CS2102

Tutorial 01

Question 12 A

- **Superkeys:** subset of attributes in a relation that *uniquely identifies* its tuples
  - No two distinct tuples of relation have the same values in all attributes of superkey
  - Finding superkey?
    - By enumeration, then
    - By process of elimination

Question 12 A

- **Superkeys:** subset of attributes in a relation that *uniquely identifies* its tuples
  - No two distinct tuples of relation have the same values in all attributes of superkey
  - Finding superkey?
    - By enumeration, then
    - By process of elimination
- **Example:**
  - {A}

R

A	B	C	D
3	0	0	1
2	1	2	0
1	1	2	0
0	0	1	2

Question 12 A

- **Superkeys:** subset of attributes in a relation that ***uniquely identifies*** its tuples
  - No two distinct tuples of relation have the same values in all attributes of superkey
  - Finding superkey?
    - By enumeration, then
    - By process of elimination
- **Example:**
  - {A}
    - do not violate any superkey property

R

A	B	C	D
3	0	0	1
2	1	2	0
1	1	2	0
0	0	1	2

Question 10 A

- **Superkeys:** subset of attributes in a relation that *uniquely identifies* its tuples
  - No two distinct tuples of relation have the same values in all attributes of superkey
  - Finding superkey?
    - By enumeration, then
    - By process of elimination
- **Example:**
  - {B}

R

A	B	C	D
3	0	0	1
2	1	2	0
1	1	2	0
0	0	1	2

Question 12 A

- **Superkeys:** subset of attributes in a relation that ***uniquely identifies*** its tuples
  - No two distinct tuples of relation have the same values in all attributes of superkey
  - Finding superkey?
    - By enumeration, then
    - By process of elimination
- **Example:**
  - {B}
    - (**2**,*1*,2,0) and (**1**,*1*,2,0) violates superkey property

R

A	B	C	D
3	0	0	1
2	1	2	0
1	1	2	0
0	0	1	2

Question 12 A

- **Solution:**
  - Continuing the process, we get the following combinations of attributes
    - {A} {B} {C} {D}
    - {A,B} {A,C} {A,D} {B,C} {B,D} {C,D}
    - {A,B,C} {A,B,D} {A,C,D} {B,C,D}
    - {A,B,C,D}

R

A	B	C	D
3	0	0	1
2	1	2	0
1	1	2	0
0	0	1	2

Question 10 A

- **Solution:**
  - Continuing the process, we get the following combinations of attributes
    - {A} {B} {C} {D}
    - {A,B} {A,C} {A,D} {B,C} {B,D} {C,D}
    - {A,B,C} {A,B,D} {A,C,D} {B,C,D}
    - {A,B,C,D}
  - Only the combinations above are *possible* superkeys

R

A	B	C	D
3	0	0	1
2	1	2	0
1	1	2	0
0	0	1	2

Question 12 A

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  - Continuing the process, we get the following combinations of attributes
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    - {A,B} {A,C} {A,D} {B,C} {B,D} {C,D}
    - {A,B,C} {A,B,D} {A,C,D} {B,C,D}
    - {A,B,C,D}
  - How many combinations in total?
    - $2^n - 1$ where n is the number of attributes
    - *Can we not check them all?*

R

A	B	C	D
3	0	0	1
2	1	2	0
1	1	2	0
0	0	1	2

Question 12 A

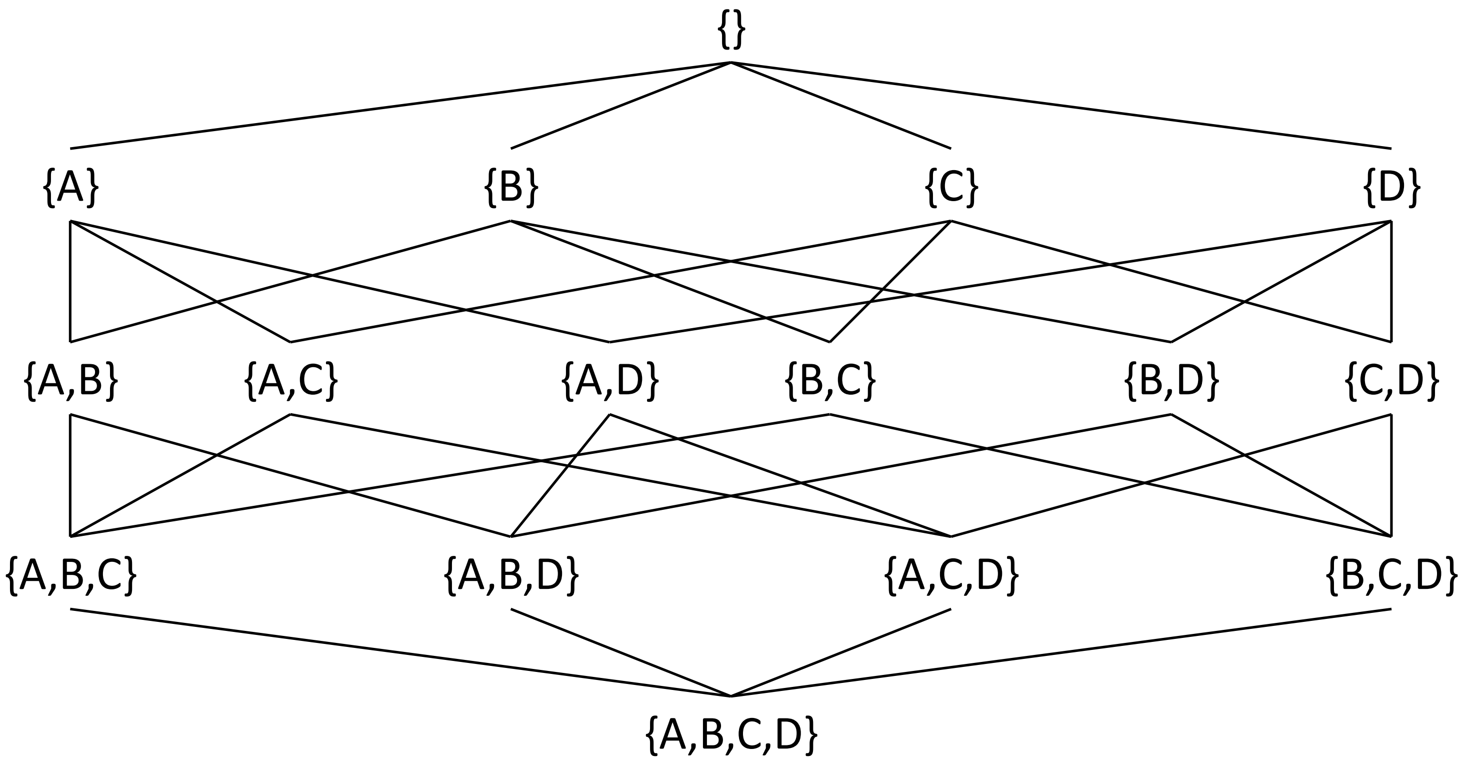
- **Solution:**
  - Continuing the process, we get the following combinations of attributes
    - {A} {B} {C} {D}
    - {A,B} {A,C} {A,D} {B,C} {B,D} {C,D}
    - {A,B,C} {A,B,D} {A,C,D} {B,C,D}
    - {A,B,C,D}
  - How many combinations in total?
    - $2^n - 1$ where n is the number of attributes
    - *Can we not check them all?*

R

A	B	C	D
3	0	0	1
2	1	2	0
1	1	2	0
0	0	1	2

Question 12 A

- **Improvement:**
  - Arrange the attributes as a *subset* of other attributes

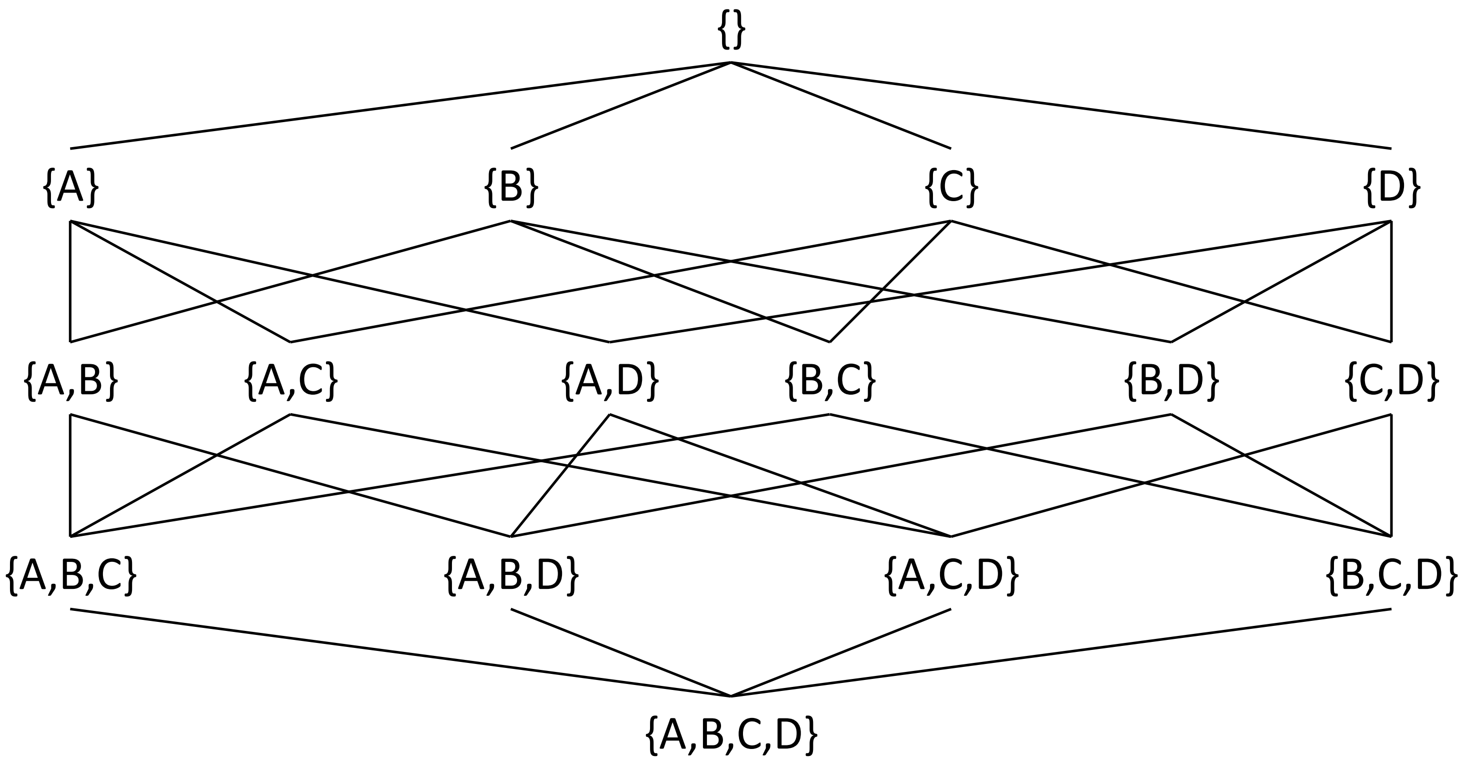


R

A	B	C	D
3	0	0	1
2	1	2	0
1	1	2	0
0	0	1	2

Question 12 A

- **Improvement:**
  - Check from top to bottom

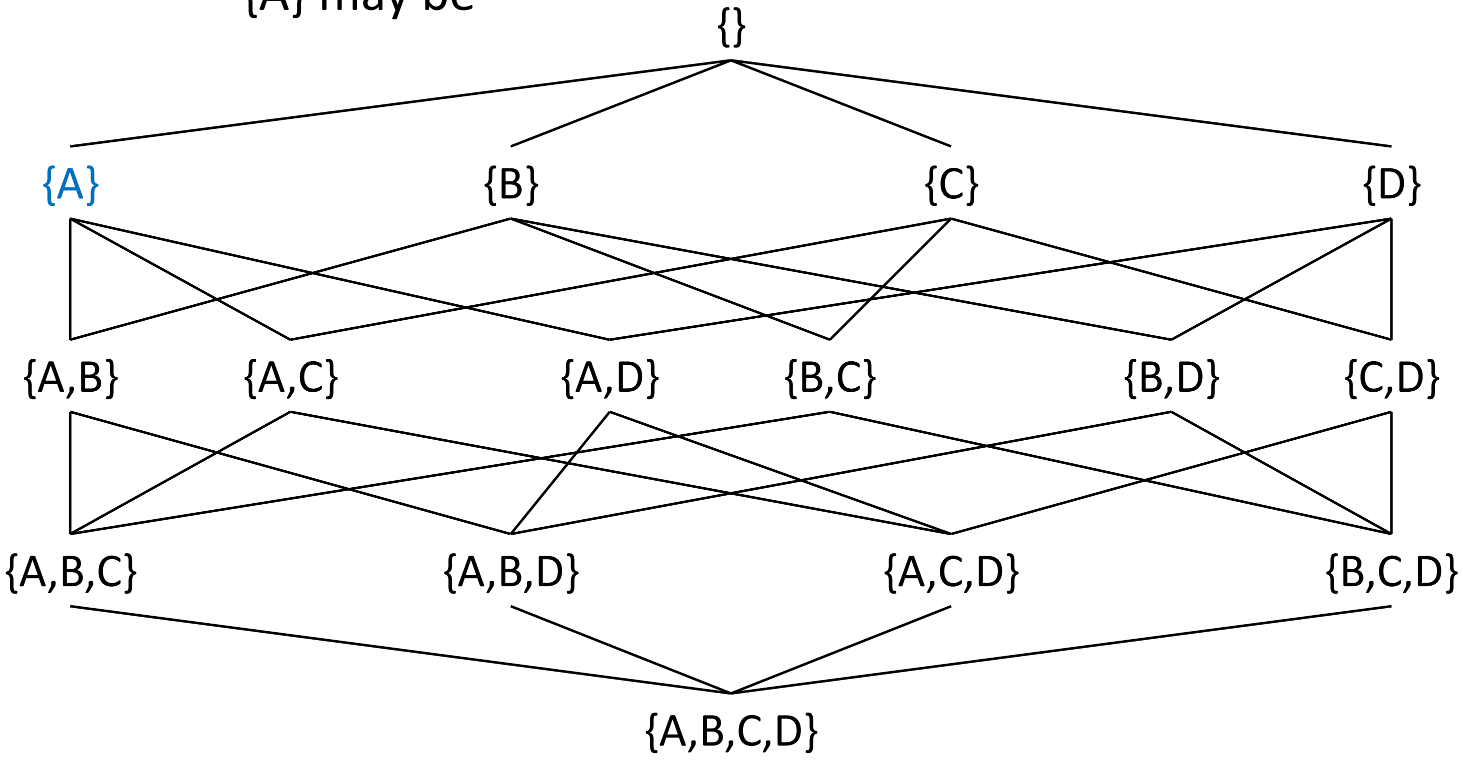


R

A	B	C	D
3	0	0	1
2	1	2	0
1	1	2	0
0	0	1	2

Question 12 A

- **Improvement:**
  - Check from top to bottom
    - {A} may be

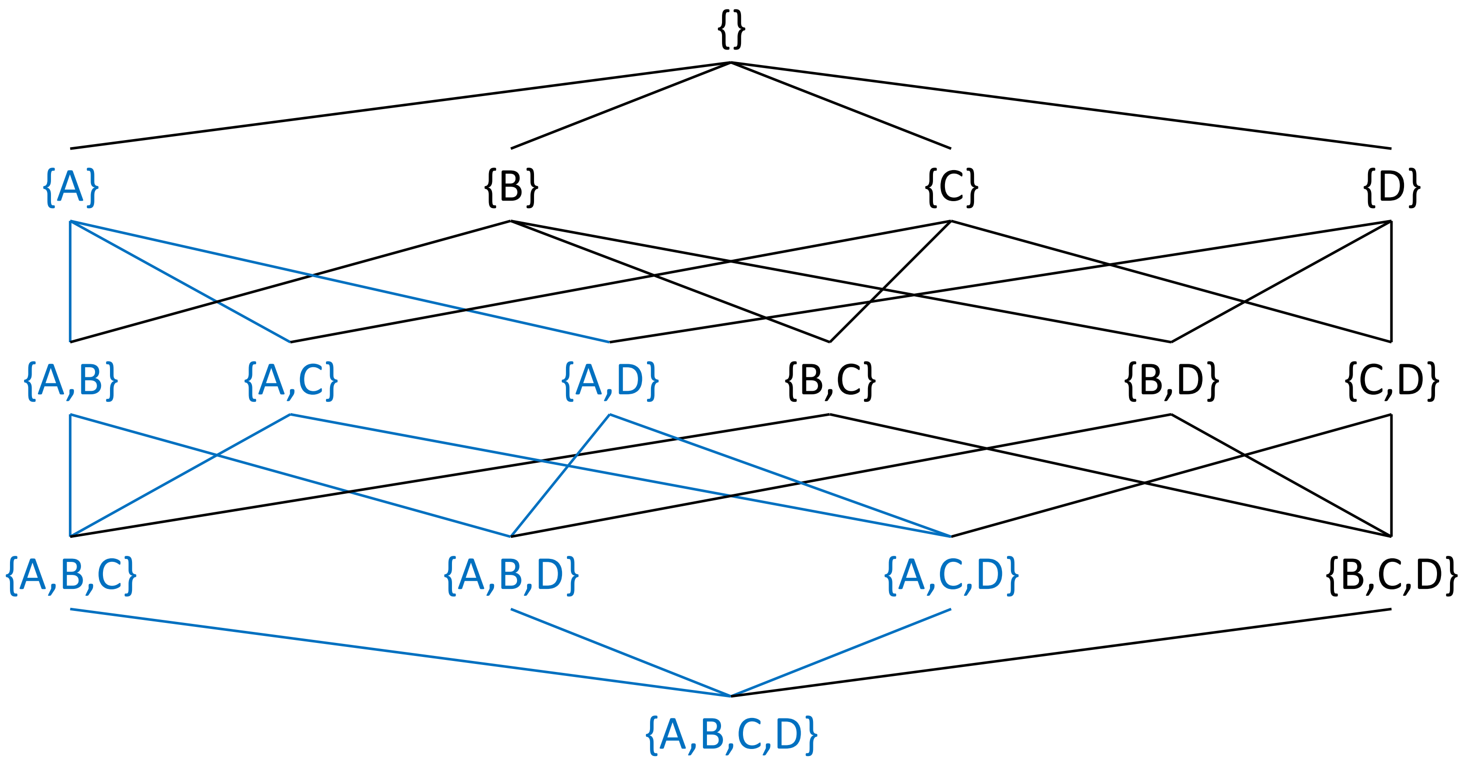


R

A	B	C	D
3	0	0	1
2	1	2	0
1	1	2	0
0	0	1	2

Question 12 A

- **Improvement:**
  - Anything set that includes {A} may be a superkey!

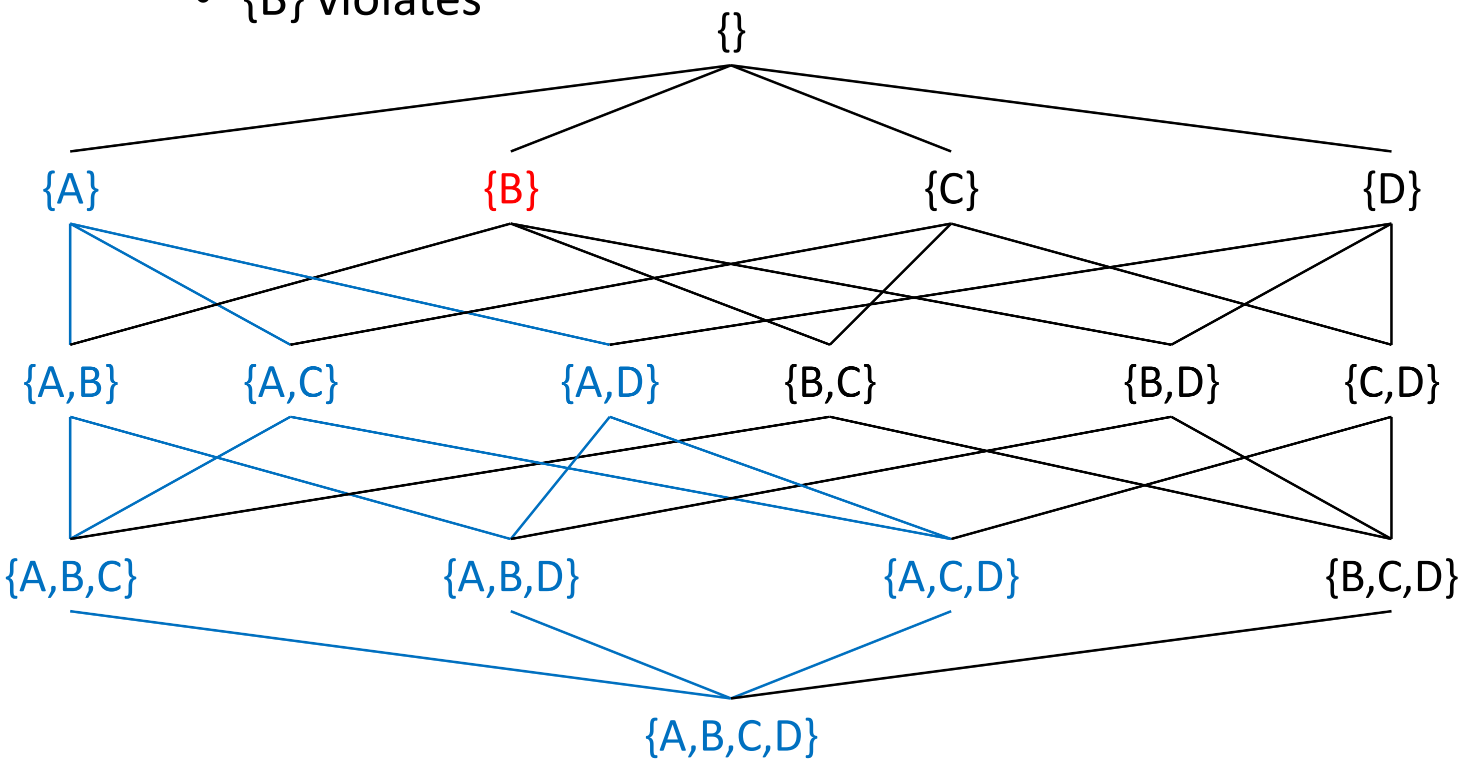


R

A	B	C	D
3	0	0	1
2	1	2	0
1	1	2	0
0	0	1	2

Question 12 A

- **Improvement:**
  - Check from top to bottom
    - {B} violates

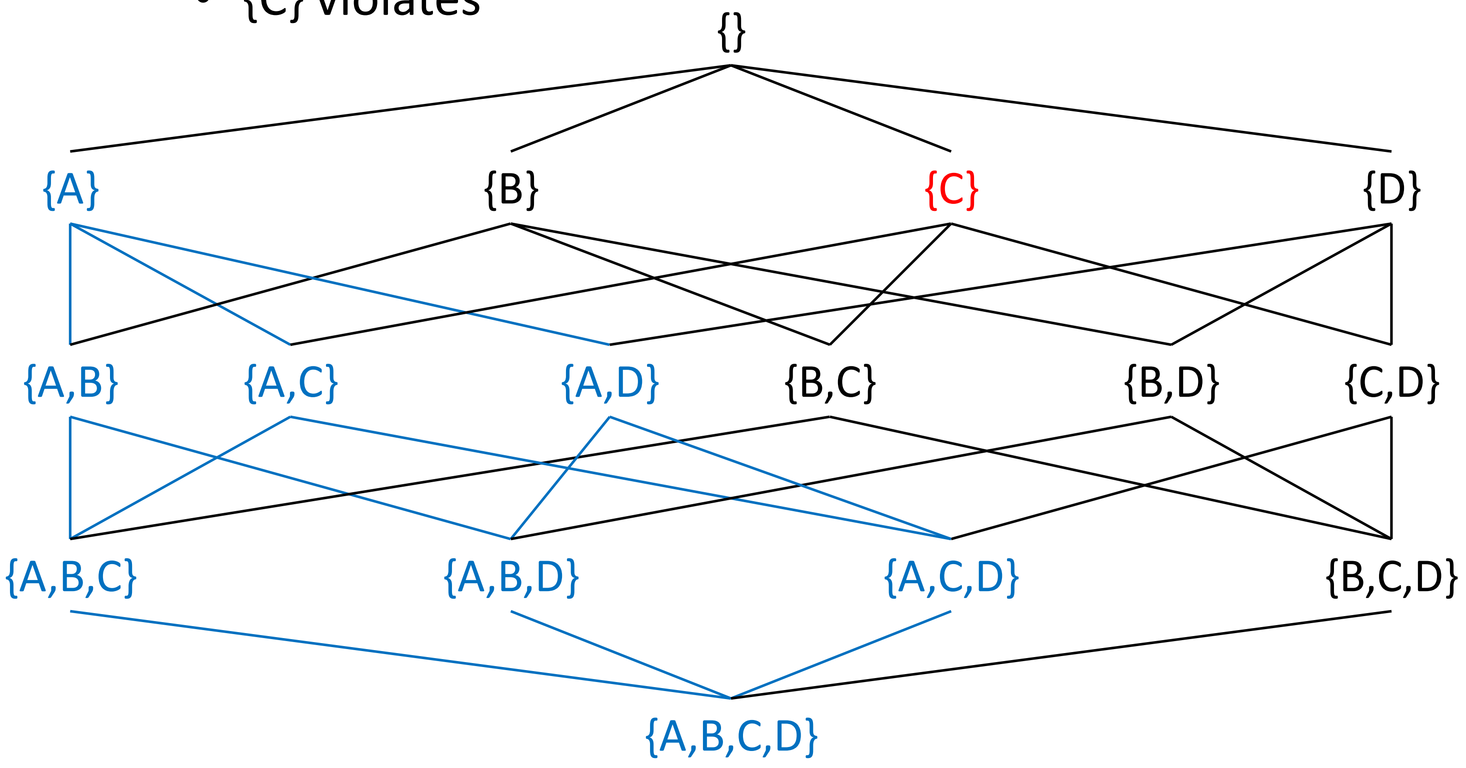


R

A	B	C	D
3	0	0	1
2	1	2	0
1	1	2	0
0	0	1	2

Question 12 A

- **Improvement:**
  - Check from top to bottom
    - {C} violates

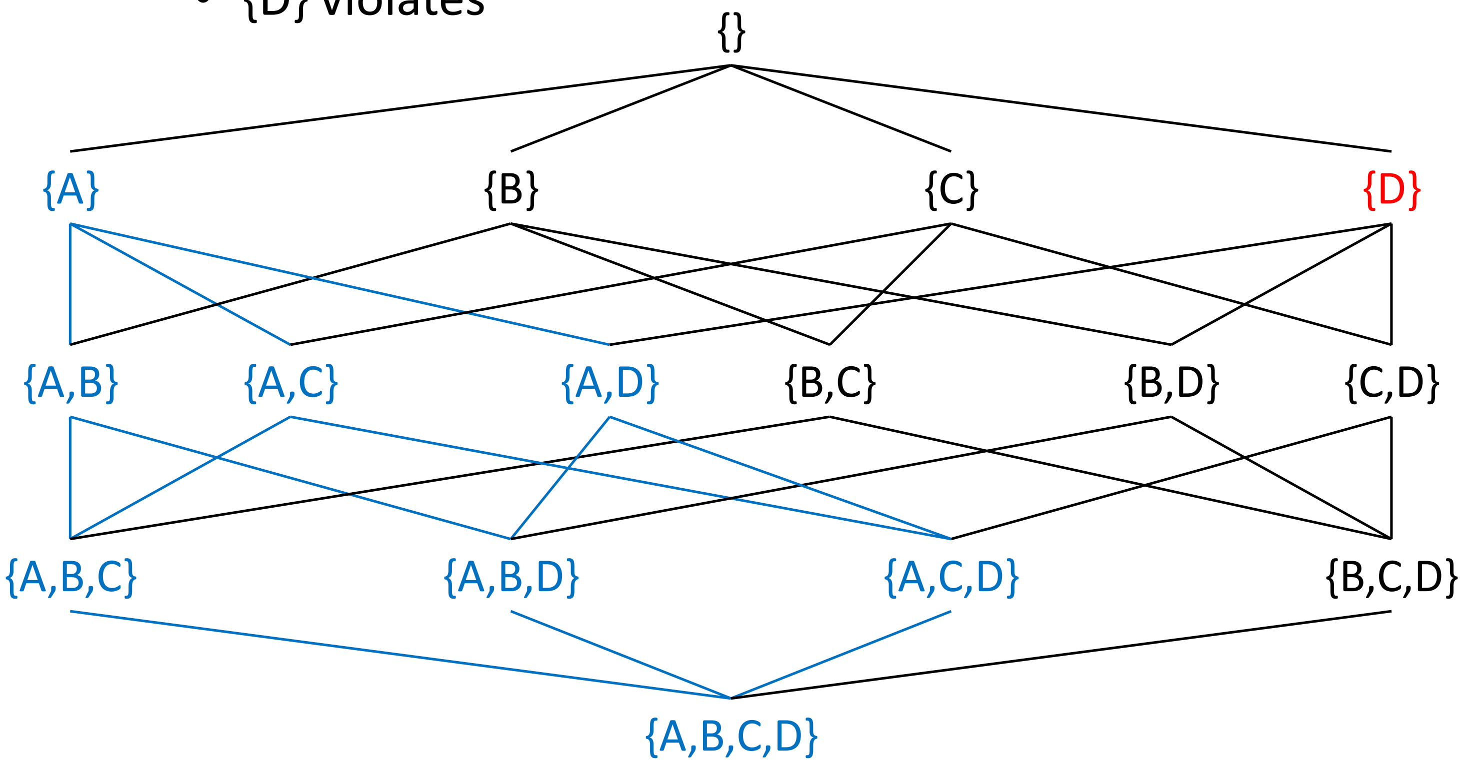


R

A	B	C	D
3	0	0	1
2	1	2	0
1	1	2	0
0	0	1	2

Question 12 A

- **Improvement:**
  - Check from top to bottom
    - {D} violates

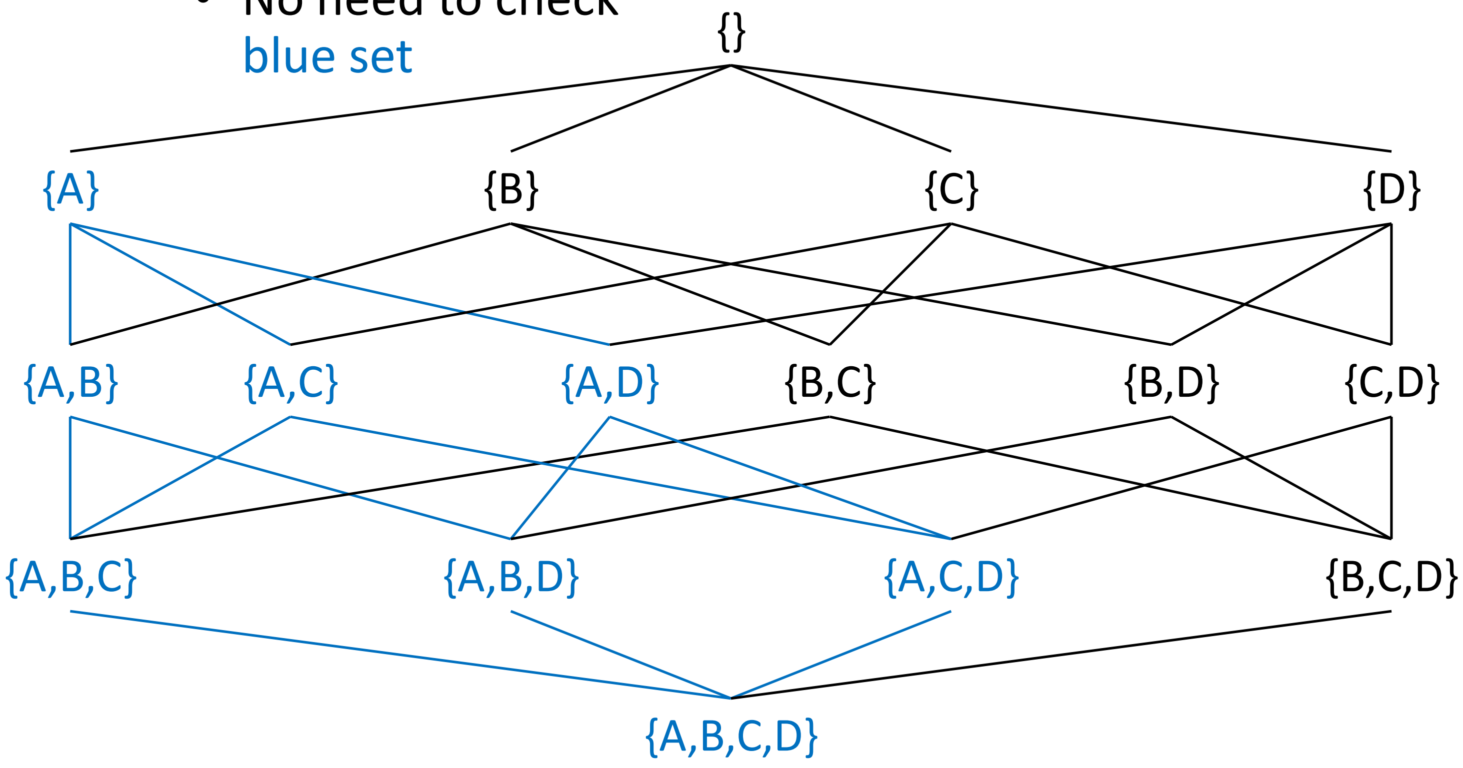


R

A	B	C	D
3	0	0	1
2	1	2	0
1	1	2	0
0	0	1	2

Question 12 A

- **Improvement:**
  - Check from top to bottom (*at second level*)
    - No need to check blue set

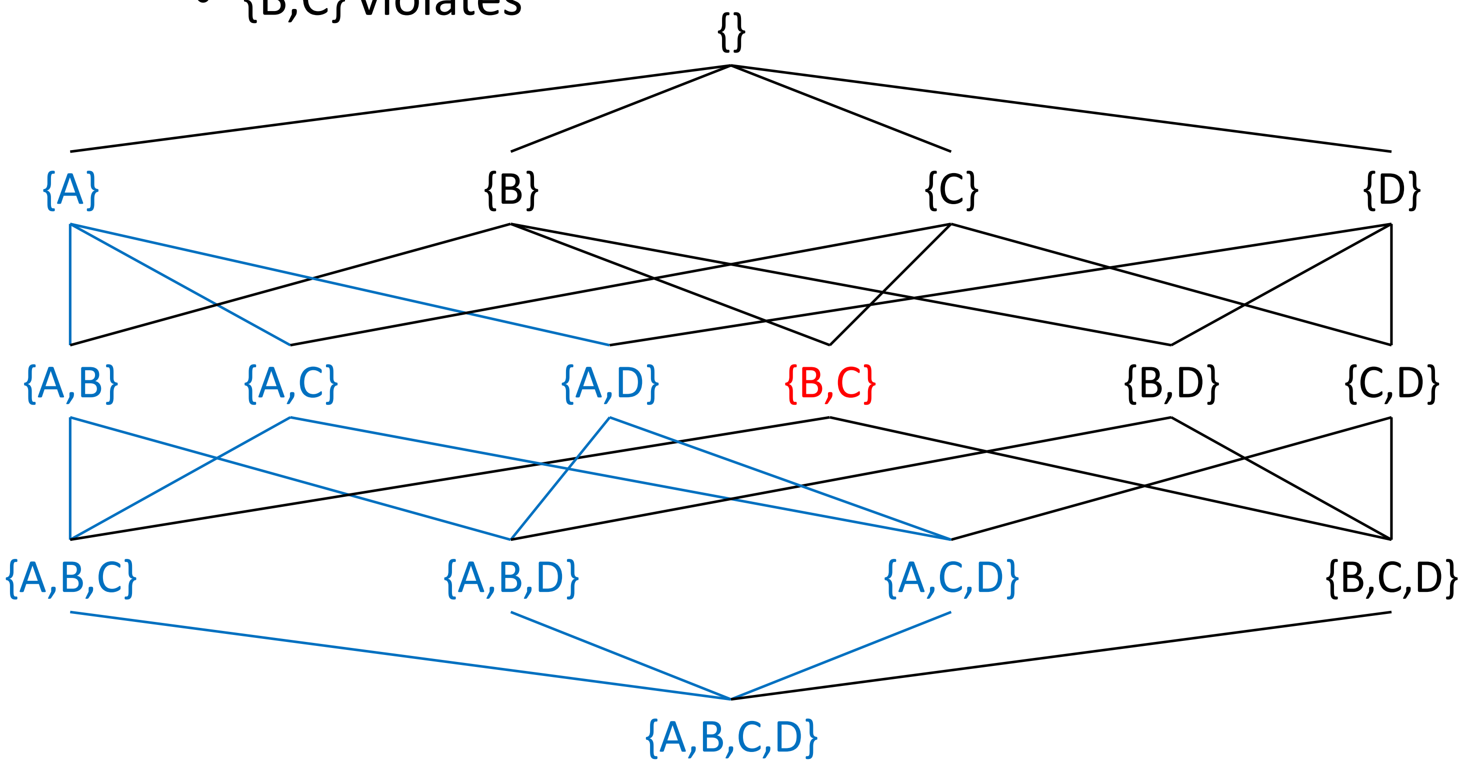


R

A	B	C	D
3	0	0	1
2	1	2	0
1	1	2	0
0	0	1	2

Question 12 A

- **Improvement:**
  - Check from top to bottom (*at second level*)
    - {B,C} violates

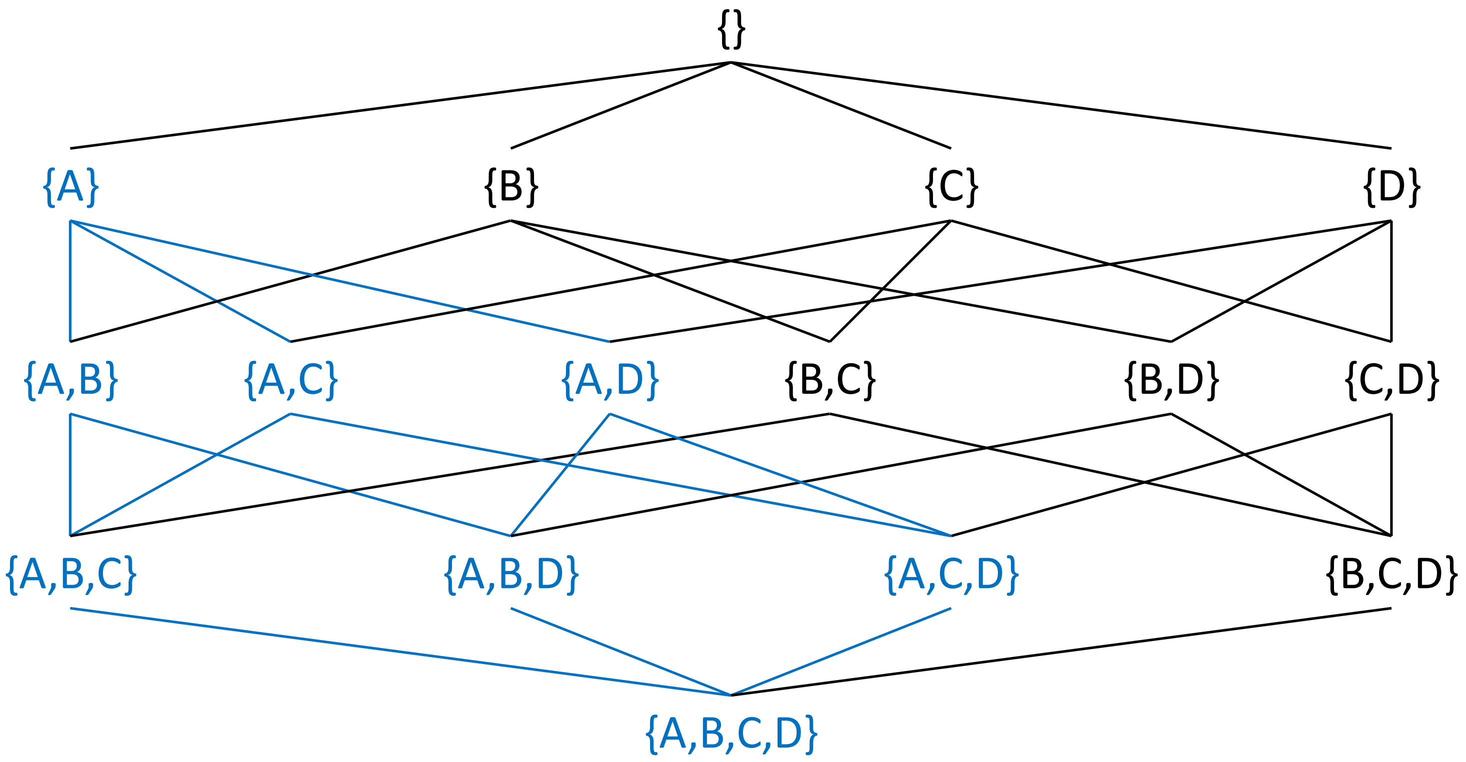


R

A	B	C	D
3	0	0	1
2	1	2	0
1	1	2	0
0	0	1	2

Question 12 B

- **Candidate keys:** superkey that is *non-null* & *no proper subset* of a key is a superkey

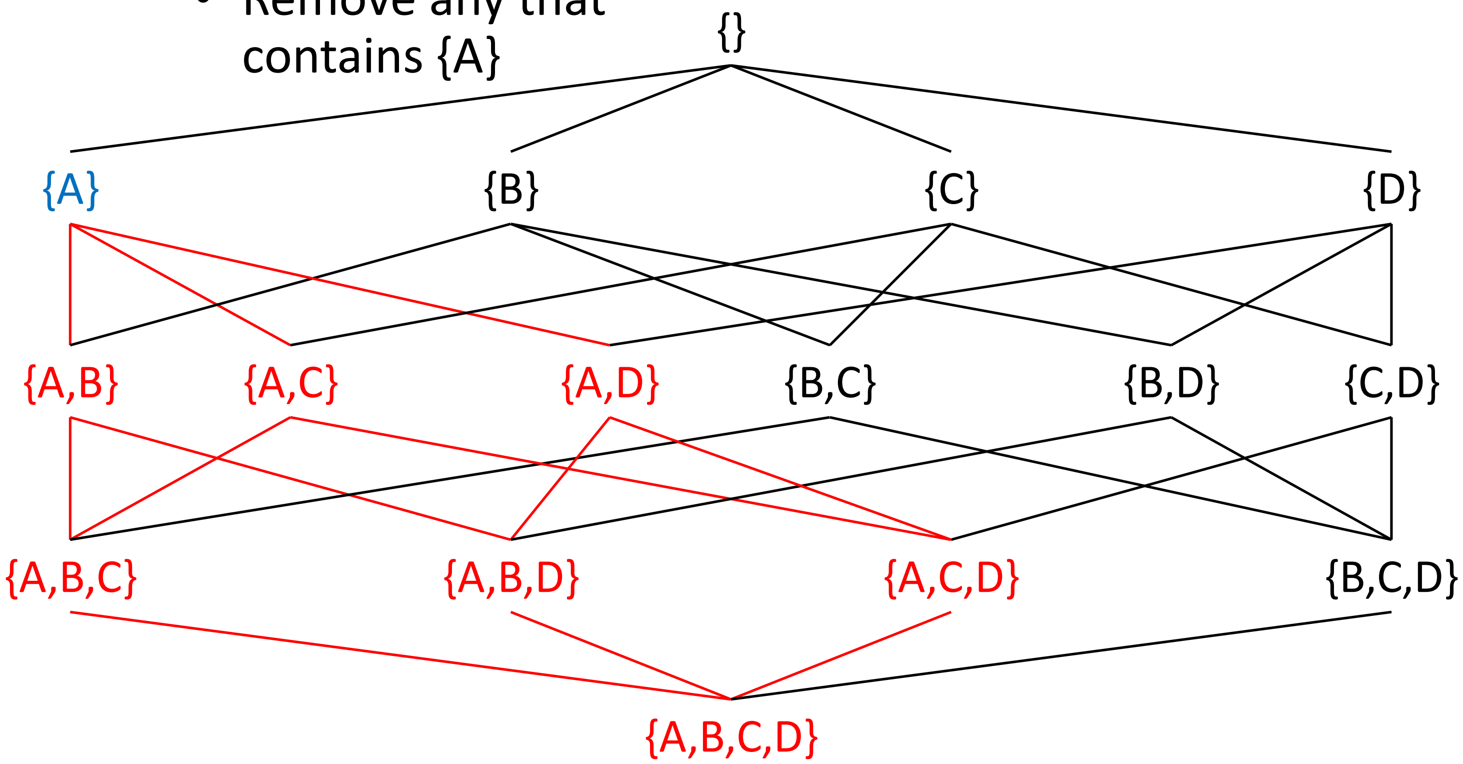


R

A	B	C	D
3	0	0	1
2	1	2	0
1	1	2	0
0	0	1	2

Question 12 B

- **Candidate keys**
  - We can do top-down approach again, but now remove any superset
    - Remove any that contains {A}

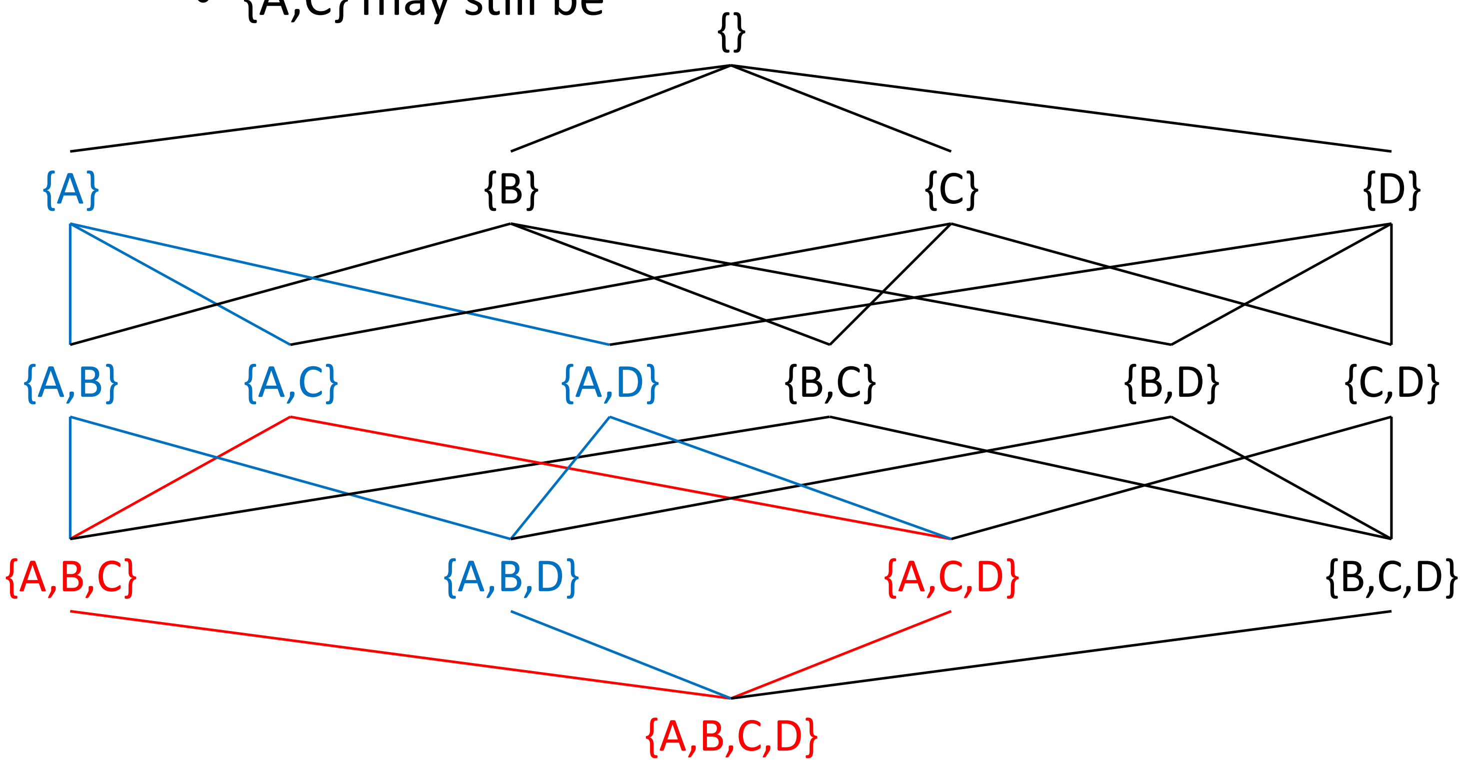


R

A	B	C	D
3	0	0	1
2	1	2	0
1	1	2	0
0	0	1	2

Question 12 B

- **Candidate keys**
  - But, {A} may NOT be an actual superkey, it is only a possible superkey
    - {A,C} may still be

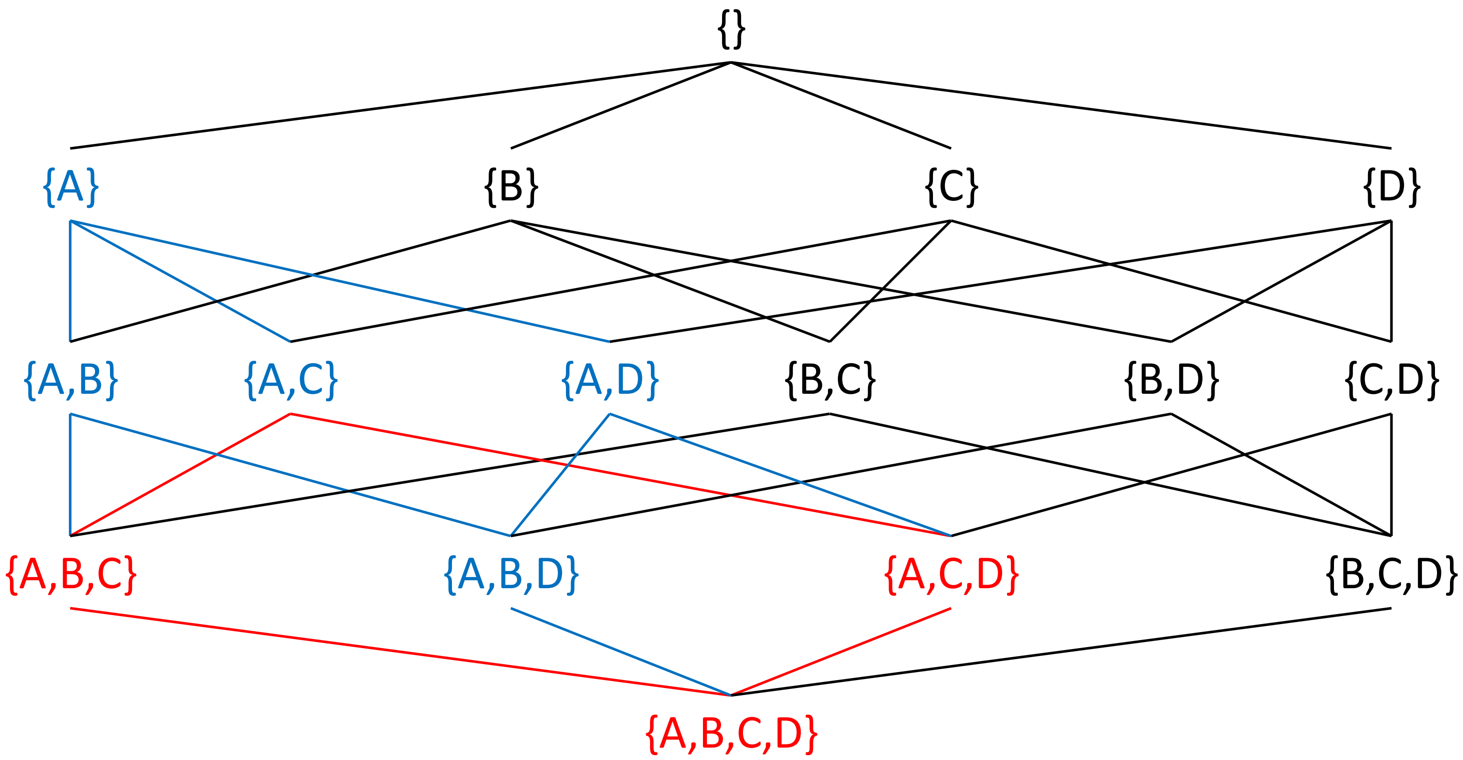


R

A	B	C	D
3	0	0	1
2	1	2	0
1	1	2	0
0	0	1	2

Question 12 B

- **Candidate keys**
  - So the *possible* candidate keys are those in blue



R

A	B	C	D
3	0	0	1
2	1	2	0
1	1	2	0
0	0	1	2

Question 13

- **Foreign key:** either *null* or appear as *primary key* in a referenced relation
  - Finding foreign key?
    - Check every attribute and eliminate violations

r

A	B
3	0
2	1
1	1
0	0

s

W	X	Y	Z
0	4	0	null
1	Null	2	null
2	1	2	null
3	0	1	null

Question 13

- **Foreign key:** either *null* or appear as *primary key* in a referenced relation
  - Finding foreign key?
    - Check every attribute and eliminate violations
- **Example:**
  - W No violation
  - X
  - Y
  - Z

r

A	B
3	0
2	1
1	1
0	0

s

W	X	Y	Z
0	4	0	null
1	Null	2	null
2	1	2	null
3	0	1	null

Question 13

- **Foreign key:** either *null* or appear as *primary key* in a referenced relation
  - Finding foreign key?
    - Check every attribute and eliminate violations
- **Example:**
  - W No violation
  - X 4 does not appear in r.A
  - Y
  - Z

r

A	B
3	0
2	1
1	1
0	0

s

W	X	Y	Z
0	4	0	null
1	Null	2	null
2	1	2	null
3	0	1	null

Question 13

- **Foreign key:** either *null* or appear as *primary key* in a referenced relation
  - Finding foreign key?
    - Check every attribute and eliminate violations
- **Example:**
  - W   No violation
  - X   4 does not appear in r.A
  - Y   No violation
  - Z

r

A	B
3	0
2	1
1	1
0	0

s

W	X	Y	Z
0	4	0	null
1	Null	2	null
2	1	2	null
3	0	1	null

Question 13

- **Foreign key:** either *null* or appear as *primary key* in a referenced relation
  - Finding foreign key?
    - Check every attribute and eliminate violations
- **Example:**
  - W   No violation
  - X   4 does not appear in r.A
  - Y   No violation
  - Z   No violation (all null)

r

A	B
3	0
2	1
1	1
0	0

s

W	X	Y	Z
0	4	0	null
1	Null	2	null
2	1	2	null
3	0	1	null

Question 14

- **Equivalent queries:** for every legal instance *d* of *D*, both Q_1 and Q_2 compute the same results on *d*
  - In general, no specific way to check
  - You can use certain property to help find violations/guide your thinking
- **Examples:**
  - Set difference is non-commutative $R - S \neq S - R$
  - Projection removes duplicates
    - Subsequent operations may be affected by this removal of duplicates
  - Operation must be valid
    - Union-compatible
    - The attribute referred must exists

Question 14

a) Equivalent
   - σ removes rows; π removes columns; in the end only the valid cells remain

b) Not equivalent
   - Q_2 refers to non-existent attributes; hence invalid

c) Equivalent
   - For both Q_1 and Q_2, we have D as first column and Y as second column

d) Equivalent
   - π will re-order the columns to be the same

Question 14

e) Equivalent

- This cross-product is associative due to the tuple being “merged”. Normally, cross-product are non-associative in other algebra (like set algebra.

f) Equivalent

- Union before or after projection does not change the order. Duplicates will be removed either way.

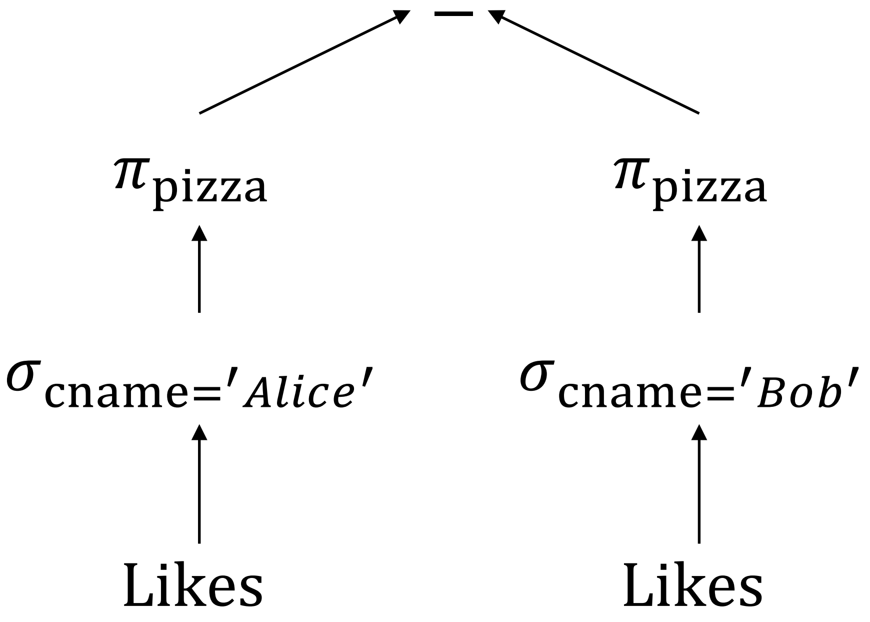
g) Not equivalent

- Let $r = \{(10,10)\}$ and $s = \{(10,20)\}$
- $Q_1 = \pi_A(\{(10,10)\} - \{(10,20)\}) = \pi_A(\{(10,10)\}) = \{(10)\}$
- $Q_2 = \pi_A(\{(10,10)\}) - \pi_A(\{(10,20)\}) = \{(10)\} - \{(10)\} = \emptyset$

Question 15

a) Find pizza that Alice likes but Bob does not like

- Let P_1 be the pizza Alice likes
- Let P_2 be the pizza Bob likes
- Then result is $P_1 - P_2$
- $P_1 = \pi_{\text{pizza}}\left(\sigma_{\text{cname}='\text{Alice}'}(\text{Likes})\right)$
- $P_2 = \pi_{\text{pizza}}\left(\sigma_{\text{cname}='\text{Bob}'}(\text{Likes})\right)$



Question 15

b) Find all customer-restaurant pairs (C,R) where `C` and `R` are both located in the same area, and C likes some pizza that is sold by R.

- To find out location of C
  - `Customers` table
- To find out location of R
  - `Restaurants` table
- To find out what R sells
  - `Sells` table
- To find out what C likes
  - `Likes` table

$\text{Customers} \times \text{Restaurants} \times \text{Sells} \times \text{Likes}$
But need renaming to make sure the columns all have unique names

Question 15

b) Find all customer-restaurant pairs (C,R) where C and R are both located in the same area, and C likes some pizza that is sold by R.

- To find out location of C
  - `Customers` table
- To find out location of R
  - `Restaurants` table
- To find out what R sells
  - `Sells` table
- To find out what C likes
  - `Likes` table

$$\rho_{(\mathrm{n}_1,\mathrm{a}_1)}(\mathrm{Customers}) \\ \times \\ \rho_{(\mathrm{n}_2,\mathrm{a}_2)}(\mathrm{Restaurants}) \\ \times \\ \rho_{(\mathrm{n}_3,\mathrm{p}_3,\mathrm{price})}(\mathrm{Sells}) \\ \times \\ \rho_{(\mathrm{n}_4,\mathrm{p}_4)}(\mathrm{Likes})$$

Question 15

b) Find all customer-restaurant pairs (C,R) where C and R are both located in the same area, and C likes some pizza that is sold by R.

- (C,R) located in the same area
  - $\mathrm{a}_1 = \mathrm{a}_2$
- C likes some pizza sold by R
  - $\mathrm{p}_3 = \mathrm{p}_4$
- Connect `Restaurants` and `Sells`
  - $\mathrm{n}_2 = \mathrm{n}_3$
- Connect `Customers` and `Likes`
  - $\mathrm{n}_1 = \mathrm{n}_4$

$$\sigma_{(a_1=a_2)\wedge(p_3=p_4)\wedge(n_2=n_3)\wedge(n_1=n_4)}\left(\rho_{(\mathrm{n}_1,\mathrm{a}_1)}(\text{Customers}) \times \rho_{(\mathrm{n}_2,\mathrm{a}_2)}(\text{Restaurants}) \times \rho_{(\mathrm{n}_3,\mathrm{p}_3,\text{price})}(\text{Sells}) \times \rho_{(\mathrm{n}_4,\mathrm{p}_4)}(\text{Likes})\right)$$

Question 15

b) Find all customer-restaurant pairs (C,R) where C and R are both located in the same area, and C likes some pizza that is sold by R.

- Projection on only (C,R)
  - $\mathrm{n}_1, \mathrm{n}_2$

$$\boxed{\pi_{\mathrm{n}_1,\mathrm{n}_2}}\ \boxed{\sigma_{\substack{(\mathrm{a}_1=\mathrm{a}_2)\wedge(\mathrm{p}_3=\mathrm{p}_4)\wedge \\ (\mathrm{n}_2=\mathrm{n}_3)\wedge(\mathrm{n}_1=\mathrm{n}_4)}}}\ \boxed{\begin{array}{l} \rho_{(\mathrm{n}_1,\mathrm{a}_1)}(\text{Customers}) \\ \times \\ \rho_{(\mathrm{n}_2,\mathrm{a}_2)}(\text{Restaurants}) \\ \times \\ \rho_{(\mathrm{n}_3,\mathrm{p}_3,\mathrm{price})}(\text{Sells}) \\ \times \\ \rho_{(\mathrm{n}_4,\mathrm{p}_4)}(\text{Likes}) \end{array}}$$

Question 15

c) Suppose that the database contains an additional relation `Dislikes(cname,pizza)` which indicates the pizzas that customers do not like. The database also satisfies the following constraint: for every customer $c \in \pi_{\text{cname}}(\text{Customers})$ and for every pizza $p \in \pi_{\text{pizza}}(\text{Contains})$, either $(c, p) \in \text{Likes}$ or $(c, p) \in \text{Dislikes}$ (*in other words, you know the likes and dislikes of every customers with respect to all pizzas*). Given this database, find all customer pairs (C_1, C_2) such that C_1 likes some pizza that C_2 does not like.

- What C_1 likes
  - `Like` table
- What C_2 dislikes
  - `Dislike` table

$$\rho_{(\text{n}_1,\text{p}_1)}(\text{Likes}) \\ \times \\ \rho_{(\text{n}_2,\text{p}_2)}(\text{Dislikes})$$

Question 15

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- The pizza must be the same
  - $\mathrm{p}_1 = \mathrm{p}_2$
- Do we need to check that the two customers are different?
  - i.e., $\mathrm{n}_1 \neq \mathrm{n}_2$
  - No, because it is guaranteed to be distinct

$$\sigma_{\mathrm{p}_1=\mathrm{p}_2}\left(\rho_{(\mathrm{n}_1,\mathrm{p}_1)}(\text{Likes}) \times \rho_{(\mathrm{n}_2,\mathrm{p}_2)}(\text{Dislikes})\right)$$

Question 15

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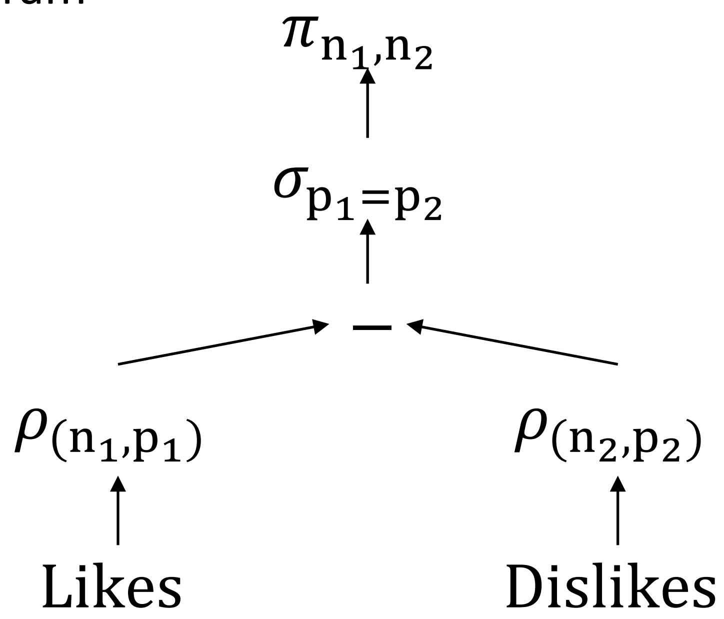
- Project only on (C_1, C_2)
  - $\mathrm{n}_1, \mathrm{n}_2$

$$\boxed{\pi_{\mathrm{n}_1,\mathrm{n}_2}}\ \boxed{\sigma_{\mathrm{p}_1=\mathrm{p}_2}}\ \boxed{\begin{array}{l}\rho_{(\mathrm{n}_1,\mathrm{p}_1)}(\text{Likes}) \\ \times \\ \rho_{(\mathrm{n}_2,\mathrm{p}_2)}(\text{Dislikes})\end{array}}$$

Question 15

c) Suppose that the database contains an additional relation `Dislikes(cname,pizza)` which indicates the pizzas that customers do not like. The database also satisfies the following constraint: for every customer $c \in \pi_{\text{cname}}(\text{Customers})$ and for every pizza $p \in \pi_{\text{pizza}}(\text{Contains})$, either $(c, p) \in \text{Likes}$ or $(c, p) \in \text{Dislikes}$ (*in other words, you know the likes and dislikes of every customers with respect to all pizzas*). Given this database, find all customer pairs (C_1, C_2) such that C_1 likes some pizza that C_2 does not like.

- Diagram



$\pi_{\mathrm{n_1,n_2}}$	$\sigma_{\mathrm{p_1=p_2}}$	$\rho_{(\mathrm{n_1,p_1})}(\text{Likes})$ $\times$ $\rho_{(\mathrm{n_2,p_2})}(\text{Dislikes})$

Question 15

d) Consider the original database schema without the `Dislikes` relation. Write a query to compute the `Dislikes` relation.

- Since we know all the `Likes`
- We need to get all combination of customer name and pizza

- Then remove the `Likes`

Question 15

d) Consider the original database schema without the `Dislikes` relation. Write a query to compute the `Dislikes` relation.
- Since we know all the `Likes`
- We need to get all combination of customer name and pizza
  - Customer name: $\pi_{\text{cname}}(\text{Customers})$
- Then remove the `Likes`

Question 15

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- Since we know all the `Likes`
- We need to get all combination of customer name and pizza
  - Customer name: $\pi_{\text{cname}}(\text{Customers})$
  - Combinarion: $\pi_{\text{cname}}(\text{Customers}) \times \text{Pizza}$
- Then remove the `Likes`

Question 15

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- Since we know all the `Likes`
- We need to get all combination of customer name and pizza
  - Customer name: $\pi_{\text{cname}}(\text{Customers})$
  - Combinarion: $\pi_{\text{cname}}(\text{Customers}) \times \text{Pizza}$
- Then remove the `Likes`
  - $(\pi_{\text{cname}}(\text{Customers}) \times \text{Pizza}) - \text{Likes}$

Question 15

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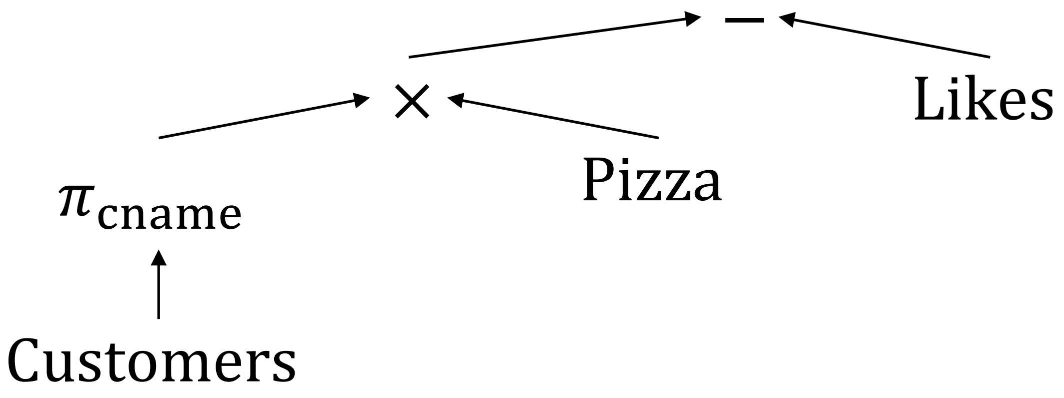
- Since we know all the `Likes`
- We need to get all combination of customer name and pizza
  - Customer name: $\pi_{\text{cname}}(\text{Customers})$
  - Combinarion: $\pi_{\text{cname}}(\text{Customers}) \times \text{Pizza}$
- Then remove the `Likes`
  - $(\pi_{\text{cname}}(\text{Customers}) \times \text{Pizza}) - \text{Likes}$



Question 15

e) Find all customer pairs (C_1, C_2) such that $C_1 < C_2$ and they like exactly the same pizzas.
  - *Deceptively simple statement!*
  - We need to first get customers that like some pizza another customer dislikes
    - We already have this: from Q15 (c)
    - Let's call it LD

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But LD does not have ordering!
We need $C_1 < C_2$

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Problem But LD does not have ordering! We need $C_1 < C_2$
Solution Reorder column from LD and union it with original LD; then we have both ordering.

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- Question: *<u>must they like at least one pizza</u>*?
  - YES: Use the Likes table (if not there, customer likes no pizza)
  - NO: Use Customers table (all customers are there)

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f) For each restaurant, find the price of the most expensive pizzas sold by that restaurant. Excludes restaurants that do not sell any pizza.

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  - $\text{price} \geq \text{price}_2$ for any price
  - $\text{rname} = \text{rname}_2$ must be the same restaurant
  - BUT WAIT!
    - This is the most expensive pizza from ALL possible restaurants!

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f) For each restaurant, find the price of the most expensive pizzas sold by that restaurant. Excludes restaurants that do not sell any pizza.

- How to find the most expensive pizza?
    - Think in reverse!
    - What if we find all the NOT most expensive pizza?
        - $(\text{price} < \text{price}_2) \wedge (\text{rname} = \text{rname}_2)$
    - Then we remove this pizza from the solution!

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    - $Q_{\text{not\_expensive}} \text{Sells} \times \rho_{(\text{rname}_2, \text{pizza}_2, \text{price}_2)}(\text{Sells})$
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  - Then we remove this pizza from the solution!
    - $\pi_{\mathrm{rname,price}}(\mathrm{Sells}) - \pi_{\mathrm{rname,price}}\left(\mathrm{Q}_{\mathrm{not\_expensive}}\right)$