

CS245: Databases

SQL

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Table Operators

Binary Operator - Union

$$\begin{array}{|c|c|c|} \hline a1 & a2 & a3 \\ \hline 1 & 2 & 3 \\ \hline 4 & 5 & 6 \\ \hline \end{array} \cup \begin{array}{|c|c|c|} \hline b1 & b2 & b3 \\ \hline 1 & 2 & 3 \\ \hline 7 & 8 & 9 \\ \hline \end{array} = \begin{array}{|c|c|c|} \hline a1 & a2 & a3 \\ \hline 1 & 2 & 3 \\ \hline 4 & 5 & 6 \\ \hline 7 & 8 & 9 \\ \hline \end{array}$$

Union Compatibility

- Two tables should have identical number of columns
- Every column must have identical data type

Union - SQL Statement

The diagram illustrates the UNION operation on two tables, TableA and TableB. On the left, TableA is shown as a 3x3 grid with columns labeled a1, a2, a3 and rows containing values 1, 2, 3; 4, 5, 6; and 7, 8, 9 respectively. To its right is a large union symbol (U). To the right of the union symbol is TableB, also a 3x3 grid with columns b1, b2, b3 and rows containing values 1, 2, 3; 4, 5, 6; and 7, 8, 9 respectively. An equals sign follows TableB, indicating the result of the union. The resulting table on the right has columns a1, a2, a3 and rows 1, 2, 3; 4, 5, 6; and 7, 8, 9, reflecting the combined data from both tables.

a1	a2	a3
1	2	3
4	5	6

U

b1	b2	b3
1	2	3
7	8	9

=

a1	a2	a3
1	2	3
4	5	6
7	8	9

```
(SELECT a1 ,  a2 ,  a3 FROM TableA )  
UNION  
(SELECT b1 ,  b2 ,  b3 FROM TableB );
```

Union Computation - 01

Binary Operator - Union

$$A \cup B = \{ e \mid e \in A \text{ OR } e \in B \}$$

Binary Operator - Union

a1	a2	a3
1	2	3
4	5	6

\cup

b1	b2	b3
1	2	3
7	8	9

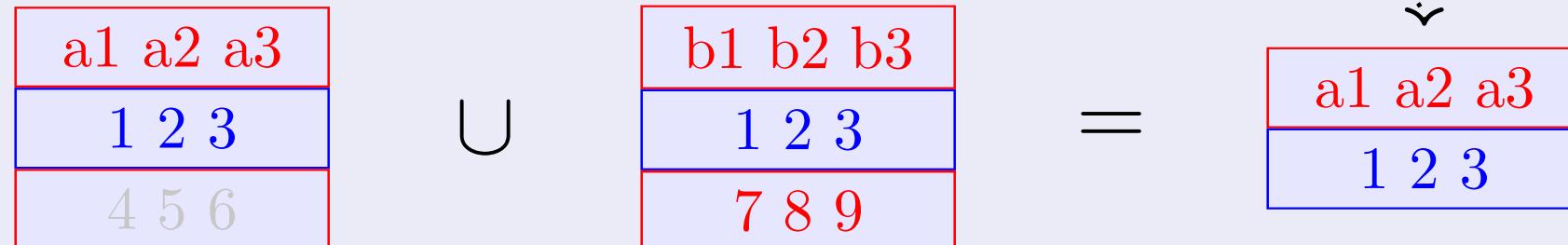
 =

Union Computation - 02

Binary Operator - Union

$$A \cup B = \{ e \mid e \in A \text{ OR } e \in B \}$$

Binary Operator - Union

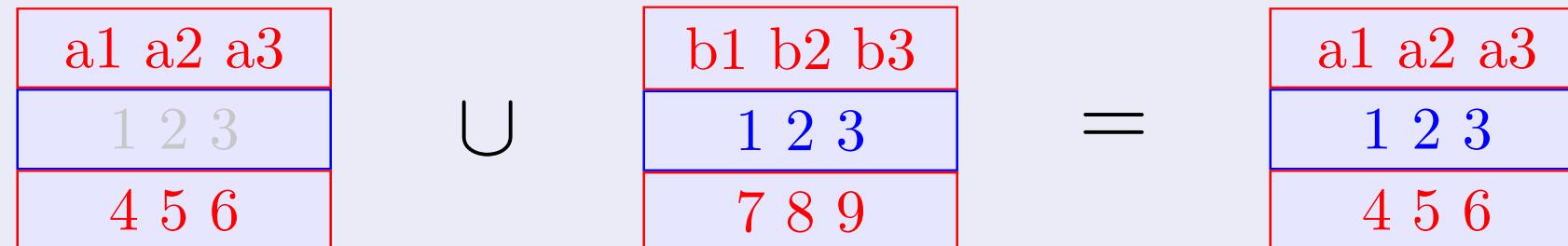


Union Computation - 03

Binary Operator - Union

$$A \cup B = \{ e \mid e \in A \text{ OR } e \in B \}$$

Binary Operator - Union

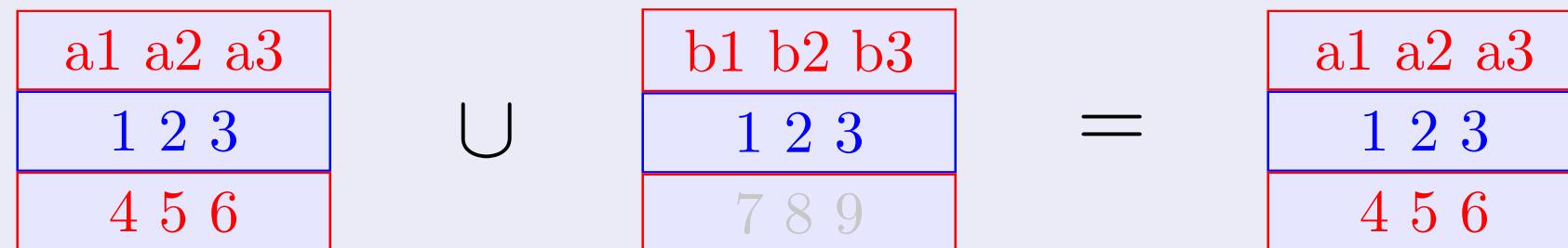


Union Computation - 04

Binary Operator - Union

$$A \cup B = \{ e \mid e \in A \text{ OR } e \in B \}$$

Binary Operator - Union



Binary Operator - Union

Include in the result table when explicitly stated to retain duplicates!

Union Computation - 05

Binary Operator - Union

$$A \cup B = \{ e \mid e \in A \text{ OR } e \in B \}$$

Binary Operator - Union

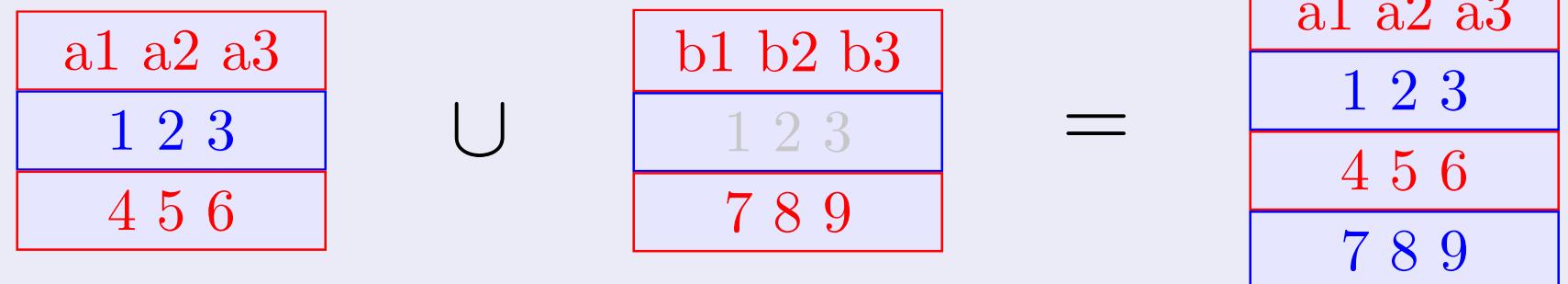
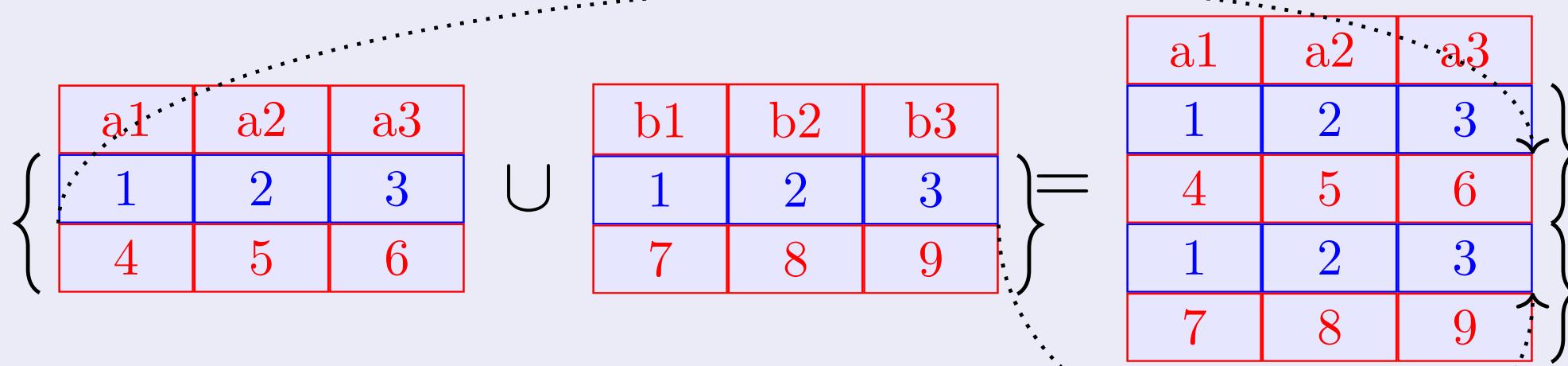


Table Operators

Binary Operator - Union Duplicates?



(SELECT a1 , a2 , a3 FROM TableA)

UNION ALL

(SELECT b1 , b2 , b3 FROM TableB);

Table Operators

Binary Operator - Union Duplicates?

a1	a2	a3
1	2	3
4	5	6
7	8	9

A

b1	b2	b3
1	2	3
4	5	6
7	8	9

B

a1	a2	a3
1	2	3
4	5	6
7	8	9
1	2	3
4	5	6
7	8	9

A B

Table Operators

Binary Operator - Union

a1	a2	a3
1	2	3
4	5	6

\cup

b1	b2	b3
AA	AB	AC
BB	BC	BD

= Error!

Union Compatibility

- Two tables should have identical number of columns
- Incompatible data types

Table Operators

Binary Operator - Union

a1	a2	a3
1	2	3
4	5	6

\cup

b1	b2	b3	b4
1	2	3	4
10	20	30	40

= Error!

Union Compatibility

- Two tables have different number of columns
- Every column must have identical data type

Table Operators

Binary Operator - Intersect

$$A \cap B = \{ e \mid e \in A \text{ AND } e \in B \}$$

Binary Operator - Intersection

a1	a2	a3
1	2	3
4	5	6

∩

b1	b2	b3
1	2	3
7	8	9

=

a1	a2	a3
1	2	3

Union Compatibility

- Two tables should have identical number of columns
- Every column must have identical data type

```
SELECT a1, a2, a3  
FROM TableA  
WHERE (a1, a2, a3)  
IN  
(SELECT b1, b2, b3 FROM Table B)
```

Table Operators

Binary Operator - Intersect

$$A \cap B = \{ e \mid e \in A \text{ AND } e \in B \}$$

Binary Operator - Intersection

b1	b2	b3
1	2	3
7	8	9

∩

a1	a2	a3
1	2	3
4	5	6

=

b1	b2	b3
1	2	3

Union Compatibility

- Two tables should have identical number of columns
- Every column must have identical data type

Table Operators

Binary Operator - Intersect

$$A \cap B = \{ e \mid e \in A \text{ AND } e \in B \}$$

Binary Operator - Intersect

The diagram illustrates the intersection of two tables, A and B. Table A has columns a1, a2, a3 and rows 1, 2, 3. Table B has columns b1, b2, b3 and rows 1, 2, 3. The intersection results in a new table with columns a1, a2, a3 and rows 1, 2, 3.

a1	a2	a3
1	2	3
4	5	6

∩

b1	b2	b3
1	2	3
7	8	9

=

a1	a2	a3
1	2	3

Binary Operator - Intersect testing

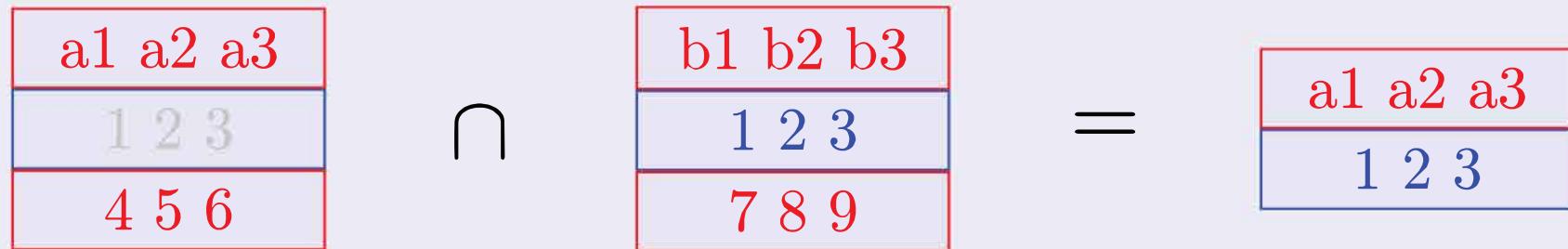
- $(a1 == b1) \text{ AND } (a2 == b2) \text{ AND } (a3 == b3)$?
- That is: $(1 == 1) \text{ AND } (2 == 2) \text{ AND } (3 == 3)$? Yes;
- Include first row of tableA in result table

Table Operators

Binary Operator - Intersect

$$A \cap B = \{ e \mid e \in A \text{ AND } e \in B \}$$

Binary Operator - Intersect



Binary Operator - Intersect testing

- $(a1 == b1) \text{ AND } (a2 == b2) \text{ AND } (a3 == b3)$?
- That is: $(4 == 1) \text{ AND } (5 == 2) \text{ AND } (6 == 3)$? No;
- Test next row of tableB
- That is: $(4 == 7) \text{ AND } (5 == 8) \text{ AND } (6 == 9)$? No;
- There are no row in tableB; Do not include (4, 5, 6) in result table

Table Operators

Binary Operator - Intersect

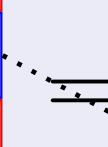
$$A \cap B = \{ e \mid e \in A \text{ AND } e \in B \}$$

Binary Operator - Intersection Duplicates?

a1	a2	a3
1	2	3
1	2	3
1	2	3
4	5	6



b1	b2	b3
1	2	3
4	5	6
7	8	9



a1	a2	a3
1	2	3

Table Operators

Binary Operator - Intersect

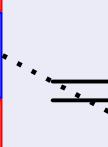
$$A \cap B = \{ e \mid e \in A \text{ AND } e \in B \}$$

Binary Operator - Intersection Duplicates?

a1	a2	a3
1	2	3
1	2	3
1	2	3
4	5	6



b1	b2	b3
1	2	3
4	5	6
7	8	9



a1	a2	a3
1	2	3

Table Operators

Binary Operator - Intersect

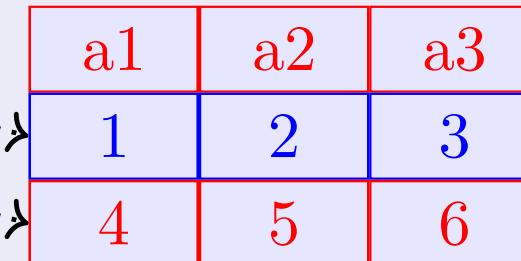
$$A \cap B = \{ e \mid e \in A \text{ AND } e \in B \}$$

Binary Operator - Intersection Duplicates?

a1	a2	a3
1	2	3
1	2	3
1	2	3
4	5	6



b1	b2	b3
1	2	3
4	5	6
7	8	9



The result of the intersection operation is shown in a table with two rows. The first row contains values 1, 2, and 3, which are identical to the first three rows of table A. The second row contains values 4, 5, and 6, which are identical to the last three rows of table A. This indicates that the intersection operation does not remove duplicates.

a1	a2	a3
1	2	3
4	5	6

Table Operators

Binary Operator - Intersect

$$A \cap B = \{ e \mid e \in A \text{ AND } e \in B \}$$

Binary Operator - Intersection

a1	a2	a3
1	2	3
4	5	6

$$\cap$$

b1	b2	b3
AA	AB	AC
BB	BC	BD

= Error!

Union Compatibility

- Two tables should have identical number of columns
- Incompatible data types

Table Operators

Binary Operator - Intersect

$$A \cap B = \{ e \mid e \in A \text{ AND } e \in B \}$$

Binary Operator - Intersection

a1	a2	a3
1	2	3
4	5	6

 \cap

b1	b2	b3	b4
1	2	3	4
10	20	30	40

= Error!

Union Compatibility

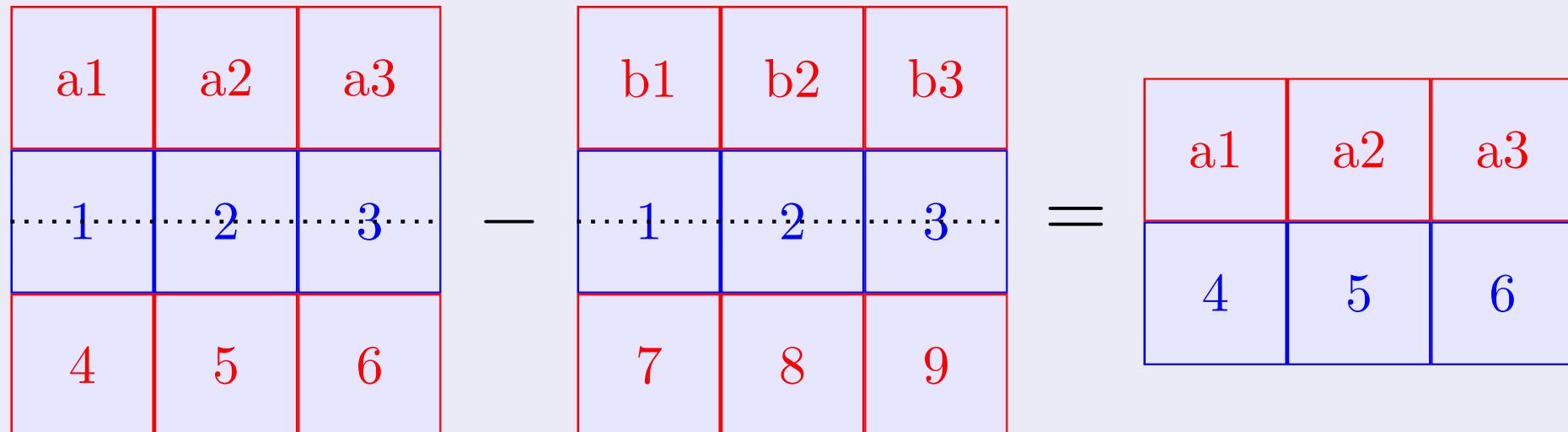
- Two tables have different number of columns
- Every column must have identical data type

Table Operators

Binary Operator - Difference

$$A - B = \{ e \mid e \in A \text{ AND } e \notin B \}$$

Binary Operator - Difference



Union Compatibility

- Two tables should have identical number of columns
- Every column must have identical data type

Table Operators

Binary Operator - Difference

The diagram illustrates the difference operation between two tables, b and a . The result is a new table $b - a$.

Table b (left) has columns $b1$, $b2$, and $b3$. Its rows are $(1, 2, 3)$ and $(7, 8, 9)$.

Table a (middle) has columns $a1$, $a2$, and $a3$. Its rows are $(1, 2, 3)$ and $(4, 5, 6)$.

The result of $b - a$ (right) is a table with columns $b1$, $b2$, and $b3$. Its rows are $(7, 8, 9)$.

b1	b2	b3
1	2	3
7	8	9

a1	a2	a3
1	2	3
4	5	6

b1	b2	b3
7	8	9

Union Compatibility

- Two tables should have identical number of columns
- Every column must have identical data type

Table Operators

Binary Operator - Difference

$$A - B = \{ e \mid e \in A \text{ AND } e \notin B \}$$

Binary Operator - Difference

a1	a2	a3
1	2	3
4	5	6

—

b1	b2	b3
1	2	3
7	8	9

=

a1	a2	a3
4	5	6

```
SELECT a1 , a2 , a3  
FROM TableA  
WHERE ( a1 , a2 , a3 )  
NOT IN  
(SELECT b1 , b2 , b3 FROM TableB );
```

Table Operators

Binary Operator - Difference Duplicates?

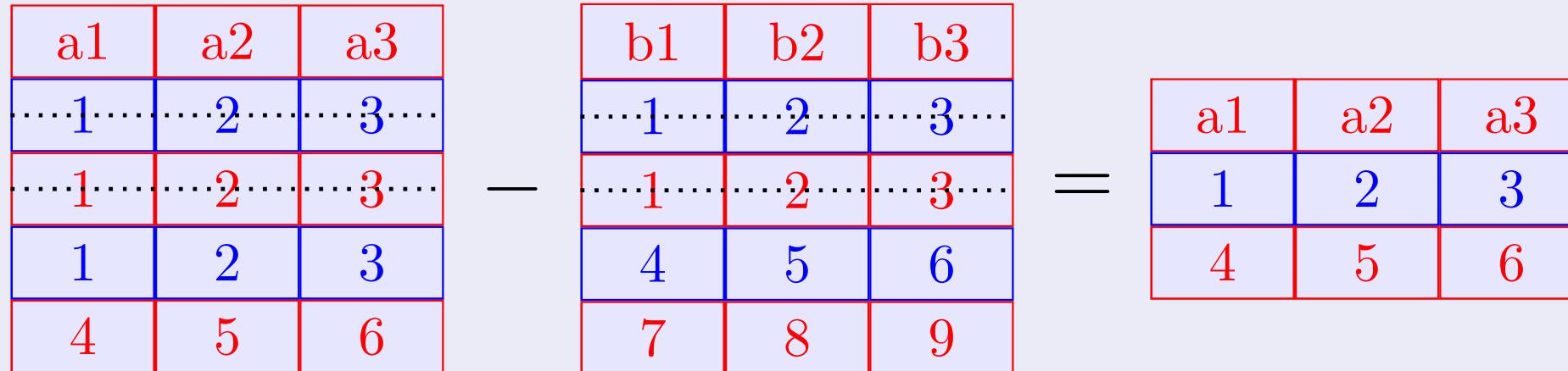


Table Operators

Binary Operator - Difference

a1	a2	a3
1	2	3
4	5	6

—

b1	b2	b3
AA	AB	AC
BB	BC	BD

= Error!

Union Compatibility

- Two tables should have identical number of columns
- Incompatible data types

Table Operators

Binary Operator - Difference

a1	a2	a3	
1	2	3	-
4	5	6	
b1	b2	b3	b4
1	2	3	4
10	20	30	40

= Error!

Union Compatibility

- Two tables have different number of columns
- Every column must have identical data type

Table operators summary of definitions

Union of involving duplicates

- Let a row $t \in R$ appears n times
- Let $t \in S$ appears m times
- $t \in (R \cup S)$ appears $(n + m)$ times

Intersection involving duplicates

- Let a row $t \in R$ appears n times
- Let $t \in S$ appears m times
- $t \in (R \cap S)$ appears $\min(n, m)$ times

Difference involving duplicates

- Let a row $t \in R$ appears n times
- Let $t \in S$ appears m times
- $t \in (R - S)$ appears $\max(0, (n - m))$ times

SQL Statements Summary - Union

- Union (Distinct rows)

```
(SELECT a1 , a2 , a3 FROM TableA )  
    UNION  
(SELECT b1 , b2 , b3 FROM TableB );
```

- Union (Retain Duplicates)

```
(SELECT a1 , a2 , a3 FROM TableA )  
    UNION ALL  
(SELECT b1 , b2 , b3 FROM TableB );
```

SQL Statements Summary - Intersection

- Intersection (Distinct rows)

```
SELECT DISTINCT a1 , a2 , a3  
FROM   TableA  
WHERE  ( a1 , a2 , a3 )  
IN  
(SELECT b1 , b2 , b3 FROM TableB );
```

- Intersection (Retain Duplicates)

```
SELECT a1 , a2 , a3  
FROM   TableA  
WHERE  ( a1 , a2 , a3 )  
IN  
(SELECT b1 , b2 , b3 FROM TableB );
```

SQL Statements Summary - Difference

- Difference (Distinct)

```
SELECT DISTINCT a1 , a2 , a3  
FROM   TableA  
WHERE  ( a1 , a2 , a3 )  
NOT IN  
(SELECT b1 , b2 , b3 FROM TableB );
```

- Difference (Retain Duplicates)

```
SELECT a1 , a2 , a3  
FROM   TableA  
WHERE  ( a1 , a2 , a3 )  
NOT IN  
(SELECT b1 , b2 , b3 FROM TableB );
```

Set Comparison Operators

Operators

IN a given attribute is a member of a specified set

EXISTS given set is nonempty or not

op ANY with example

op ALL with example

ANY operator

Example

- Find sid's whose rating is better than some sailor named Horatio
- Inner query results a set of ratings of Horatios' say {3, 5, 7, 9}
- Every row of outer query is examined with the obtained set.
- If the rating is $> \text{ANY}$ from the set {3, 5, 7, 9} then the row will be part of the output relation
- That is the one row from S1 and its corresponding rating is, say, 4 and the sailor name is, say, Art.
- $4 > \text{ANY } \{3, 5, 7, 9\}$ condition satisfies and Art is included in the result table

```
SELECT S1.sname
FROM   Sailors AS S1
WHERE  S1.rating > ANY (
    SELECT S2.rating
    FROM   Sailors AS S2
    WHERE  S2.name = 'Horatio')
```

ALL operator

Example

- Find the sid's with highest rating
- Inner query results a set of ratings from Sailors say {7, 1, 8, 8, 10, 7, 10, 9, 3, 3}
- Every row of outer query is examined with the obtained set.
- If the rating is \geq ALL of the ratings in {7, 1, 8, 8, 10, 7, 10, 9, 3, 3} then the row will be part of the output relation

```
SELECT S.sid
FROM   Sailors AS S
WHERE  S.rating >= ALL (
    SELECT S2.rating
    FROM   Sailors AS S2)
```

Pit falls

- Find name and age of oldest sailor
- Intent is to find maximum age of a sailor and his/her name
- Use of MAX along with other attributes in a relation may not make sense
- The following query is illegal

```
SELECT S.sname, MAX(S.age)
FROM   Sailors AS S;
```

Altenate query formulation

Alternate query

- Aggregation operation result in a relation
- = in where clause is being compared with a relation
- SQL converts it to a single value
- This query is still legal and yields the correct output

```
SELECT S.sname, S.age
FROM   Sailors AS S
WHERE  S.age =
       (SELECT MAX(S2.age)
        FROM  Sailors AS S2);
```