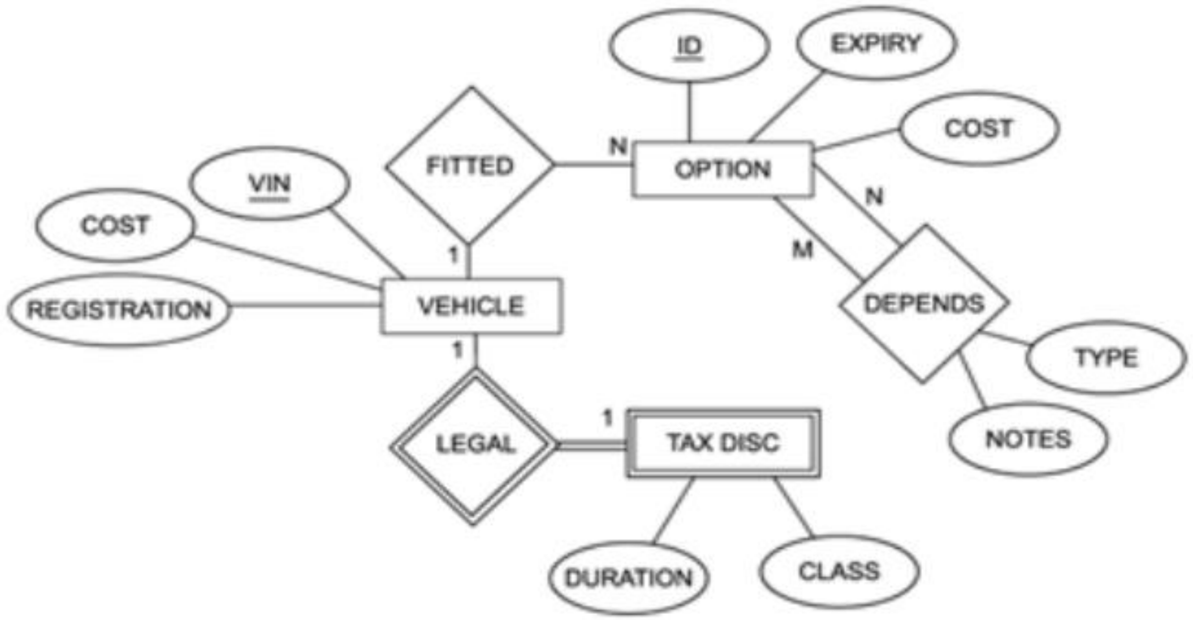
EXERCISE FROM LAST TIME

Translate the following ER Diagram into a relational database schema.



Vehicle(<u>VIN</u>,cost,registration)

Option(<u>ID</u>,expiry,cost)

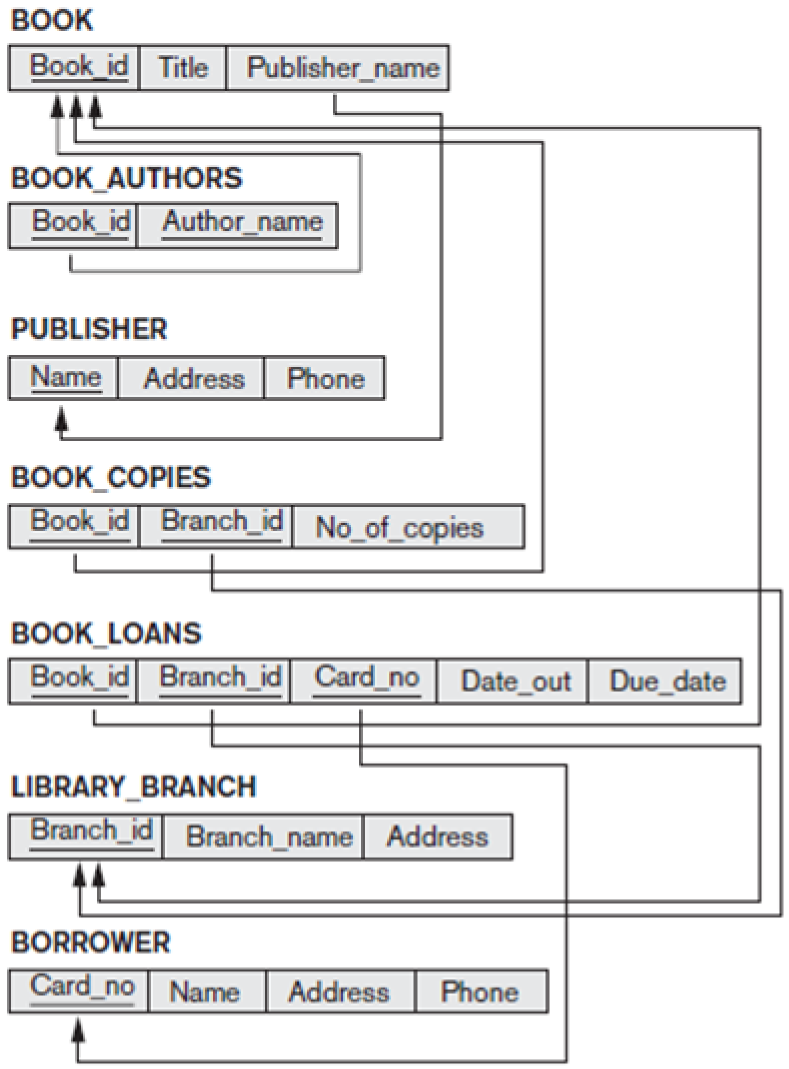
TaxDisc(<u>VIN</u>,duration,class)

Fitted(VIN,<u>ID</u>) *or augment Option(…) to be* Option(<u>ID</u>,expiry,cost,VIN)

Depends(<u>MasterID,SlaveID</u>,notes,type)

EXERCISE

What ER Diagram might produce the following relational database schema?



BOOK

Book_id	Title	Publisher_name

BOOK_AUTHORS

Book_id	Author_name

PUBLISHER

Name	Address	Phone

BOOK_COPIES

Book_id	Branch_id	No_of_copies

BOOK_LOANS

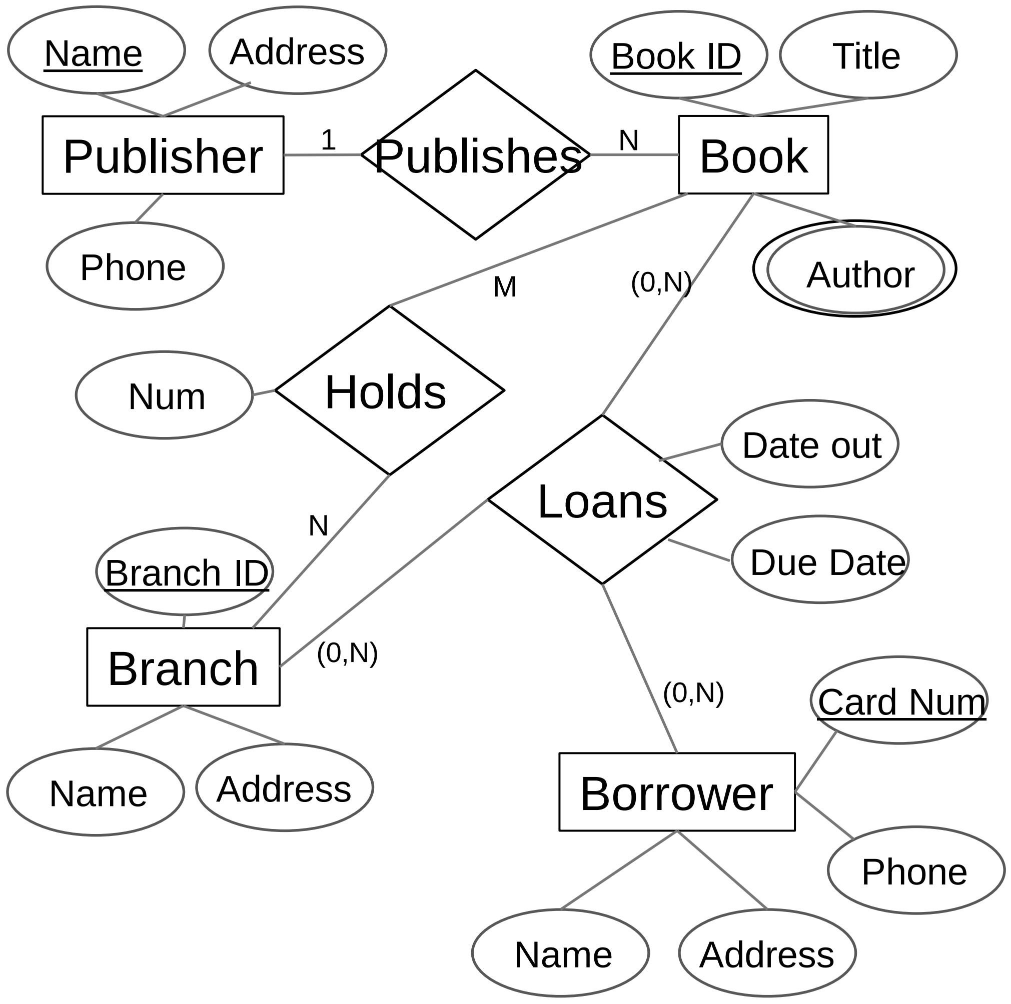
Book_id	Branch_id	Card_no	Date_out	Due_date

LIBRARY_BRANCH

Branch_id	Branch_name	Address

BORROWER

Card_no	Name	Address	Phone



FUNCTIONAL DEPENDENCIES

CHAPTER 15.1-15.2, 15.5 (6/E)

CHAPTER 10.1-10.2, 10.5 (5/E)

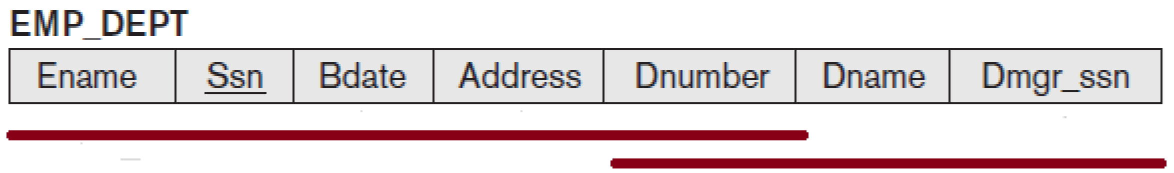
CHAPTER 15 OUTLINE

- Design guidelines for relation schemas
- Functional dependencies
  - Definition and interpretation
  - Formal definition of keys
- Boyce-Codd Normal Form (BCNF)
  - Application of dependency theory to checking DB design

GOODNESS IN RELATIONAL DESIGN

- Clarity of attributes provides semantics for relation schema.
  - Naming of attributes
  - *Fit* of attributes with each other
  - **Guideline 1**
    - Design each relation schema so that it is easy to explain its meaning.
      - Natural result of good ER design
    - Do not arbitrarily combine attributes from multiple entity types and relationship types into a single relation.
- How can we measure how well attributes fit together?
  - Amount of redundant information in tuples
  - Amount of NULL values in tuples
  - Possibility of generating spurious tuples

MIS-PACKAGED ATTRIBUTES



EMP_DEPT

Ename	<u>Ssn</u>	Bdate	Address	Dnumber	Dname	Dmgr_ssn

- Every tuple includes employee data and department data
- Redundancy
  - Dept name and manager id repeated for every employee in dept
- Potential for too many NULL values
  - Departments with no employees need to pad tuple with NULLS
  - Employees not in any department need to pad tuples with NULLS
- Update anomalies
  - Deleting the last employee in a dept should not delete dept
  - Changing the dept name/mgr requires many tuples to be updated
  - Inserting employees requires checking for consistency of its dept name and manager
- **Guideline 2**
  - Design relational DB schema so that every fact can be stored in one and only one tuple.

SIMPLE DEPENDENCIES

Actor

name	birth	city
Ben Affleck	1972	Berkeley
Alan Arkin	1934	New York
Tommy Lee Jones	1946	San Saba
John Wells	1957	Alexandria
Steven Spielberg	1946	Cincinnati
Daniel Day-Lewis	1957	Greenwich

- *Assume that no two actors have the same name*.
- Each actor has a unique date and city of birth.
- Therefore, given an actor's `name`, there is only one possible value for `birth` and for `city`.
  - `name → birth`
  - `name → city`
- However, given a birth year, we do not have a unique corresponding name or city.
  - `birth ↛ name`
  - `birth ↛ city`
- Cannot tell from example whether or not city determines name or birth

FUNCTIONAL DEPENDENCY

- Constraint between two sets of attributes from the database

> Given relation scheme $R(A_1,A_2,\ldots,A_n)$ and sets of attributes $X \subseteq \{A_1,A_2,\ldots,A_n\}$, $Y \subseteq \{A_1,A_2,\ldots,A_n\}$, $X \rightarrow Y$ specifies the following constraint: for *any* tuples t_1 and t_2 in *any* valid relation state r of R, if $t_1[X] = t_2[X]$ then $t_1[Y] = t_2[Y]$.

- Property of semantics or meaning of the attributes
- Recognized and recorded as part of database design
- Given a relation state
  - Cannot determine which functional dependencies hold
  - Can state that functional dependency does not hold if there are tuples that show violation of the dependency
- Write $\{B_1,B_2,\ldots,B_i\} \rightarrow \{C_1,C_2,\ldots,C_j\}$ but can omit set braces if *i*=1 or *j*=1, respectively.
  - $\{name\} \rightarrow \{birth,city\}$ or $name \rightarrow \{birth,city\}$

TRIVIAL FUNCTIONAL DEPENDENCIES

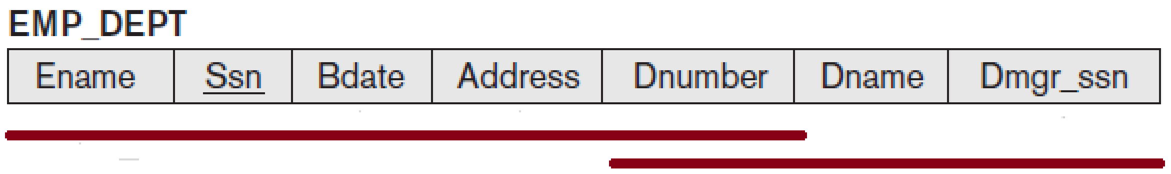
- Some dependencies must always hold
  - {birth, date} $\rightarrow$ {birth, date}
  - {birth, date} $\rightarrow$ date
  - {birth, date} $\rightarrow$ birth
- For any relation schema R and subsets of attributes X and Y in R, if Y $\subseteq$ X, then X$\rightarrow$ Y.

ANOTHER LOOK AT KEYS

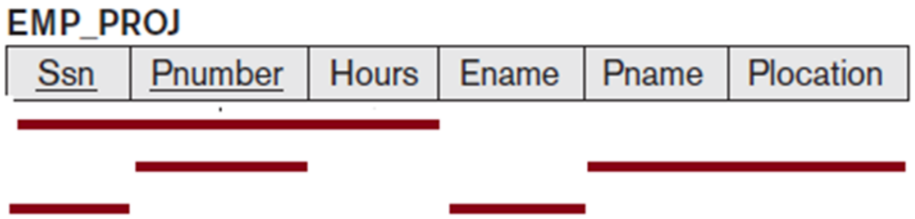
- Assume that EMPLOYEE(EmpNo, FirstName, LastName, Department, Email, Phone) has keys:
    1. EmpNo
    2. Email
    3. (FirstName, LastName, Department)
- Some functional dependencies:
    - EmpNo$\rightarrow$ {EmpNo ,FirstName, LastName, Department, Email, Phone}
    - Email $\rightarrow$ {EmpNo ,FirstName, LastName, Department, Email, Phone}
    - {FirstName, LastName, Department} $\rightarrow$ {EmpNo ,FirstName, LastName, Department, Email, Phone}
    - {EmpNo, Email, Phone} $\rightarrow$ {EmpNo ,FirstName, LastName, Department, Email, Phone}
- Given relation scheme $R(A_1,A_2,\ldots,A_n)$ and set of attributes X in R. X is a superkey for R if $X \rightarrow \{A_1,A_2,\ldots,A_n\}$.
    - Often written as $X \rightarrow R$
- To determine that X is a key, need to also show that no proper subset of X determines R
    - $\nexists Y$ such that $Y \subsetneq X$ and $Y \rightarrow R$

BOYCE-CODD NORMAL FORM

- A relation schema R is in **Boyce-Codd Normal Form** (**BCNF**) if whenever a nontrivial functional dependency $X \rightarrow A$ holds in R, then X is a superkey of R.
  - If $X \rightarrow A$ and $A \notin X$, then $X \rightarrow R$
- Relation schemas in BCNF avoid the problems of redundancy
  - We won't worry about *other normal forms* in this class.
  - Examples



- Dnumber $\rightarrow$ {Dname, Dmgr_ssn} but Dnumber $\nrightarrow$ Ename



- Pnumber $\rightarrow$ {Pname, Plocation} but Dnumber $\nrightarrow$ SSn
- SSn $\rightarrow$ Ename but SSn $\nrightarrow$ Pnumber

SUMMARY

- Informal guidelines for good design
- Functional dependency
  - Basic tool for analyzing relational schemas
  - Check for Boyce-Codd Normal Form (BCNF) to validate designs