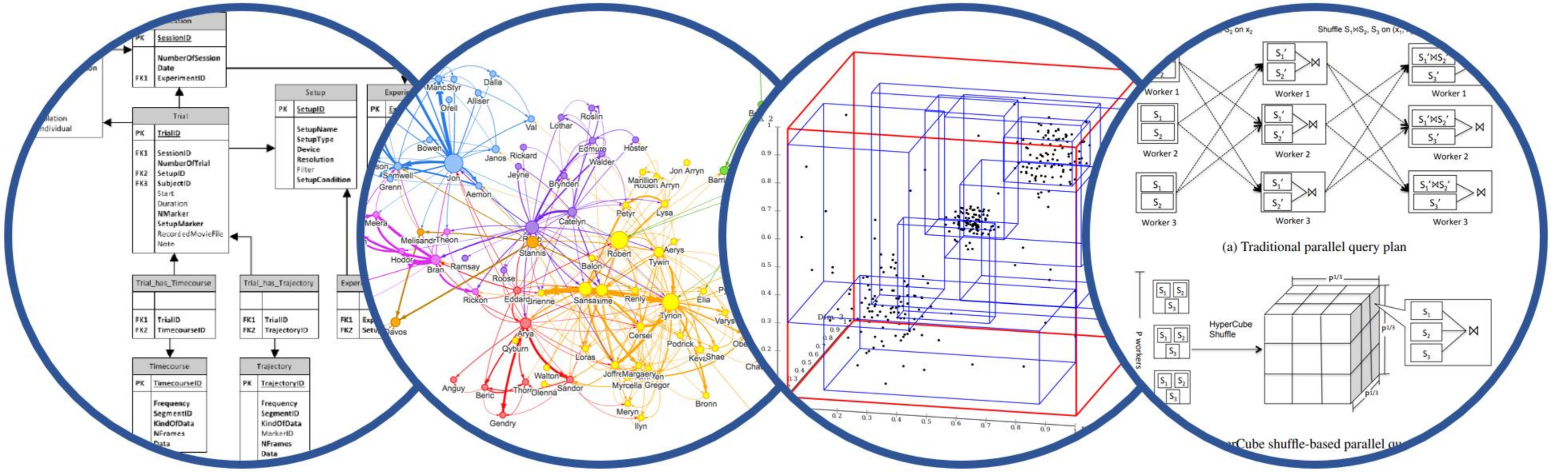

Introduction to Data Management

BCNF Decomposition

Paul G. Allen School of Computer Science and Engineering
University of Washington, Seattle

Usefulness of Keys in Design

Restaurants(rid, name, rating, popularity)

rid → name

rid → rating

Fine because rid is a superkey

rating → popularity

Redundancy!

rid	name	rating	popularity
1	Mee Sum Pastry	3	Respectable
2	Café on the Ave	4	Poppin
3	Guanaco's Tacos	4	Poppin
4	Aladdin Gyro-Cery	5	Poppin

Database Design

Database Design is about

(1) characterizing data and (2) organizing data

How to talk about properties

we know or see in the data

Database Design

Database Design is about

(1) characterizing data and (2) organizing data

How to organize data to promote

ease of use and efficiency

Normal Forms

Normal Forms

- 1NF → Flat
- 2NF → No partial FDs (obsolete)
- 3NF → Preserve all FDs, but allow anomalies
- BCNF → No transitive FDs, but can lose FDs
- 4NF → Considers multi-valued dependencies
- 5NF → Considers join dependencies (hard to do)

In 414, we only discuss this

Normal Forms

1NF

A relation R is in **First Normal Form** if all attribute values are atomic. Attribute values cannot be multivalued. Nested relations are not allowed.

We call data in 1NF "flat."

BCNF

BCNF

A relation R is in **Boyce-Codd Normal Form (BCNF)** if for every non-trivial dependency, $X \rightarrow A$, X is a superkey.

Equivalently, a relation R is in BCNF if $\forall X$ either $X^+ = X$ or $X^+ = C$ where C is the set of all attributes in R

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Fred	123-45-6789	206-555-9999	Seattle
Fred	123-45-6789	206-555-8888	Seattle
Joe	987-65-4321	415-555-7777	San Francisco

SSN → SSN, Name, City

We often call these “bad FDs” because they prevent the relation from being in BCNF

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We often call these “bad FDs” because they prevent the relation from being in BCNF

Remove all the bad FDs, then the relation is in BCNF

Decomposition

- "Extracting" attributes can be done with **decomposition** (split the schema into smaller parts)
- For this class, decomposition means the following:

$$R(A_1, \dots, A_n, B_1, \dots, B_m, C_1, \dots, C_k) \begin{cases} R_1(A_1, \dots, A_n, B_1, \dots, B_m) \\ R_2(A_1, \dots, A_n, C_1, \dots, C_k) \end{cases}$$

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Some common attributes are present so we can rejoin data

BCNF Decomposition Algorithm

$Normalize(R)$
  $C \leftarrow$ the set of all attributes in R
  find X **s.t.** $X^+ \neq X$ **and** $X^+ \neq C$
  if X is not found
  then "R is in BCNF"
  else
    decompose R into $R_1(X^+)$ and $R_2\big((C - X^+) \cup X\big)$
    $Normalize(R_1)$
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BCNF Decomposition Algorithm

Determine if R is in BCNF already

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Determine if R is in BCNF already

Decompose into a relation where X is a superkey

Decompose into a relation with X and attributes X cannot determine

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Finished?

BCNF Decomposition Example

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Finished? NO! (popularity → recommended) is still "bad"

We decompose R1 into R3, R4

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R2 = ride, name, rating R3 = rating, popularity R4 = popularity, recommended

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These three tables are the final decomp.

R2 = ride, name, rating R3 = rating, popularity R4 = popularity, recommended

BCNF Decomposition Order

Restaurants(rid, name, rating, popularity, recommended)

rid → name, rating

rating → popularity

popularity → recommended

Note that we chose to split the tables on (rating → rating, popularity, recommended) first. We could have instead chosen (popularity → recommended) first.

In this case the final tables in BCNF will have the same attributes, but not always.

As long as the end result is in BCNF, the particular distribution of attributes doesn't matter for correctness.

Losslessness

Definition

Lossless Decomposition is a reversible decomposition, i.e. rejoining all decomposed relations will always result exactly with the original data.

This is the opposite of a **Lossy Decomposition**, an irreversible decomposition, where rejoining all decomposed relations may result something other than the original data, specifically with extra tuples.

This concept might be familiar if you have ever encountered lossless data compression (e.g. Huffman encoding or PNG) or lossy data compression (e.g. JPEG).

Losslessness

Is BCNF decomposition lossless?

Losslessness

Is BCNF decomposition lossless?

Yes!

In our example:

R2 = ride, name, rating

R4 = rating, popularity

R4 = popularity, recommended

Losslessness

Is BCNF decomposition lossless?

Yes!

In our example:

R2 = ride, name, rating

R4 = rating, popularity

R4 = popularity, recommended

…gives us original R

More examples

Consider this example:

R (A, B, C, D, E, F)

A -> CD

F -> AE

D -> B

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A -> CD

F -> AE

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Good idea to start with closures first:

A+ = {ABCD}

So what's our first decomp?

More examples

Consider this example:

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Good idea to start with closures first:

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So what’s our first decomp?