2.12 Consider the relational database of Figure 2.14. Give an expression in the relational algebra to express each of the following queries:

a. Find the names of all employees who work for "First Bank Corporation".

b. Find the names and cities of residence of all employees who work for "First Bank Corporation".

c. Find the names, street address, and cities of residence of all employees who work for "First Bank Corporation" and earn more than $10,000.

2.13 Consider the bank database of Figure 2.15. Give an expression in the relational algebra for each of the following queries:

a. Find all loan numbers with a loan value greater than $10,000.

b. Find the names of all depositors who have an account with a value greater than $6,000.

c. Find the names of all depositors who have an account with a value greater than $6,000 at the "Uptown" branch.

2.14 List two reasons why null values might be introduced into the database.

2.15 Discuss the relative merits of procedural and nonprocedural languages.

bibliographical Notes

E. F. Codd of the IBM San Jose Research Laboratory proposed the relational model in the late 1960s (Codd [1970]). This work led to the prestigious ACM Turing Award to Codd in 1981 (Codd [1982]).

After Codd published his original paper, several research projects were formed with the goal of constructing practical relational database systems, including System R at the IBM San Jose Research Laboratory, Ingres at the University of California at Berkeley, and Query-by-Example at the IBM T. J. Watson Research Center.

Many relational database products are now commercially available. These include IBM’s DB2 and Informix, Oracle, Sybase, and Microsoft SQL Server. Open source relational database systems include MySQL and PostgreSQL. Microsoft Access is a single-user database product that is part of the Microsoft Office suite.

Atzeni and Antonellis [1993], Maier [1983], and Abiteboul et al. [1995] are texts devoted exclusively to the theory of the relational data model.
Chapter 2  Introduction to the Relational Model

branch(branch_name, branch_city, assets)
customer (customer_name, customer_street, customer_city)
loan (loan_number, branch_name, amount)
borrower (customer_name, loan_number)
account (account_number, branch_name, balance)
depositor (customer_name, account_number)

Figure 2.15  Banking database for Exercises 2.8, 2.9, and 2.13.

2.6  Consider the following expressions, which use the result of a relational algebra operation as the input to another operation. For each expression, explain in words what the expression does.

a. \( \sigma_{\text{year} \geq 2009}(\text{takes}) \bowtie \text{student} \)
b. \( \sigma_{\text{year} \geq 2009}(\text{takes} \bowtie \text{student}) \)
c. \( \Pi_{\text{ID, name, course_id}}(\text{student} \bowtie \text{takes}) \)

2.7  Consider the relational database of Figure 2.14. Give an expression in the relational algebra to express each of the following queries:

a. Find the names of all employees who live in city “Miami”.
b. Find the names of all employees whose salary is greater than $100,000.
c. Find the names of all employees who live in “Miami” and whose salary is greater than $100,000.

2.8  Consider the bank database of Figure 2.15. Give an expression in the relational algebra for each of the following queries.

a. Find the names of all branches located in “Chicago”.
b. Find the names of all borrowers who have a loan in branch “Downtown”.

Exercises

2.9  Consider the bank database of Figure 2.15.

a. What are the appropriate primary keys?
b. Given your choice of primary keys, identify appropriate foreign keys.

2.10  Consider the advisor relation shown in Figure 2.8, with s.id as the primary key of advisor. Suppose a student can have more than one advisor. Then, would s.id still be a primary key of the advisor relation? If not, what should the primary key of advisor be?

2.11  Describe the difference...
- Candidate key
- Primary key
- Foreign key
  - Referencing relation
  - Referenced relation
- Selection of tuples
- Selection of attributes
- Natural join
- Cartesian product
- Set operations
- Relational algebra

### Exercise

2.1 Consider the relational database of Figure 2.14. What are the appropriate primary keys?

2.2 Consider the foreign key constraint from the dept.name attribute of instructor to the department relation. Give examples of inserts and deletes to these relations, which can cause a violation of the foreign key constraint.

2.3 Consider the time_slot relation. Given that a particular time slot can meet more than once in a week, explain why day and start_time are part of the primary key of this relation, while end_time is not.

2.4 In the instance of instructor shown in Figure 2.1, no two instructors have the same name. From this, can we conclude that name can be used as a superkey (or primary key) of instructor?

2.5 What is the result of first performing the cross product of student and advisor, and then performing a selection operation on the result with the predicate s.id = ID? (Using the symbolic notation of relational algebra, this query can be written as \( \sigma_{s.id=ID}(\text{student} \times \text{advisor}) \).)

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employee (person.name, street, city)
works (person.name, company.name, salary)
company (company.name, city)
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**Figure 2.14** Relational database for Exercises 2.1, 2.7, and 2.12.