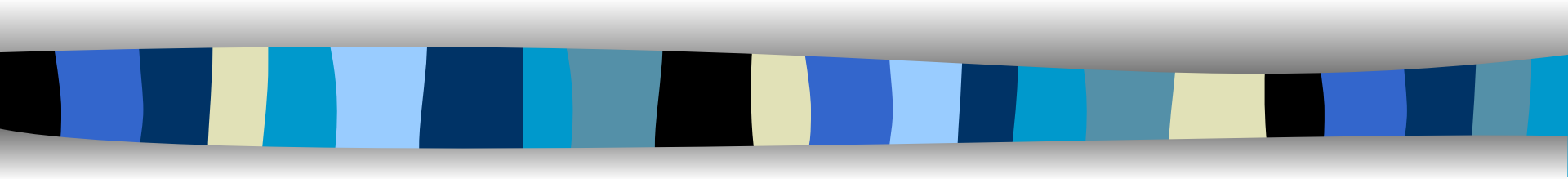
Lecture 3



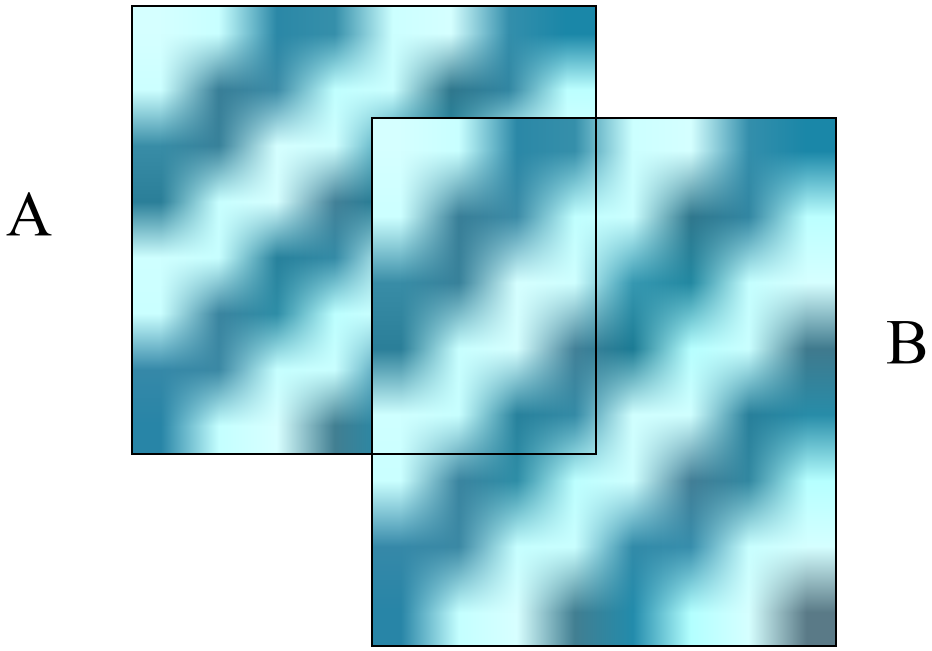
Introduction to Relational Algebra

What is Relational Algebra?

- Operators
  - Relational Algebra consists of eight operators:
    - Four traditional set operators: **UNION**, **INTERSECTION**, **DIFFERENCE**, **CARTESIAN PRODUCT**
    - Four special relational operators: **RESTRICTION**, **PROJECTION**, **JOIN**, **DIVISION**
- Operands
  - Relations are the operands used in Relational Algebra
- Closure property of Relations
  - output from some relational operator is always a relation.

Traditional Set Operators

- UNION
  - the union of two type-compatible relations A and B (A UNION B) is a relation with the same heading as each of A and B and with a body consisting of the set of all tuples belonging to A and B.
  - relations must have same heading
  - same tuples are included once



Traditional Set Operators

- UNION
  - Returns a relation consisting of all tuples appearing in either or both relations

A

ID	Name	Age	Department	NIC
S1	Ahmad	23	Sales	245-77-245367
S2	Salman	34	Marketing	234-66-245368
S4	Tariq	29	Admin	245-71-325370

B

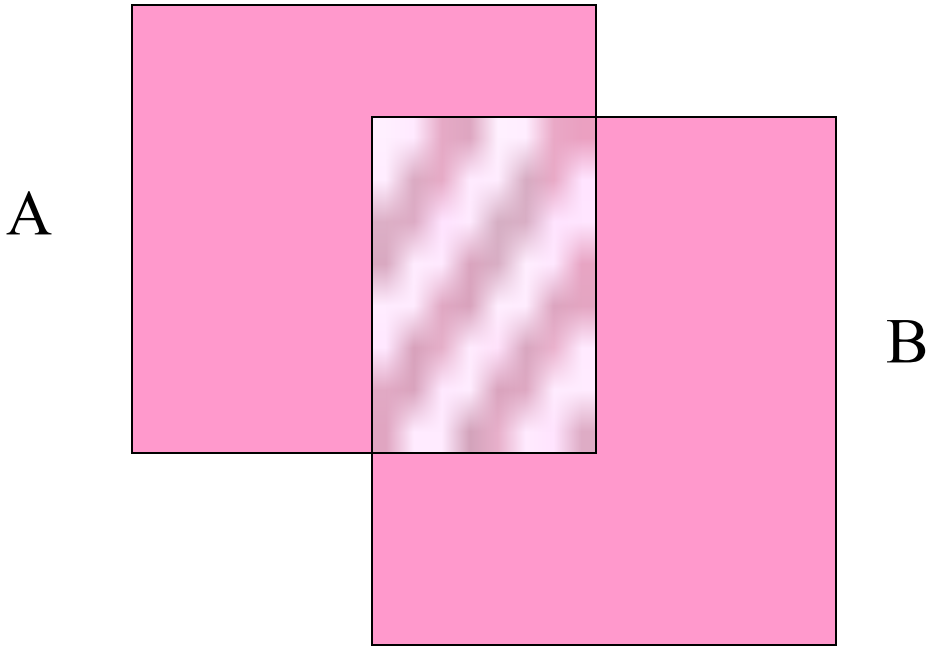
ID	Name	Age	Department	NIC
S3	Karim	21	Sales	255-79-256369
S4	Tariq	29	Admin	245-71-325370
S5	Sadiq	32	Sales	245-68-345371

A UNION B

ID	Name	Age	Department	NIC
S1	Ahmad	23	Sales	245-77-245367
S2	Salman	34	Marketing	234-66-245368
S3	Karim	21	Sales	255-79-256369
S4	Tariq	29	Admin	245-71-325370
S5	Sadiq	32	Sales	245-68-345371

Traditional Set Operators

- INTERSECTION
  - the intersection of two type-compatible relations A and B (A INTERSECT B) is a relation with the same heading as each of A and B and with a body consisting of the set of all tuples belonging to both A and B.
  - relations must have same heading



Traditional Set Operators

- INTERSECTION
  - Returns a relation consisting of all tuples appearing in both of two specified relations

A

ID	Name	Age	Department	NIC
S1	Ahmad	23	Sales	245-77-245367
S2	Salman	34	Marketing	234-66-245368
S4	Tariq	29	Admin	245-71-325370

B

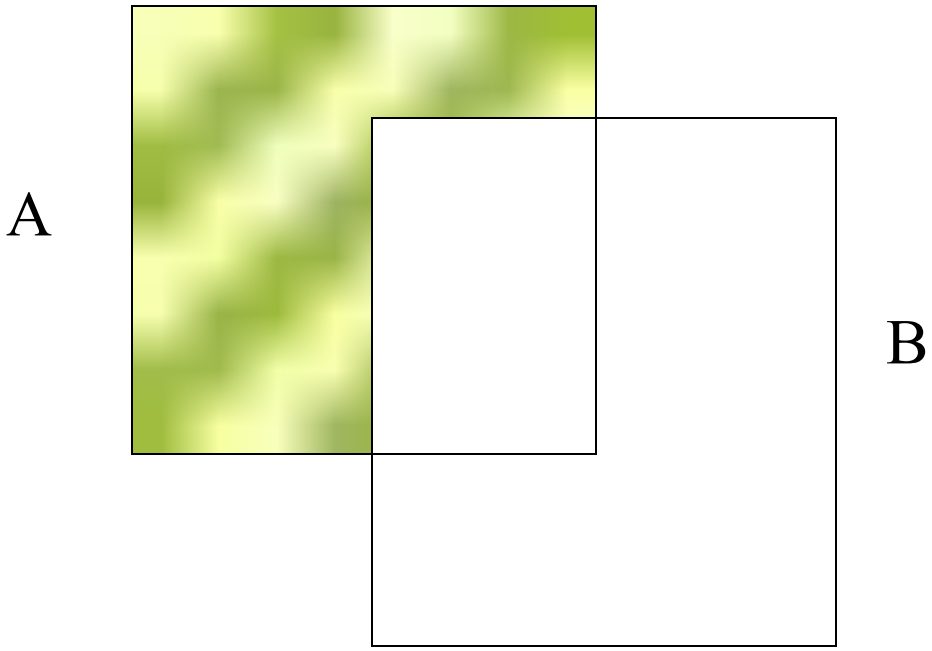
ID	Name	Age	Department	NIC
S3	Karim	21	Sales	255-79-256369
S4	Tariq	29	Admin	245-71-325370
S5	Sadiq	32	Sales	245-68-345371

A INTERSECT B

ID	Name	Age	Department	NIC
S4	Tariq	29	Admin	245-71-325370

Traditional Set Operators

- DIFFERENCE
  - the difference between two type-compatible relations A and B, in that order (A MINUS B) is a relation with the same heading as each of A and B and with a body consisting of the set of all tuples belonging to A and not to B.
  - relations must have same heading
  - direction of operation does matter



Traditional Set Operators

- DIFFERENCE
  - Returns a relation consisting of all tuples appearing in the first and not in the second of two specified relations

A

ID	Name	Age	Department	NIC
S1	Ahmad	23	Sales	245-77-245367
S2	Salman	34	Marketing	234-66-245368
S4	Tariq	29	Admin	245-71-325370

B

ID	Name	Age	Department	NIC
S3	Karim	21	Sales	255-79-256369
S4	Tariq	29	Admin	245-71-325370
S5	Sadiq	32	Sales	245-68-345371

A MINUS B

ID	Name	Age	Department	NIC
S1	Ahmad	23	Sales	245-77-245367
S2	Salman	34	Marketing	234-66-245368

B MINUS A

ID	Name	Age	Department	NIC
S3	Karim	21	Sales	255-79-256369
S5	Sadiq	32	Sales	245-68-345371

Traditional Set Operators

- PRODUCT (CARTESIAN PRODUCT)
  - the product of two relations A and B with no common attribute, (A TIMES B) is a relation with a same heading as set of all attributes in each of A and B and with a body consisting of the set of all tuples such that each resulting tuple is combination of a tuple from A and a tuple from B.
  - Cardinality of resulting relation is equal to the product of the cardinalities of A and B.
  - Degree of resulting relation is equal to the sum of the degrees of A and B.
- **Returns a relation consisting of all possible tuples that are a combination of two tuples, one from each of two specified relations.**

Traditional Set Operators

- PRODUCT (CARTESIAN PRODUCT)

A

ID	Name	Age
S1	Ahmad	23
S2	Salman	34
S4	Tariq	29

B

Department	NIC
Sales	255-79-256369
Admin	245-71-325370
Sales	245-68-345371

A TIMES B

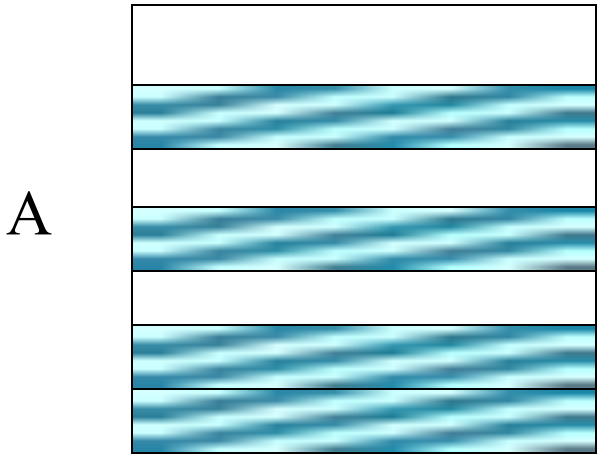
ID	Name	Age	Department	NIC
S1	Ahmad	23	Sales	255-79-256369
S1	Ahmad	23	Admin	245-71-325370
S1	Ahmad	23	Sales	245-68-345371
S2	Salman	34	Sales	255-79-256369
S2	Salman	34	Admin	245-71-325370
S2	Salman	34	Sales	245-68-345371
S4	Tariq	29	Sales	255-79-256369
S4	Tariq	29	Admin	245-71-325370
S4	Tariq	29	Sales	245-68-345371

Some more about Traditional Set Operators

- Commutative
  - **Union**, **Intersect** and **Times** are Commutative:
    - **A UNION B** is equal to **B UNION A**
    - **A INTERSECT B** is equal to **B INTERSECT A**
    - **A TIMES B** is equal to **B TIMES A**
  - **MINUS** is not Commutative i.e.,
    - **A MINUS B** is not equal to **B MINUS A**
- Associative
  - **Union**, **Intersect** and **Times** are Associative:
    - **(A UNION B) UNION C** is equal to **A UNION (B UNION C)**
    - **(A INTERSECT B) INTERSECT C** is equal to **A INTERSECT (B INERSECT C)**
    - **(A TIMES B) TIMES C** is equal to **A TIMES (B TIMES C)**
  - **MINUS** is not Associative i.e.,
    - **(A MINUS B) MINUS C** is not equal to **A MINUS (B MINUS C)**

Special Relational Set Operators

- RESTRICTION
  - is actually abbreviation for ***θ*-restriction**, where "***θ***" stands for any simple scalar comparison operator(=,<,>,=)
  - ***θ*-restriction** of relation **A** on attributes **X** and **Y**(in that order)
    A where X *θ* Y is a relation with the same heading as **A** and with a body consisting of the set of all tuples of **A** such that the condition "**X *θ* Y**" evaluates true for those tuples.
  - **X** and **Y** must be defined on the same domain
  - operator must make sense for that domain



Special Relational Operators

- RESTRICTION
  - Returns a relation consisting of all tuples from a specified relation that satisfy a specified condition.

A

ID	Name	Age	Department	NIC
S1	Ahmad	23	Sales	245-77-245367
S2	Salman	34	Marketing	234-66-245368
S3	Karim	21	Sales	255-79-256369
S4	Tariq	29	Admin	245-71-325370
S5	Sadiq	32	Sales	245-68-345371

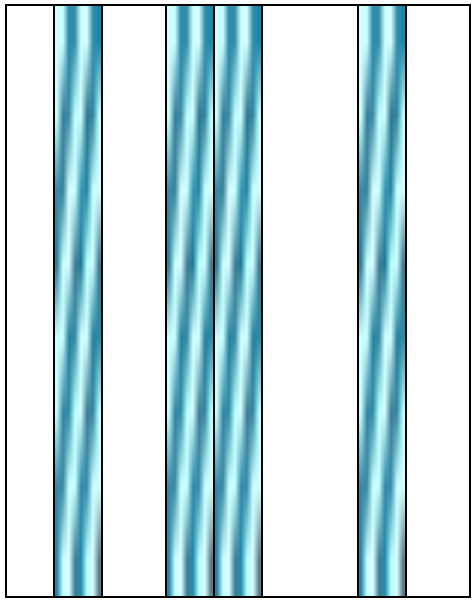
A WHERE Department="Sales"

ID	Name	Age	Department	NIC
S1	Ahmad	23	Sales	245-77-245367
S3	Karim	21	Sales	255-79-256369
S5	Sadiq	32	Sales	245-68-345371

Special Relational Operators

- PROJECTION
  - the projection of relation A on X,Y,….,Z (where each of X,Y,….,Z is an attribute of A) is a relation with heading {X,Y,…,Z } and body consisting of the set of all tuples {X:x,Y:y,…,Z:z } such that a tuple appears in A with X-value x, Y-value y,…., Z-value z.
  - projection yields a vertical subset of relation

A



Special Relational Operators

- PROJECTION
  - Returns a relation consisting of all tuples that remain as (sub) tuples in a specified relation after specified attributes have been eliminated

A

ID	Name	Age	Department	NIC
S1	Ahmad	23	Sales	245-77-245367
S2	Salman	34	Marketing	234-66-245368
S3	Karim	21	Sales	255-79-256369
S4	Tariq	29	Admin	245-71-325370
S5	Sadiq	32	Sales	245-68-345371

A [Name]

Name
Ahmad
Salman
Karim
Tariq
Sadiq

A where Department="Sales" [Name,Department]

Name	Age	Department
Ahmad	23	Sales
Karim	21	Sales
Sadiq	32	Sales

Special Relational Operators

- JOIN(NATURAL JOIN)
  - Returns a relation consisting of all possible tuples that are combination of two tuples, one from each of the two specified relations, such that two tuples contributing to any given combination have a common value for the common attributes (and that value appears just once)

A

ID	Name
S1	Ahmad
S2	Salman
S3	Karim

B

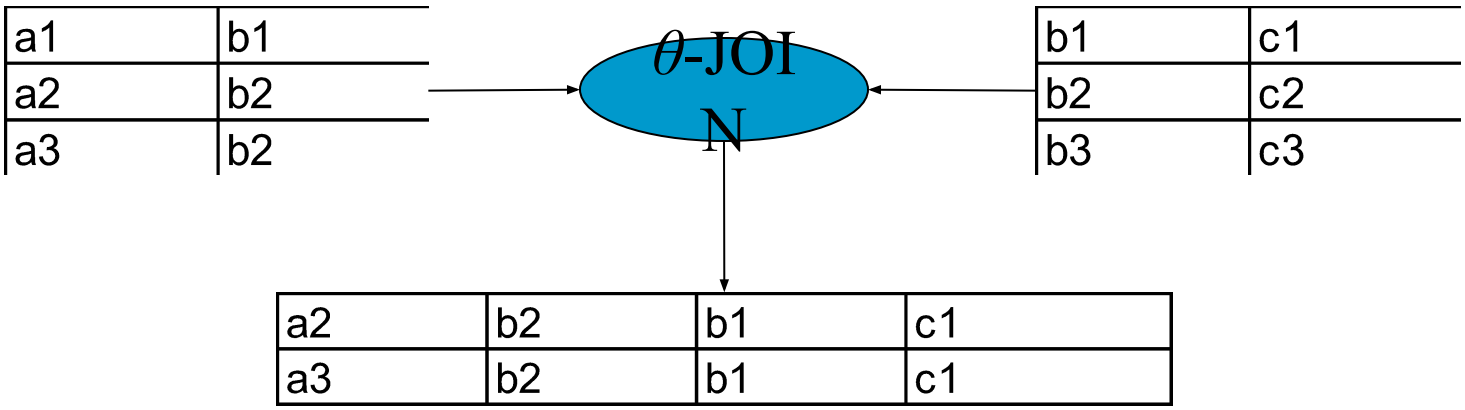
ID	Subject
S1	Math
S2	Urdu
S1	English

A JOIN B

ID	Name	Subject
S1	Ahmad	Math
S1	Ahmad	English
S2	Salman	Urdu

Special Relational Operators

- *θ*-JOIN
  - Let relations A and B have no attribute names in common (as in Cartesian Product), and let ***θ*** be as defined in restriction. Then the ***θ*-** JOIN of relation A on attribute X with relation B on attribute Y is defined by the result of the expression **(A TIMES B)**
    where X *θ* Y
  - it is a relation with same heading as Cartesian Product of A and B and with a body consisting of the set of all those tuples belonging to that Cartesian Product of that evaluate true for **X *θ* Y**.
  - if ***θ*** is “equals”, the ***θ***-JOIN is called an EQUIJOIN.



Special Relational Operators

- θ- JOIN

A

ID	Name
S1	Ahmad
S2	Salman
S3	Karim

B

ID	Subject
S1	Math
S2	Urdu
S1	English

(A TIMES B) where IDA > IDB

IDA	Name	IDB	Subject
S2	Salman	S1	Math
S2	Salman	S1	English
S3	Karim	S1	Math
S3	Karim	S1	English
S3	Karim	S2	Urdu

(A TIMES B) where IDA = IDB

IDA	Name	IDB	Subject
S1	Ahmad	S1	Math
S1	Ahmad	S1	English
S2	Salman	S2	Urdu

Some more about Relational Operators

- Primitive Operators
  - **Union, Difference, Product, Restriction** and **Projection**
- Type Compatible Relations / UNION Compatible
- Three more operators
  - **RENAME**
  - **SUMMARIZE**
  - **EXTEND**