

WORKSIN(SSN, DNUMBER, HOURS)

(IC:DNUMBER references DNUMBER in DEPARTMENT table)

(ESSN reference SSN in EMPLOYEE table)

Write the relational algebra expressions for the following queries:

1) List the names of employees whose salary is greater than 30000 $\pi_{Name}(\sigma_{Salary>3000}\ (Employee))$

2) List the names of employees who work in "shoes" department $\pi_{Name}(Employee \bowtie_{SSN=MGRSS}\ (\sigma_{DNAME=shoe}\ (Department)))$

3) List the names of employees who work in all departments

Example

Lancaster University

EMPLOYEE(NAME, SSN, BDATE, ADDRESS, SALARY)

DEPARTMENT(DNAME, DNUMBER, MGRSSN)

(IC: MGRSSN references SSN in EMPLOYEE table)

WORKSIN(SSN, DNUMBER, HOURS)

(IC:DNUMBER references DNUMBER in DEPARTMENT table)

(ESSN reference SSN in EMPLOYEE table)

Write the relational algebra expressions for the following queries:

1) List the names of employees whose salary is greater than 30000 $\pi_{Name}(\sigma_{Salary>30000}(Employee))$

2) List the names of employees who work in "shoes" department $\pi_{Name}(Employee \bowtie_{SSN=} \; _{SSN}(\sigma_{DNAME=shoes}(Department)))$

3) List the names of employees who work in all departments

List the names of employees who work in “shoes” department

Lancaster University

EMPLOYEE(NAME, SSN, BDATE, ADDRESS, SALARY)

DEPARTMENT(DNAME, DNUMBER, MGRSSN)

(IC: MGRSSN references SSN in EMPLOYEE table)

WORKSIN(SSN, DNUMBER, HOURS)

(IC:DNUMBER references DNUMBER in DEPARTMENT table)

List the names of employees who work in “shoes” department

Lancaster University

EMPLOYEE(NAME, SSN, BDATE, ADDRESS, SALARY)

DEPARTMENT(DNAME, DNUMBER, MGRSSN)

(IC: MGRSSN references SSN in EMPLOYEE table)

WORKSIN(SSN, DNUMBER, HOURS)

(IC:DNUMBER references DNUMBER in DEPARTMENT table)

$$\pi_{DNUMBER}(\sigma_{DNAME=shoes}(Department))$$

List the names of employees who work in “shoes” department

Lancaster University

EMPLOYEE(NAME, SSN, BDATE, ADDRESS, SALARY)

DEPARTMENT(DNAME, DNUMBER, MGRSSN)

(IC: MGRSSN references SSN in EMPLOYEE table)

WORKSIN(SSN, DNUMBER, HOURS)

(IC:DNUMBER references DNUMBER in DEPARTMENT table)

$$\pi_{DNUMBER}(\sigma_{DNAME=shoe}\ (Department)) \bowtie$$

List the names of employees who work in “shoes” department

Lancaster University

EMPLOYEE(NAME, SSN, BDATE, ADDRESS, SALARY)

DEPARTMENT(DNAME, DNUMBER, MGRSSN)

(IC: MGRSSN references SSN in EMPLOYEE table)

WORKSIN(SSN, DNUMBER, HOURS)

(IC:DNUMBER references DNUMBER in DEPARTMENT table)

$$(\pi_{DNUMBER}(\sigma_{DNAME=shoes}(Department)) \bowtie WorksIn)$$

List the names of employees who work in “shoes” department

Lancaster University

EMPLOYEE(NAME, SSN, BDATE, ADDRESS, SALARY)

DEPARTMENT(DNAME, DNUMBER, MGRSSN)

(IC: MGRSSN references SSN in EMPLOYEE table)

WORKSIN(SSN, DNUMBER, HOURS)

(IC:DNUMBER references DNUMBER in DEPARTMENT table)

$$\pi_{Names}((\pi_{DNUMBER}(\sigma_{DNAME=shoes}(Department)) \bowtie WorksIn) \bowtie Employee)$$

Example

Lancaster University

EMPLOYEE(NAME, SSN, BDATE, ADDRESS, SALARY)

DEPARTMENT(DNAME, DNUMBER, MGRSSN)

(IC: MGRSSN references SSN in EMPLOYEE table)

WORKSIN(SSN, DNUMBER, HOURS)

(IC:DNUMBER references DNUMBER in DEPARTMENT table)

(ESSN reference SSN in EMPLOYEE table)

Write the relational algebra expressions for the following queries:

1) List the names of employees whose salary is greater than 30000 $\pi_{Name}(\sigma_{Salary>3000}\ (Employee))$

2) List the names of employees who work in "shoes" department

$\pi_{Names}((\pi_{DNUMBER}(\sigma_{DNAME=shoes}(Department)) \bowtie WorksIn) \bowtie Employee\ )$

3) List the names of employees who work in all departments

List the names of employees who work in all departments

Lancaster University

EMPLOYEE(NAME, SSN, BDATE, ADDRESS, SALARY)

DEPARTMENT(DNAME, DNUMBER, MGRSSN)

(IC: MGRSSN references SSN in EMPLOYEE table)

WORKSIN(SSN, DNUMBER, HOURS)

(IC:DNUMBER references DNUMBER in DEPARTMENT table)

List the names of employees who work in all departments

Lancaster University

EMPLOYEE(NAME, SSN, BDATE, ADDRESS, SALARY)

DEPARTMENT(DNAME, DNUMBER, MGRSSN)

(IC: MGRSSN references SSN in EMPLOYEE table)

WORKSIN(SSN, DNUMBER, HOURS)

(IC:DNUMBER references DNUMBER in DEPARTMENT table)

List the names of employees who work in all departments

Lancaster University

EMPLOYEE(NAME, SSN, BDATE, ADDRESS, SALARY)

DEPARTMENT(DNAME, DNUMBER, MGRSSN)

(IC: MGRSSN references SSN in EMPLOYEE table)

WORKSIN(SSN, DNUMBER, HOURS)

(IC:DNUMBER references DNUMBER in DEPARTMENT table)

$$\pi_{DNUMBER}(Department)$$

List the names of employees who work in all departments

Lancaster University

EMPLOYEE(NAME, SSN, BDATE, ADDRESS, SALARY)

DEPARTMENT(DNAME, DNUMBER, MGRSSN)

(IC: MGRSSN references SSN in EMPLOYEE table)

WORKSIN(SSN, DNUMBER, HOURS)

(IC:DNUMBER references DNUMBER in DEPARTMENT table)

$\pi_{SSN,DNUMBER}(WorksIN)$ $\pi_{DNUMBER}(Department)$

List the names of employees who work in all departments

Lancaster University

EMPLOYEE(NAME, SSN, BDATE, ADDRESS, SALARY)

DEPARTMENT(DNAME, DNUMBER, MGRSSN)

(IC: MGRSSN references SSN in EMPLOYEE table)

WORKSIN(SSN, DNUMBER, HOURS)

(IC:DNUMBER references DNUMBER in DEPARTMENT table)

$$\pi_{SSN,DNUMBER}(WorksIN) \ / \ \pi_{DNUMBER}(Department)$$

List the names of employees who work in all departments

Lancaster University

EMPLOYEE(NAME, SSN, BDATE, ADDRESS, SALARY)

DEPARTMENT(DNAME, DNUMBER, MGRSSN)

(IC: MGRSSN references SSN in EMPLOYEE table)

WORKSIN(SSN, DNUMBER, HOURS)

(IC:DNUMBER references DNUMBER in DEPARTMENT table)

$$(Employee \bowtie (\pi_{SSN,DNUMBER}(WorksIN) \ / \ \pi_{DNUMBER}(Department)\ )$$

List the names of employees who work in all departments

Lancaster University

EMPLOYEE(NAME, SSN, BDATE, ADDRESS, SALARY)

DEPARTMENT(DNAME, DNUMBER, MGRSSN)

(IC: MGRSSN references SSN in EMPLOYEE table)

WORKSIN(SSN, DNUMBER, HOURS)

(IC:DNUMBER references DNUMBER in DEPARTMENT table)

$$\pi_{Name} \quad (Employee \bowtie (\pi_{SSN,DNUMBER}(WorksIN) \;\; / \;\; \pi_{DNUMBER}(Department) \;\;)$$

Exam Questions

Lancaster University

Consider the tables:

Players (playerId, AccountNo, email)

Characters (AccountNo, CharName, Power, Rating, Money, ExperienceScore, Item_type)

Inventory (Item_type, Price, Wearable)

B) Write the Relational Algebra statements for the given queries:

a. `Retrieve the email address of player with AccountNo 18811938` **(5pts)**

b. `Retrieve the playerId of the player who uses item type where Wearable=1` **(4pts)**

c. `Retrieve the email address of plyers who use all wearable items` **(1pt)**

Exam Questions

Lancaster University

Consider the tables:

Players (playerId, AccountNo, email)

Characters (AccountNo, CharName, Power, Rating, Money, ExperienceScore, Item_type)

Inventory (Item_type, Price, Wearable)

B) Write the Relational Algebra statements for the given queries:

a. `Retrieve the email address of player with AccountNo 18811938` (5pts)

b. `Retrieve the playerId of the player who uses item type where Wearable=1` (4pts)

c. `Retrieve the email address of plyers who use all wearable items` (1pt)

a) $\pi_{email}(\sigma_{AccountNo=18811938}(Players))$

Exam Questions

Lancaster University

Consider the tables:

Players (playerId, AccountNo, email)

Characters (AccountNo, CharName, Power, Rating, Money, ExperienceScore, Item_type)

Inventory (Item_type, Price, Wearable)

B) Write the Relational Algebra statements for the given queries:

a. Retrieve the email address of player with AccountNo 18811938 (5pts)

b. Retrieve the playerId of the player who uses item type where Wearable=1 (4pts)

c. Retrieve the email address of plyers who use all wearable items (1pt)

a) $\pi_{email}(\sigma_{AccountNo=18811938}(Players))$

b) $\pi_{playerID}\left((\pi_{ite\ \ type}(\sigma_{wearable=}\ (Inventory)) \bowtie Characters) \bowtie Players\right)$

Exam Questions

Lancaster University

Consider the tables:

Players (playerId, AccountNo, email)

Characters (AccountNo, CharName, Power, Rating, Money, ExperienceScore, Item_type)

Inventory (Item_type, Price, Wearable)

B) Write the Relational Algebra statements for the given queries:

a. Retrieve the email address of player with AccountNo 18811938 (5pts)

b. Retrieve the playerId of the player who uses item type where Wearable=1 (4pts)

c. Retrieve the email address of plyers who use all wearable items (1pt)

a) $\pi_{email}(\sigma_{AccountNo=18811938}(Players))$

b) $\pi_{playerID}\left((\pi_{item_{type}}(\sigma_{wearable=1}(Inventory)) \bowtie Characters) \bowtie Players\right)$

c) $W1 = \pi_{item\_type}(\sigma_{wearable=1}(Inventory))$

Exam Questions

Lancaster University

Consider the tables:

Players (playerId, AccountNo, email)

Characters (AccountNo, CharName, Power, Rating, Money, ExperienceScore, Item_type)

Inventory (Item_type, Price, Wearable)

B) Write the Relational Algebra statements for the given queries:

a. Retrieve the email address of player with AccountNo 18811938 (5pts)

b. Retrieve the playerId of the player who uses item type where Wearable=1 (4pts)

c. Retrieve the email address of plyers who use all wearable items (1pt)

a) $\pi_{email}(\sigma_{AccountNo=18811938}(Players))$

b) $\pi_{playerID}\left((\pi_{item_{type}}(\sigma_{wearable=1}(Inventory)) \bowtie Characters) \bowtie Players\right)$

c) W1 $= \pi_{item\_type}(\sigma_{wearable=}\ (Inventory))$

W2 $= \pi_{AccountNo,item\_type}(Characters)$

Exam Questions

Lancaster University

Consider the tables:

Players (playerId, AccountNo, email)

Characters (AccountNo, CharName, Power, Rating, Money, ExperienceScore, Item_type)

Inventory (Item_type, Price, Wearable)

B) Write the Relational Algebra statements for the given queries:

a. Retrieve the email address of player with AccountNo 18811938 (5pts)

b. Retrieve the playerId of the player who uses item type where Wearable=1 (4pts)

c. Retrieve the email address of plyers who use all wearable items (1pt)

a) $\pi_{email}(\sigma_{AccountNo=18811938}(Players))$

b) $\pi_{playerID}\left((\pi_{item_{type}}(\sigma_{wearable=}\ (Inventory)) \bowtie Characters) \bowtie Players\right)$

c) $W1 = \pi_{item\_type}(\sigma_{wearable=1}(Inventory))$

$W2 = \pi_{AccountNo,item\_type}(Characters)$

$W3 = W2/W1$

Exam Questions

Lancaster University

Consider the tables:

Players (playerId, AccountNo, email)

Characters (AccountNo, CharName, Power, Rating, Money, ExperienceScore, Item_type)

Inventory (Item_type, Price, Wearable)

B) Write the Relational Algebra statements for the given queries:

a. Retrieve the email address of player with AccountNo 18811938 (5pts)

b. Retrieve the playerId of the player who uses item type where Wearable=1 (4pts)

c. Retrieve the email address of plyers who use all wearable items (1pt)

a) $\pi_{email}(\sigma_{AccountNo=18811938}(Players))$

b) $\pi_{playerID}\left((\pi_{item_{type}}(\sigma_{wearable=}\ (Inventory)) \bowtie Characters) \bowtie Players\right)$

c) $W1 = \pi_{item\_type}(\sigma_{wearable=1}(Inventory))$

$W2 = \pi_{AccountNo,item\_type}(Characters)$

$W3 = W2/W1$

$\pi_{emai(}W3 \bowtie Players)$