Overview

- SQL un-nesting example

- E/R Diagrams
  - Translation from English or table schema to E/R
  - Translation E/R to table schema

- Functional Dependencies

- Boyce Codd Normal Form
  - Examples
Find persons that frequent some bar that serves some drink they like

-- How can we unnest this?

select F.person
from Frequents F
where exists (select *
    from Serves S
    where S.bar = F.bar and
    exists (select *
        from Likes L
        where L.person = F.person
            and S.drink = L.drink))
Find persons that frequent some bar that serves some drink they like

-- unnested version

select F.person
from Frequents F, Likes L, Serves S
where F.person = L.person and
    F.bar = S.bar and
    L.drink = S.drink
English to E/R Diagram

- **Attributes**
  - Professors have: ssn, age, rank, specialty
  - Projects have: pid, sponsor, start-date, end-date, budget
English to E/R Diagram

- Each project is managed by one professor (principal investigator)
- Professor can manage multiple projects
English to E/R Diagram

- Each project is worked on by one or more professors
- Professors can work on multiple projects

Example courtesy: Database Management Systems, 3rd E, R. Ramakrishnan and J. Gehrke
Convert to tables

- Professor(ssn, age, rank, specialty)
- Project(pid, sponsor, start_date, end_date, budget)
- Work_in(ssn, pid)
- Manages(ssn, pid)

Example courtesy: Database Management Systems, 3rd E, R. Ramakrishnan and J. Gehrke
Convert to tables

- Professor(ssn, age, rank, specialty)
- Project(pid, sponsor, start_date, end_date, budget, ssn)
- Work_in(ssn, pid)
Convert to tables

CREATE TABLE Professor (  
    ssn INT PRIMARY KEY,  
    age INT,  
    urank VARCHAR(30),  
    specialty VARCHAR(30)  
) ;

CREATE TABLE Project (  
    pid INT PRIMARY KEY,  
    sponsor INT,  
    start_date DATE,  
    end_date DATE,  
    budget FLOAT,  
    ssn INT REFERENCES Professor(ssn)  
) ;

CREATE TABLE Work_In (  
    ssn INT REFERENCES Professor(ssn),  
    pid INT REFERENCES Project(pid),  
    PRIMARY KEY (ssn, pid)  
) ;

• Professor(ssn, age, rank, specialty)  
• Project(pid, sponsor, start_date, end_date, budget, ssn)  
• Work_in(ssn, pid)
Data Anomalies

- Redundancy is Bad, why?
- Redundancy
- Update
- Delete
### Functional Dependencies

<table>
<thead>
<tr>
<th>R</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>a1</td>
<td>b1</td>
<td>c1</td>
<td>d1</td>
<td>e1</td>
<td>f1</td>
<td></td>
</tr>
<tr>
<td>a1</td>
<td>b1</td>
<td>c2</td>
<td>d1</td>
<td>e2</td>
<td>f3</td>
<td></td>
</tr>
<tr>
<td>a2</td>
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<td>c2</td>
<td>d3</td>
<td>e2</td>
<td>f3</td>
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<tr>
<td>a3</td>
<td>b2</td>
<td>c3</td>
<td>d4</td>
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<tr>
<td>a2</td>
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<tr>
<td>a4</td>
<td>b1</td>
<td>c1</td>
<td>d5</td>
<td>e1</td>
<td>f1</td>
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</tr>
</tbody>
</table>

- Dependencies for this relation:
  - A → B
  - A → D
  - B,C → E,F
- Do they all hold in this instance of the relation R?

- How would you go by finding these in an unknown table?

- Functional dependencies are specified by the database programmer based on the intended meaning of the attributes.
Keys

- Keys
  - Superkey
  - Key
Consider a relation $S(A,B,C,D)$ with FDs $A \rightarrow B$, $B \rightarrow C$, and $B \rightarrow D$.

a. Give the nontrivial FDs that follow from the given FDs. Restrict to 1 attr on right side.

b. What are all the keys of $S$?

c. What are the superkeys that aren’t keys?

a) $A \rightarrow C$, $A \rightarrow D$

b) Only $\{A\}$

c) Any set of two or more keys that includes $A$
Boyce-Codd Normal Form (BCNF)

• What is it?

• Why do it?
BCNF Decomposition Algorithm

BCNF_Decompose(R)

find X s.t.: $X \neq X^+ \neq [\text{all attributes}]$

if (not found) then “R is in BCNF”

let $Y = X^+ - X$

let $Z = [\text{all attributes}] - X^+$

decompose $R$ into $R_1(X \cup Y)$ and $R_2(X \cup Z)$

continue to decompose recursively $R_1$ and $R_2$
Consider the following FDs:

- $CD \rightarrow E$  
- $D \rightarrow B$  
- $A \rightarrow CD$

Which one are the bad dependences?

- $CD+ = BCDE$  
- $D+ = BD$  
- $A+ = ABCDE$

**NOTE:** A SET OF ATTRIBUTES $X$ IS A SUPERKEY IF $X+ = ABCDE$
A table $R(A,B,C,D,E)$ : Example 1

Consider the following FDs:
- $CD \rightarrow E$ BAD
- $D \rightarrow B$ BAD
- $A \rightarrow CD$

R(A,B,C,D,E) [CD+ = BCDE ≠ ABCDE]

R2(B,C,D,E) [D+ = BD ≠ BCDE]

R3(A,C,D) [BCNF]

R4(B,D) [BCNF]

R5(C,D,E) [BCNF]

NOTE: A SET OF ATTRIBUTES X IS A SUPERKEY IF X+ = ABCDE
2 more BCNF decompositions

R(A, B, C, D)
   C → D, C → A, B → C

S(A, B, C, D, E)
   AB → C, DE → C, B → D
A table $R(A,B,C,D)$: Example 2

Consider the following FDs:

- $C \rightarrow D$, $C^+ = AD$  BAD
- $C \rightarrow A$, $C^+ = AD$  BAD
- $B \rightarrow C$, $B^+ = ABCD$

**NOTE: A SET OF ATTRIBUTES X IS A SUPERKEY IF $X^+ = ABCD$**
A table $S(A,B,C,D,E)$: Example 3

Consider the following FDs:
- $AB \rightarrow C$, $AB^+ = ABCD$  
- $DE \rightarrow C$, $DE^+ = CDE$  
- $B \rightarrow D$, $B^+ = BD$

1st Solution:

$S(A,B,C,D,E)$  
$[AB^+ = ABCD \neq ABCDE]$

$S2(A,B,C,D)$  
$[B^+ = BD \neq ABCD]$

$S3(A,B,E)$  
$[BCNF]$

$S4(B,D)$  
$[BCNF]$

$S5(A,B,C)$  
$[BCNF]$

NOTE: A SET OF ATTRIBUTES X IS A SUPERKEY IF $X^+ = ABCDE$
A table $S(A,B,C,D,E)$: Example 3

Consider the following FDs:

- $AB \rightarrow C$, $AB^+ = ABCD$ \textbf{BAD}
- $DE \rightarrow C$, $DE^+ = CDE$ \textbf{BAD}
- $B \rightarrow D$, $B^+ = BD$ \textbf{BAD}

2\textsuperscript{nd} Solution:

- $S(A,B,C,D,E)$ $[DE^+ = CDE \neq ABCDE]$
- $S2(A,B,D,E)$ $[B^+ = BD \neq ABDE]$
- $S3(C,D,E)$ $[BCNF]$
- $S4(B,D)$ $[BCNF]$
- $S5(A,B,E)$ $[BCNF]$

\textbf{NOTE: A SET OF ATTRIBUTES X IS A SUPERKEY IF X+ = ABCDE}$
A table $\text{S}(\text{A,B,C,D,E})$ : Example 3

Consider the following FDs:
- $\text{AB} \rightarrow \text{C}, \text{AB}^+ = \text{ABCD}$
- $\text{DE} \rightarrow \text{C}, \text{DE}^+ = \text{CDE}$
- $\text{B} \rightarrow \text{D}, \text{B}^+ = \text{BD}$

$\text{S}3(\text{A,B,E})$ [BCNF]

$\text{S}2(\text{A,B,C,E})$ [AB$^+$ = ABC $\neq$ ABCE]

$\text{S}4(\text{A,B,C})$ [BCNF]

$\text{S}5(\text{A,B,E})$ [BCNF]

3rd Solution:

maze.

$\text{S}(\text{A,B,C,D,E})$ [B$^+$ = BD $\neq$ ABCDE]

NOTE: A SET OF ATTRIBUTES X IS A SUPERKEY IF X$^+$ = ABCDE
Notes

• Project 1 due tomorrow January 21\textsuperscript{st}, 5pm
• Office hours 10:30-12 in 006

• Homework 1 is out, due January 28\textsuperscript{th}

• Course wiki is up
  • \url{https://cubist.cs.washington.edu/wiki/index.php/CSE444}
  • Good source of practice problems and explanations