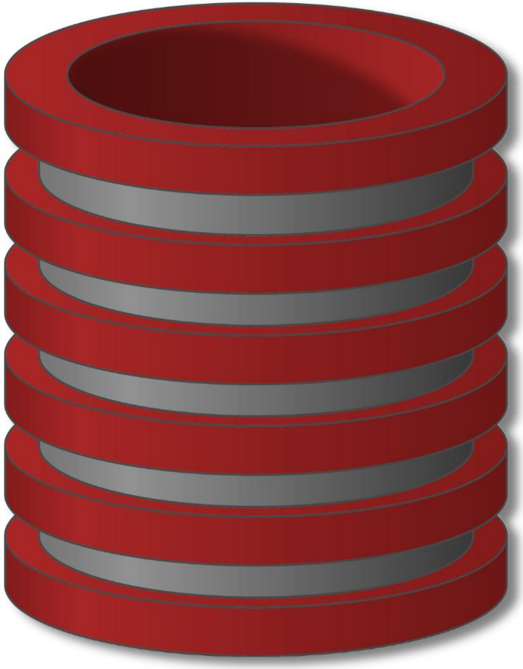


Relational Design Theory

Motivation & overview

Jennifer Widom

Designing a database schema

- Usually many designs possible
- Some are (much) better than others!
- How do we choose?

Often use higher-level design tools, but …

- Some designers go straight to relations
- Useful to understand why tools produce certain schemas

❖ Very nice theory for relational database design

Example: College application info.

- SSN and name
- Colleges applying to
- High schools attended (with city)
- Hobbies

```
Apply(SSN, sName, cName, HS, HScity, hobby)
```

Rel. design - overview

- `Apply(SSN, sName, cName, HS, HScity, hobby)`

123 Ann from PAHS (P.A.) and GHS (P.A.) plays tennis and trumpet and applied to Stanford, Berkeley, and MIT

123	Ann	Stanford	PAHS	P.A.	tennis
123	Ann	Berkeley	PAHS	P.A.	tennis
123	Ann	Berkeley	PAHS	P.A.	trumpet
	⋮	⋮	GHS	⋮	

12 tuples

Apply(SSN, sName, cName, HS, HScity, hobby)

123 Ann from PAHS (P.A.) and GHS (P.A.) plays tennis and trumpet and applied to Stanford, Berkeley, and MIT

Design "anomalies"

- Redundancy

capture info. multiple times

123 Ann PAHS tennis

MIT

Rel. design - overview

```
Apply(SSN, sName, cName, HS, HScity, hobby)
```

123 Ann from PAHS (P.A.) and GHS (P.A.) plays tennis and trumpet and applied to Stanford, Berkeley, and MIT

Design “anomalies”

- Redundancy
- Update anomaly

update facts differently

~~trumpet~~

cornet

Rel. design - overview

`Apply(SSN, sName, cName, HS, HScity, hobby)`

123 Ann from PAHS (P.A.) and GHS (P.A.) plays tennis and trumpet and applied to Stanford, Berkeley, and MIT

Design “anomalies”

- Redundancy
- Update anomaly
- Deletion anomaly

inadvertently deletion

surfing

Example: College application info.

- SSN and name
- Colleges applying to
- High schools attended (with city)
- Hobbies

No anomalies
Reconstruct orig. data

✓Student(SSN, sName)

✓Apply(SSN, cName~~)~~, hobby)

✓HighSchool(SSN, HS~~)~~, HScity)

✓~~Located(HS, HScity)~~

✓~~Hobbies(SSN, hobby)~~

Design by decomposition

- Start with “mega” relations containing everything
- Decompose into smaller, better relations with same info.
- Can do decomposition automatically

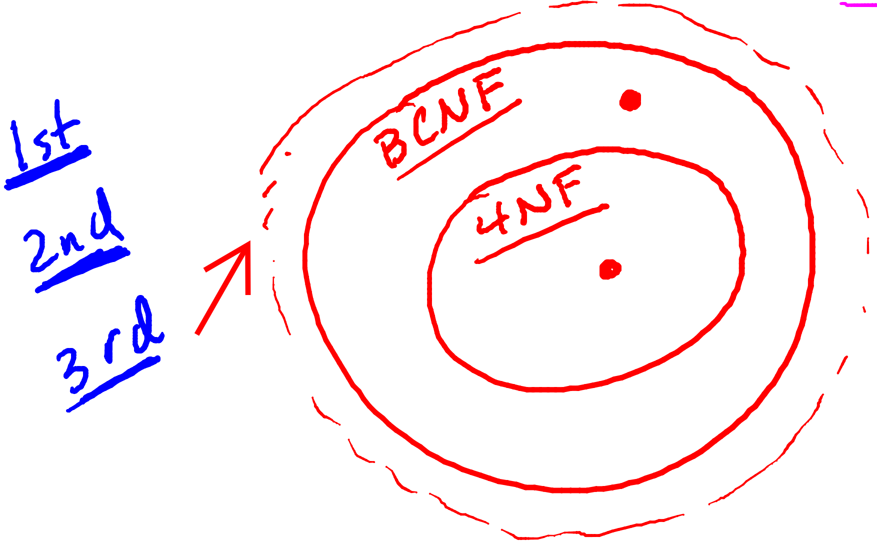
Automatic decomposition

- “Mega” relations + *properties of the data*
- System decomposes based on properties
- Final set of relations satisfies *normal form*
  - *No anomalies, no lost information*

Properties and Normal Forms

✓ *Functional dependencies ⇒ Boyce-Codd Normal Form*

✓ *+ Multivalued dependences ⇒ Fourth Normal Form*



Rel. design - overview

Functional Dependencies and BCNF

`Apply(SSN, sName, cName)` Not in BCNF

Not a key

- Redundancy; Update & Deletion Anomalies
- Storing **`SSN-sName`** pair once for each college

Functional Dependency **`SSN`** → **`sName`**

- Same **`SSN`** always has same **`sName`**
- Should store each **`SSN`**'s **`sName`** only once

Boyce-Codd Normal Form If **A → B** then **A** is a key

Decompose: **`Student(SSN, sName)`** **`Apply(SSN, cName)`**

key

Jennifer Widom

Multivalued Dependencies and 4NF

`Apply(SSN, cName, HS)`

- Redundancy; Update & Deletion Anomalies
- Multiplicative effect C colleges, H high schools C * H tuples C+H
- Not addressed by BCNF: No functional dependencies

Multivalued Dependency SSN $\twoheadrightarrow$ cName SSN $\twoheadrightarrow$ HS

- Given SSN has every combination of **cName** with **HS**
- Should store each **cName** and each **HS** for an **SSN** once

Fourth Normal Form If A $\twoheadrightarrow$ B then A is a key

Decompose: `Apply(SSN, cName)` `HighSchool(SSN, HS)`

C+H ✓

C * H

Design by decomposition

- “Mega” relations + properties of the data
- System decomposes based on properties
- Final set of relations satisfies normal form
  - No anomalies, no lost information
- Functional dependencies ⇒ Boyce-Codd Normal Form
- Multivalued dependences ⇒ Fourth Normal Form