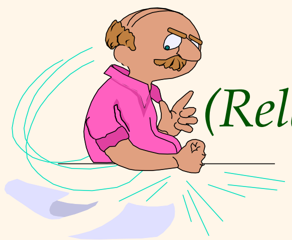
Introduction to Data Management



Lecture #8
(Relational Design Theory, cont.)

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Announcements

- Homework stuff
  - HW #2 is due this Friday (before class)
  - HW #3 will be similarly due the following Friday
- Exam stuff (time flies!)
  - Midterm #1 is a week from next Monday (**in class**)!
  - We'll use assigned seating (more info next week), so you'll want to show up a bit early to get settled in
  - An 8.5"x11" 2-sided cheat sheet will be permitted
- Today's plan:
  - Relational DB design theory (*II*)
  - *Disclaimer*: Still not the most exciting CS122A topic… ☺

Reasoning About FDs (Review)

Let's consider R(ABCDE), F = {A → B, B → C, C D → E}

- Let's work our way towards inferring F+ ...

(a) A→B (b) B→C (c) CD→E	(*given*)
(d) A→C	(a, b, and transitivity)
(e) BD→CD	(b and augmentation)
(f) BD→E	(e, c and transitivity)
(g) AD→CD	(d and augmentation)
(h) **AD→E**	(g, c and transitivity)
(i) **AD→C** (j) **AD→D**	(g and decomposition)
(k) AD→BD	(a and augmentation)
(l) **AD→B**	(k and decomposition)
(m) **AD→A**	(a and reflexivity)
(n) AD→ABCDE	(h, i, j, l, m, and union) ....

Candidate key!

Note: If some attribute *X* is not on the RHS of *any* initial FD, then *X* must be *part of the key*!

Reasoning About FDs (Cont'd.)

- Computing the closure of a set of FDs can be expensive. (Size of closure is exponential in # attrs!)
- Typically, we just want to check if a given FD *X* →*Y* is in the closure of a set of FDs *F*. An efficient check:
  - First compute *attribute closure* of X (denoted **X+**) w.r.t. *F:*
    - Set of all attributes A such that X→A is in F+ (i.e., all F+ attributes)
    - There is a *linear time algorithm* to compute this (look here): start with X and keep adding attributes that can be inferred via the FDs.
  - Then check to see if Y is in X+
- Does F = {A → B, B → C, C D →E } imply A → E?
  - I.e.: Is A → E in the closure **F+**? Equivalently: Is E in **A+**?

trivial是指平凡，比如X是Y包含的，那用Y就可以了，这个是平凡的，然后不完全包含的都是非平凡

FDs & Redundancy

hold::::non trivial 是指自己不箭头自己，trivial是A->AD

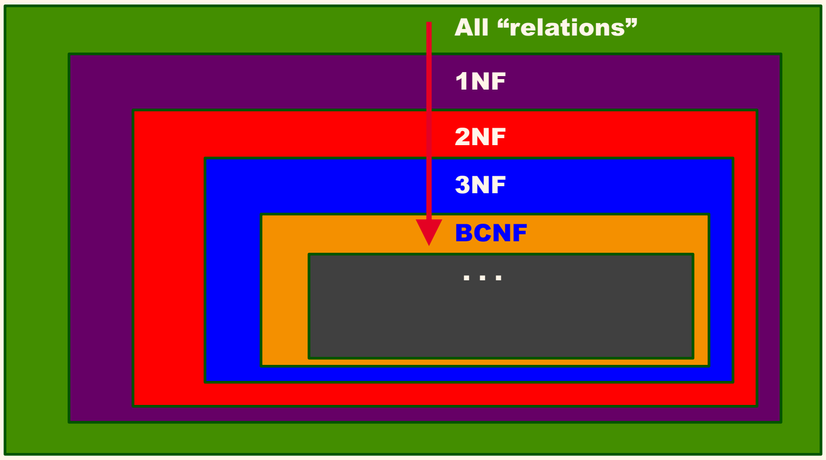
- Role of FDs in detecting redundancy in a schema:
  - Consider a relation R with 3 attributes, ABC.
    - If **no** (non-trivial) FDs hold: There is no redundancy here then. (Think about this – in fact, think hard...!)
      - *Ex:* Prescriptions(doc_name, patient_name, drug_name)
    - Given A → B: Several tuples could have the same A value – and if so, then they'll all have the same B value as well! (Thus if A is repeated for some reason, it will always have the same B "tagging along for the ride".)
      - **Ex:** Employee(emp_name, dept_no, mgr_name)

        if dept_no → mgr_name

Normal Forms

- Returning to the issue of schema refinement, the first question to ask is whether any refinement is needed!
- We will define various *normal forms* (BCNF, 3NF etc.) based on the nature of FDs that hold
- Depending upon the normal form a relation is in, it has different level of redundancy
  - E.g., a BCNF relation has NO redundancy – clearer soon!
- Checking for which normal form a relation is in will help us decide whether to decompose the relation
  - E.g., no point in decomposing a BCNF relation!

Normal Forms



Some Terms and Definitions (Review)

- If X is part of a (candidate) key, we will say that X is a *prime attribute*. 如果x是candidate的某个key，那就是Prime attribute
- If X (an attribute set) contains a candidate key, we will say that X is a *superkey*.
- X → Y can be pronounced as "X *determines* Y", or "Y is *functionally dependent* on X".
- Some types of dependencies (*on a key*): 如果attribute set里面有key是candidate key那就是superkey
  - *Trivial*: **XY → X**
  - *Partial*: XY is a key, **X → Z**
  - *Transitive*: X → Y, Y → Z, Y is non-prime, **X → Z**

First Normal Form (1NF)

- Rel'n R is in 1NF if all of its attributes are atomic.
  - No set-valued attributes! (1NF = "flat" ☺)
  - Usually goes *w/o* saying for relational model (but not for *NoSQL* systems, as we'll see at the end of the quarter ☺).
  - *Ex:*

bname	color
Interlake	blue, red
Clipper	green
Marine	red

→

bname	color
Interlake	blue
Interlake	red
Clipper	green
Marine	red

每一个都是单原子，不可以一个格放两个

(1NF is different than the other normal forms.)

Second Normal Form (2NF)

- Rel'n R is in 2NF if it is in 1NF and no non-prime attribute is *partially* dependent on a candidate key of R.
- *Ex:* Supplies(sno, sname, saddr, pno, pname, pcolor)

  where: sno → sname, sno → saddr, pno → pname, pno → pcolor

Q1: What are the candidate keys for Supplies?

Q2: What are the prime attributes for Supplies?

Q3: Why is Supplies not in 2NF?

Q4: What's the fix?

A1: (sno, pno)

A2: sno, pno

A3: *Each* of its four FDs violates 2NF!

Supplier(<u>sno</u>, sname, saddr)

Part(<u>pno</u>, pname, pcolor)

Supply(<u>sno, pno</u>)

Must not forget this! (Else "lossy join"!!)

2NF是指那些non prime attribute（就是不在candidate里的attribute） 必须要依赖全部candidate key才可以找到自己，不然不是

比如，某部分的candidate key就可以定位某个非prime的attribute就不算是2NF

那我们可以进行分桌

可以两个key并成是一个桌，但是没有attribute，或者加他们一起的attribute

Third Normal Form (3NF)

- Rel'n R is in 3NF if it is in 2NF and it has no *transitive* dependencies to non-prime attributes.
- *Ex*: Workers(eno, ename, esal, dno, dname, dfloor)

  where: eno→ename, eno→esal, eno→dno, dno→dname, dno→dfloor

  Q1: What are the candidate keys for Workers?

  Q2: What are the prime attributes for Workers?

  Q3: Why is Workers not in 3NF?

  Q4: What's the fix?

  A1: eno

  A2: eno

  A3: Two inferable FDs, eno→ dname and eno→dfloor, each violate 3NF.

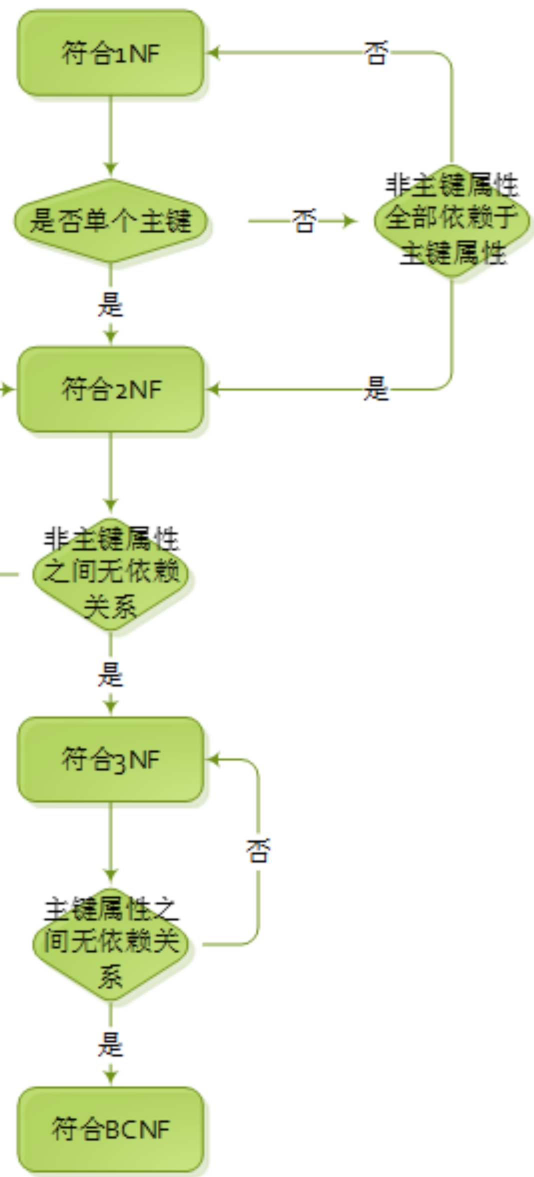
  Emp(<u>eno</u>, ename, esal, dno)

  Dept(<u>dno</u>, dname, dfloor)

  Don't forget this!
  (Else "lossy join" !!)

***<u>Note</u>:** A lossless-join, dependency-preserving decomposition of R into a collection of 3NF relations is **always possible**.*

3NF就是在2NF基础上再把transitive的分到另一个table


符合1NF
是否单个主键
否
非主键属性全部依赖于主键属性
否
是
是
符合2NF
否
非主键属性之间无依赖关系
是
符合3NF
否
主键属性之间无依赖关系
是
符合BCNF