



Relational Design Theory

Motivation & overview

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)

- 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*

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*

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

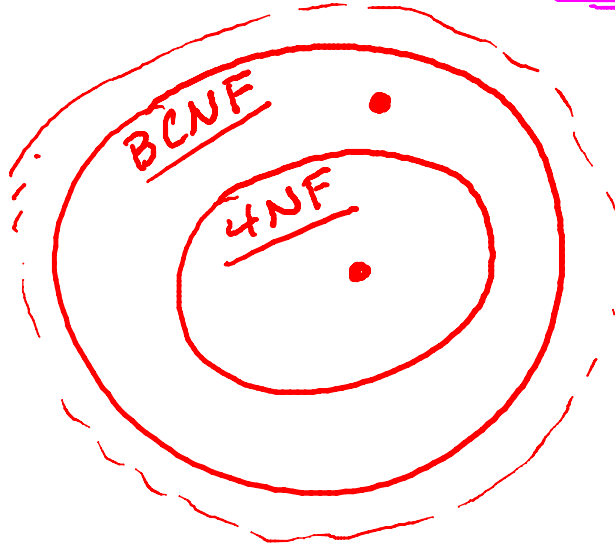
Automatic decomposition

- “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 \Rightarrow Boyce-Codd Normal Form
- ✓ + Multivalued dependences \Rightarrow Fourth Normal Form

1st
2nd
3rd



Functional Dependencies and BCNF

Apply(SSN, sName, cName)

↑ Not a key Not in BCNF

- 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 ↑ ↑

Multivalued Dependencies and 4NF

Apply(SSN, cName, HS)

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

Multivalued Dependency SSN \twoheadrightarrow cName \leq 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)

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 \Rightarrow Boyce-Codd Normal Form
- Multivalued dependences \Rightarrow Fourth Normal Form