CS448 PSO

Week 4

CS448 staff

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Example

- Consider the relation
  - $\text{Contracts}(\underline{\text{contractId}}, \text{supplierId}, \text{projectId}, \text{deptId}, \text{partId}, \text{qty}, \text{value})$
  - We will denote this relation schema by listing the attributes CSJDPQV
- Functional dependencies
  - C is the key
    - $\text{C} \rightarrow \text{CSJDPQV}$
  - Project purchases each part using single contract
    - $\text{JP} \rightarrow \text{C}$
  - Dept purchases at most one part from a supplier
    - $\text{SD} \rightarrow \text{P}$
  - Each project deals with a single supplier
    - $\text{J} \rightarrow \text{S}$

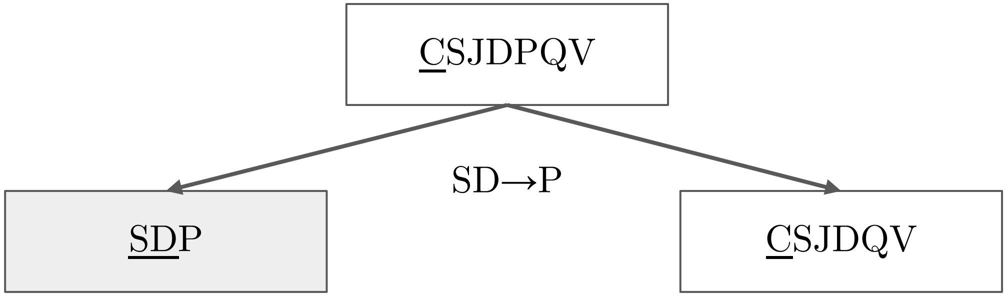
Example 1: decompose a schema into BCNF

- Schema: $\underline{\mathrm{C}}\mathrm{SJDPQV}$
- FDs: $\{\mathrm{SD}{\rightarrow}\mathrm{P},\ \mathrm{J}{\rightarrow}\mathrm{S},\ \mathrm{JP}{\rightarrow}\mathrm{C}\}$
- FDs violate BCNF

Example 1: decompose a schema into BCNF

- Schema: $\underline{C}SJDPQV$
- FDs: $\{SD \rightarrow P,\ J \rightarrow S,\ JP \rightarrow C\}$
- FDs violate BCNF

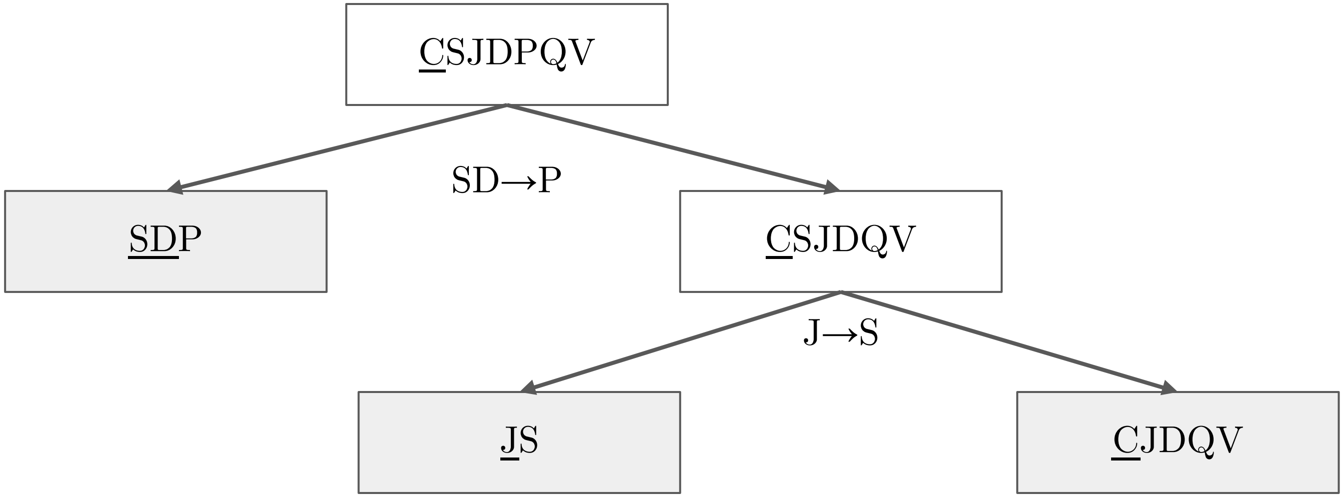
SD is not a key,
$SD \rightarrow P$ causes violation of BCNF



Example 1: decompose a schema into BCNF

- Schema: $\underline{\mathrm{C}}\mathrm{SJDPQV}$
- FDs: $\{\mathrm{SD}\rightarrow\mathrm{P},\ \mathrm{J}\rightarrow\mathrm{S},\ \mathrm{JP}\rightarrow\mathrm{C}\}$
- FDs violate BCNF

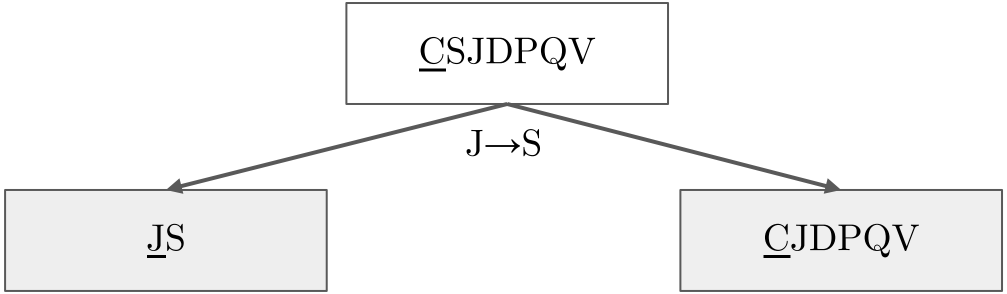
J is not a key,
$\mathrm{J}\rightarrow\mathrm{S}$ causes violation of BCNF



Alternatives in decomposing into BCNF

- Schema: $\underline{C}SJDPQV$
- FDs: $\{SD \rightarrow P,\ J \rightarrow S,\ JP \rightarrow C\}$
- FDs violate BCNF

Order in which we deal with the FDs, can lead to very different sets of relations



Which alternative should be used?

Choose the alternatives based on the semantics of the application.

Example:

R=(course id, course name, course abbreviation, year, instructor)

- course abbreviation $\rightarrow$ course name
- course name, year $\rightarrow$ instructor

- The most frequently used query:
  - selecting instructors given the course name and year.

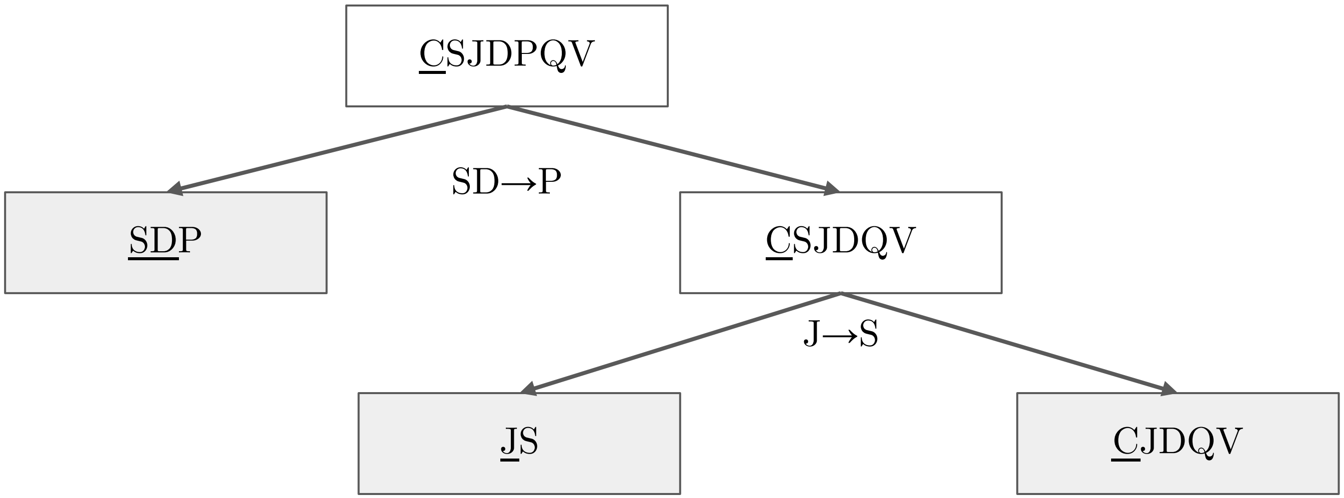
- Two decompositions:
  - (course name, course abbreviation) and (course id, course abbreviation, year, instructor)
  - (course name, year, instructor) and (course id, course name, course abbreviation, year)

Example 1: decompose a schema into BCNF

Decomposed schema: $\underline{SD}P$, $\underline{J}S$, $\underline{C}JDQV$

✓ lossless join decomposition

✗ dependency preserving decomposition



Example 2: dependency-preserving decomposition into 3NF

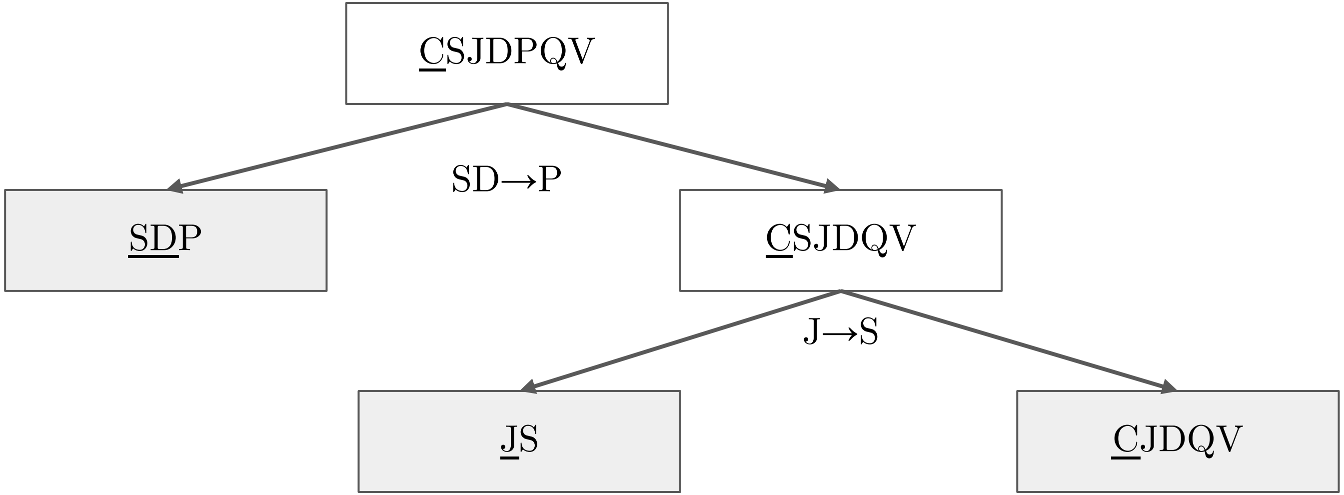
- Schema: $\underline{\mathrm{C}}\mathrm{SJDPQV}$
- FDs: $\{\mathrm{SD} \rightarrow \mathrm{P},\ \mathrm{J} \rightarrow \mathrm{S},\ \mathrm{JP} \rightarrow \mathrm{C}\}$
- $\mathrm{SD} \rightarrow \mathrm{P},\ \mathrm{J} \rightarrow \mathrm{S}$ violate 3NF

$\boxed{\underline{\mathrm{C}}\mathrm{SJDPQV}}$

Example 2: dependency-preserving decomposition into 3NF

- Schema: $\underline{C}SJDPQV$
- FDs: $\{SD \rightarrow P,\ J \rightarrow S,\ JP \rightarrow C\}$
- $SD \rightarrow P,\ J \rightarrow S$ violate 3NF

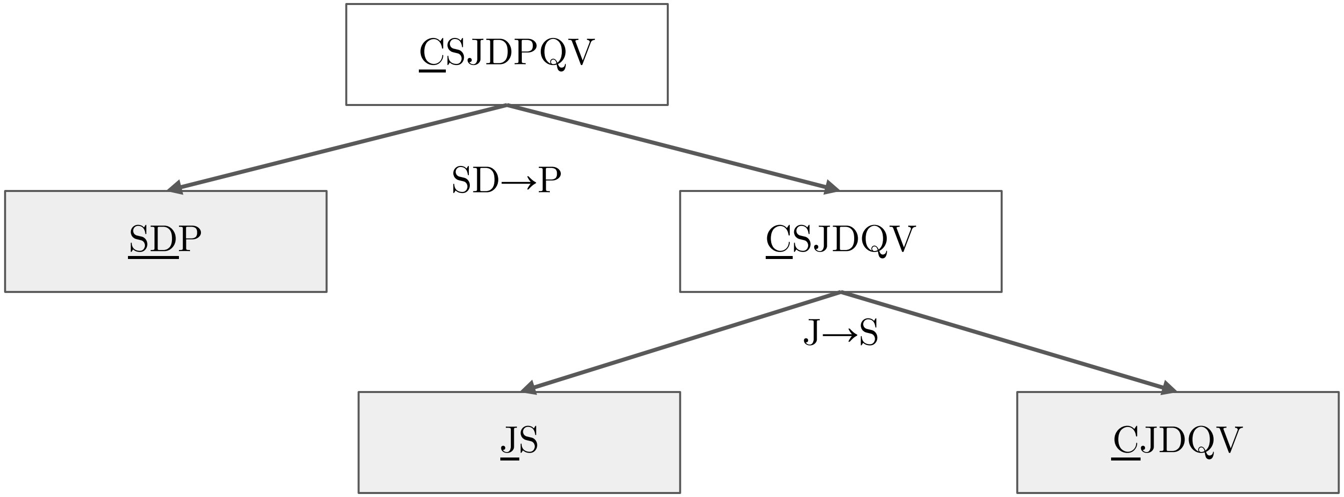
Dependency $JP \rightarrow C$ is not preserved



Example 2: dependency-preserving decomposition into 3NF

- Schema: $\underline{C}SJDPQV$
- FDs: $\{SD \rightarrow P,\ J \rightarrow S,\ JP \rightarrow C\}$
- $SD \rightarrow P,\ J \rightarrow S$ violate 3NF

Add a relation schema: CJP



Create views to consolidate a non-preserved FD

- Use materialized views to consolidate a non-preserved FD into one table
- Check the FD in that materialized view by making LHS of the FD the key for the view
- But will need to maintain the views when the base tables get updated

3NF synthesis

- Take all the attributes over the original relation R and a minimal cover F for the FDs that hold over it, and add a relation schema XA to the decomposition of R for each FD $\mathrm{X} \rightarrow \mathrm{A}$ in F.

- If no decomposed table contains a candidate key for R, add a relation schema of any candidate key for R.

Minimal cover

Minimal (Canonical) Cover for a set F of FDs is a set G of FDs such that:

1. Every dependency in G is of the form $\mathrm{X} \rightarrow \mathrm{A}$, where A is a single attribute
2. The closure F^+ is equal to the closure G^+
3. If we obtain a set H of dependencies from G by deleting one or more dependencies or by deleting attributes from a dependency in G, then $\mathrm{F}^+ \neq \mathrm{H}^+$

Example 3: find the minimal cover set

Let F be the set of dependencies:

$$\mathrm{A{\rightarrow}B,\ ABCD{\rightarrow}E,\ EF{\rightarrow}G,\ EF{\rightarrow}H,\ ACDF{\rightarrow}EG}$$

1. Rewrite $\mathrm{ACDF{\rightarrow}EG}$ to: $\mathrm{ACDF{\rightarrow}E,\ ACDF{\rightarrow}G}$
2. Delete $\mathrm{ACDF{\rightarrow}G}$ (redundant), implied by $\mathrm{A{\rightarrow}B,\ ABCD{\rightarrow}E,\ EF{\rightarrow}G}$)
3. Delete $\mathrm{ACDF{\rightarrow}E}$ (redundant)
4. Minimize left side of $\mathrm{ABCD{\rightarrow}E}$ to $\mathrm{ACD{\rightarrow}E}$, since $\mathrm{A{\rightarrow}B}$ holds

Thus, a minimal cover for F is the set:

$$\mathrm{A{\rightarrow}B,\ ACD{\rightarrow}E,\ EF{\rightarrow}G,\ EF{\rightarrow}H}$$

General algorithm for obtaining a minimal cover set

1. Put the FDs in a standard form (single attribute on the right)
2. Minimize the left side of each FD
3. Delete redundant FDs

Example 4: 3NF synthesis

- Schema: $\underline{\mathrm{C}}\mathrm{SJDPQV}$
- FDs: $\{\mathrm{C}\rightarrow\mathrm{CSJDPQV},\ \mathrm{JP}\rightarrow\mathrm{C},\ \mathrm{SD}\rightarrow\mathrm{P},\ \mathrm{J}\rightarrow\mathrm{S}\}$
- ➢ Find the minimal cover set

Example 4: 3NF synthesis

- Schema: $\underline{\mathrm{C}}\mathrm{SJDPQV}$
- FDs: $\{\mathrm{C}\rightarrow\mathrm{CSJDPQV},\ \mathrm{JP}\rightarrow\mathrm{C},\ \mathrm{SD}\rightarrow\mathrm{P},\ \mathrm{J}\rightarrow\mathrm{S}\}$

➢ Find the minimal cover set

$$\mathrm{C}\rightarrow\mathrm{S},\ \mathrm{C}\rightarrow\mathrm{J},\ \mathrm{C}\rightarrow\mathrm{D},\ \mathrm{C}\rightarrow\mathrm{P},\ \mathrm{C}\rightarrow\mathrm{Q},\ \mathrm{C}\rightarrow\mathrm{V},\ \mathrm{JP}\rightarrow\mathrm{C},\ \mathrm{SD}\rightarrow\mathrm{P},\ \mathrm{J}\rightarrow\mathrm{S}$$

Example 4: 3NF synthesis

- Schema: $\underline{C}SJDPQV$
- FDs: $\{C\rightarrow CSJDPQV,\ JP\rightarrow C,\ SD\rightarrow P,\ J\rightarrow S\}$

➢ Find the minimal cover set

$$\underline{C\rightarrow S},\ C\rightarrow J,\ \underline{C\rightarrow D},\ \boxed{C\rightarrow P}\ C\rightarrow Q,\ C\rightarrow V,\ JP\rightarrow C,\ \underline{SD\rightarrow P},\ J\rightarrow S$$

Example 4: 3NF synthesis

- Schema: $\underline{C}SJDPQV$
- FDs: $\{C \to CSJDPQV,\ JP \to C,\ SD \to P,\ J \to S\}$

➢ Find the minimal cover set

$$\boxed{C \to S},\ \underline{C \to J},\ C \to D,\ \cancel{C \to P},\ C \to Q,\ C \to V,\ JP \to C,\ SD \to P,\ \underline{J \to S}$$

Example 4: 3NF synthesis

- Schema: $\underline{\mathrm{C}}\mathrm{SJDPQV}$
- FDs: $\{\mathrm{C} \to \mathrm{CSJDPQV},\ \mathrm{JP} \to \mathrm{C},\ \mathrm{SD} \to \mathrm{P},\ \mathrm{J} \to \mathrm{S}\}$

➢ Find the minimal cover set

$$\cancel{\mathrm{C} \to \mathrm{S}},\ \mathrm{C} \to \mathrm{J},\ \mathrm{C} \to \mathrm{D},\ \cancel{\mathrm{C} \to \mathrm{P}},\ \mathrm{C} \to \mathrm{Q},\ \mathrm{C} \to \mathrm{V},\ \mathrm{JP} \to \mathrm{C},\ \mathrm{SD} \to \mathrm{P},\ \mathrm{J} \to \mathrm{S}$$

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- Schema: $\underline{\mathrm{C}}\mathrm{SJDPQV}$
- FDs: $\{\mathrm{C}\rightarrow\mathrm{CSJDPQV},\ \mathrm{JP}\rightarrow\mathrm{C},\ \mathrm{SD}\rightarrow\mathrm{P},\ \mathrm{J}\rightarrow\mathrm{S}\}$
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$$\cancel{\mathrm{C}\rightarrow\mathrm{S}},\ \mathrm{C}\rightarrow\mathrm{J},\ \mathrm{C}\rightarrow\mathrm{D},\ \cancel{\mathrm{C}\rightarrow\mathrm{P}},\ \mathrm{C}\rightarrow\mathrm{Q},\ \mathrm{C}\rightarrow\mathrm{V},\ \mathrm{JP}\rightarrow\mathrm{C},\ \mathrm{SD}\rightarrow\mathrm{P},\ \mathrm{J}\rightarrow\mathrm{S}$$

- Schemas: $\mathrm{CJ},\ \mathrm{CD},\ \mathrm{CQ},\ \mathrm{CV},\ \mathrm{SDP},\ \mathrm{JS},\ \mathrm{JPC}$
- (Optional) Combine: $\mathrm{CJDQVP},\ \mathrm{SDP},\ \mathrm{JS}$
- CJDQVP is a superkey

Case Study: The Internet shop

Relations:

- Books (<u>isbn</u>, title, author, qty_in_stock, price, year_published)
- Customers (<u>cid</u>, cname, address)
- Orders (<u>ordernum, isbn</u>, cid, cardnum, qty, order_date, ship_date)

Case Study: The Internet shop

Relations:

- $\text{Books}(\underline{\text{isbn}}, \text{title}, \text{author}, \text{qty\_in\_stock}, \text{price}, \text{year\_published})$
- $\text{Customers}(\underline{\text{cid}}, \text{cname}, \text{address})$
- $\text{Orders}(\underline{\text{ordernum}, \text{isbn}}, \text{cid}, \text{cardnum}, \text{qty}, \text{order\_date}, \text{ship\_date})$

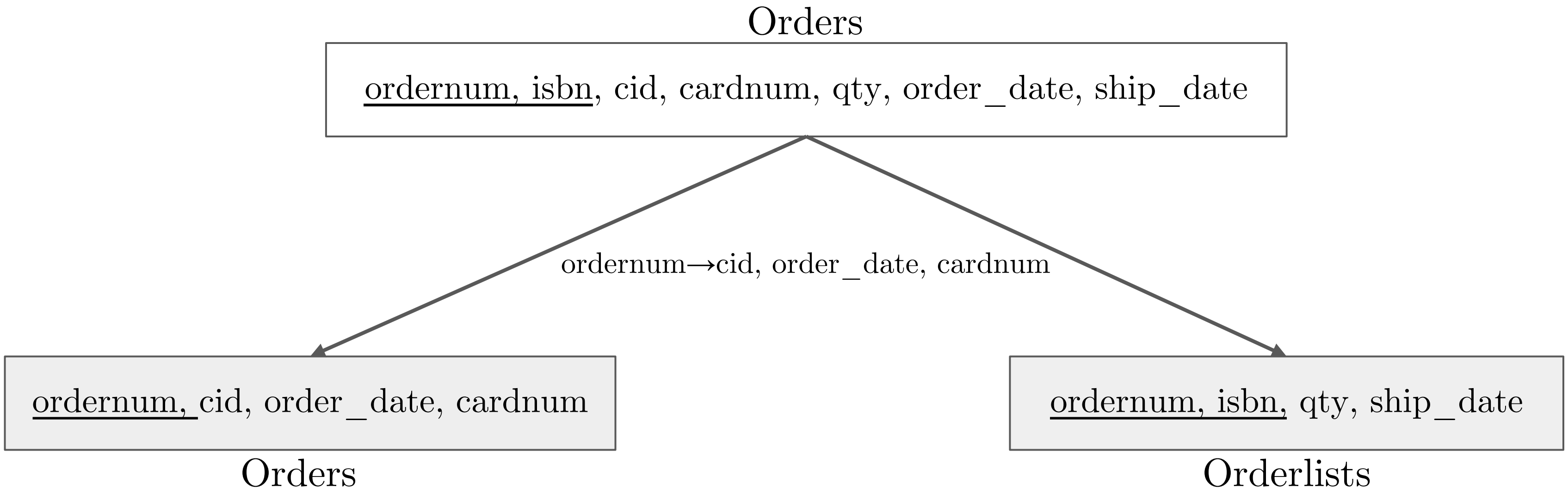
Functional Dependencies:

- Books has one key: isbn. No other FDs
- Customers has one key: cid. No other FDs
- Orders has key: $(\text{ordernum}, \text{isbn})$.

  Other FDs: $\text{ordernum} \to \text{cid}$, $\text{ordernum} \to \text{order\_date}$, $\text{ordernum} \to \text{cardnum}$

Decomposition

- Schema: Orders($\underline{\text{ordernum, isbn}}$, cid, cardnum, qty, order_date, ship_date)
- FDs: ordernum→cid, ordernum→order_date, ordernum→cardnum



References

1. "The cow book": Database management systems by Raghu Ramakrishnan and Johannes Gehrke