

Alternative Diagrammatic Notations for ER Models

Figure A.1 shows a number of different diagrammatic notations for representing ER and EER model concepts. Unfortunately, there is no standard notation: different database design practitioners prefer different notations. Similarly, various **CASE** (computer-aided software engineering) tools and **OOA** (object-oriented analysis) methodologies use various notations. Some notations are associated with models that have additional concepts and constraints beyond those of the ER and EER models described in Chapters 7 through 9, while other models have fewer concepts and constraints. The notation we used in Chapter 7 is quite close to the original notation for ER diagrams, which is still widely used. We discuss some alternate notations here.

Figure A.1(a) shows different notations for displaying entity types/classes, attributes, and relationships. In Chapters 7 through 9, we used the symbols marked (i) in Figure A.1(a)—namely, rectangle, oval, and diamond. Notice that symbol (ii) for entity types/classes, symbol (ii) for attributes, and symbol (ii) for relationships are similar, but they are used by different methodologies to represent three different concepts. The straight line symbol (iii) for representing relationships is used by several tools and methodologies.

Figure A.1(b) shows some notations for attaching attributes to entity types. We used notation (i). Notation (ii) uses the third notation (iii) for attributes from Figure A.1(a). The last two notations in Figure A.1(b)—(iii) and (iv)—are popular in OOA methodologies and in some CASE tools. In particular, the last notation displays both the attributes and the methods of a class, separated by a horizontal line.

Figure A.1
Alternative notations. (a) Symbols for entity type/class, attribute, and relationship. (b) Displaying attributes. (c) Displaying cardinality ratios. (d) Various (min, max) notations. (e) Notations for displaying specialization/generalization.

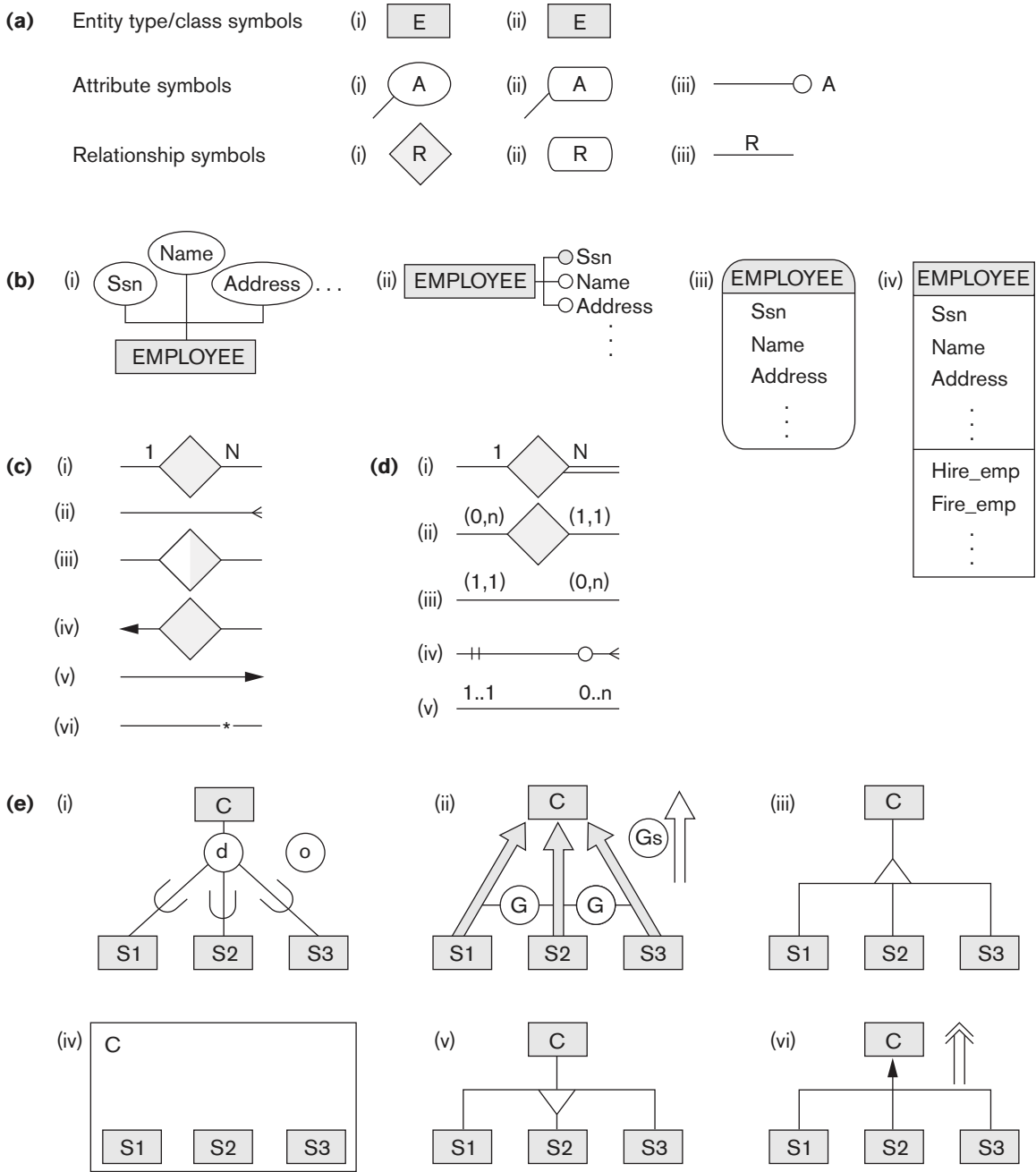


Figure A.1(c) shows various notations for representing the cardinality ratio of binary relationships. We used notation (i) in Chapters 7 through 9. Notation (ii)—known as the *chicken feet* notation—is quite popular. Notation (iv) uses the arrow as a functional reference (from the N to the 1 side) and resembles our notation for foreign keys in the relational model (see Figure 9.2); notation (v)—used in *Bachman diagrams* and the network data model—uses the arrow in the *reverse direction* (from the 1 to the N side). For a 1:1 relationship, (ii) uses a straight line without any chicken feet; (iii) makes both halves of the diamond white; and (iv) places arrowheads on both sides. For an M:N relationship, (ii) uses chicken feet at both ends of the line; (iii) makes both halves of the diamond black; and (iv) does not display any arrowheads.

Figure A.1(d) shows several variations for displaying (min, max) constraints, which are used to display both cardinality ratio and total/partial participation. We mostly used notation (i). Notation (ii) is the alternative notation we used in Figure 7.15 and discussed in Section 7.7.4. Recall that our notation specifies the constraint that each entity must participate in at least min and at most max relationship instances. Hence, for a 1:1 relationship, both max values are 1; for M:N, both max values are n. A min value greater than 0 (zero) specifies total participation (existence dependency). In methodologies that use the straight line for displaying relationships, it is common to *reverse the positioning* of the (min, max) constraints, as shown in (iii); a variation common in some tools (and in UML notation) is shown in (v). Another popular technique—which follows the same positioning as (iii)—is to display the *min* as o (“oh” or circle, which stands for zero) or as | (vertical dash, which stands for 1), and to display the max as | (vertical dash, which stands for 1) or as chicken feet (which stands for n), as shown in (iv).

Figure A.1(e) shows some notations for displaying specialization/generalization. We used notation (i) in Chapter 8, where a d in the circle specifies that the subclasses (S1, S2, and S3) are disjoint and an o in the circle specifies overlapping subclasses. Notation (ii) uses G (for generalization) to specify disjoint, and Gs to specify overlapping; some notations use the solid arrow, while others use the empty arrow (shown at the side). Notation (iii) uses a triangle pointing toward the superclass, and notation (v) uses a triangle pointing toward the subclasses; it is also possible to use both notations in the same methodology, with (iii) indicating generalization and (v) indicating specialization. Notation (iv) places the boxes representing subclasses within the box representing the superclass. Of the notations based on (vi), some use a single-lined arrow, and others use a double-lined arrow (shown at the side).

The notations shown in Figure A.1 show only some of the diagrammatic symbols that have been used or suggested for displaying database conceptual schemes. Other notations, as well as various combinations of the preceding, have also been used. It would be useful to establish a standard that everyone would adhere to, in order to prevent misunderstandings and reduce confusion.

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Parameters of Disks

The most important disk parameter is the time required to locate an arbitrary disk block, given its block address, and then to transfer the block between the disk and a main memory buffer. This is the random access time for accessing a disk block. There are three time components to consider as follows:

1. **Seek time (s).** This is the time needed to mechanically position the read/write head on the correct track for movable-head disks. (For fixed-head disks, it is the time needed to electronically switch to the appropriate read/write head.) For movable-head disks, this time varies, depending on the distance between the current track under the read/write head and the track specified in the block address. Usually, the disk manufacturer provides an average seek time in milliseconds. The typical range of average seek time is 4 to 10 msec. This is the main *culprit* for the delay involved in transferring blocks between disk and memory.
2. **Rotational delay (rd).** Once the read/write head is at the correct track, the user must wait for the beginning of the required block to rotate into position under the read/write head. On average, this takes about the time for half a revolution of the disk, but it actually ranges from immediate access (if the start of the required block is in position under the read/write head right after the seek) to a full disk revolution (if the start of the required block just passed the read/write head after the seek). If the speed of disk rotation is p revolutions per minute (rpm), then the average rotational delay rd is given by

$$rd = (1/2) * (1/p) \text{ min} = (60 * 1000)/(2 * p) \text{ msec} = 30000/p \text{ msec}$$

A typical value for p is 10,000 rpm, which gives a rotational delay of $rd = 3$ msec. For fixed-head disks, where the seek time is negligible, this component causes the greatest delay in transferring a disk block.

3. **Block transfer time (*btt*)**. Once the read/write head is at the beginning of the required block, some time is needed to transfer the data in the block. This block transfer time depends on the block size, track size, and rotational speed. If the **transfer rate** for the disk is *tr* bytes/msec and the block size is *B* bytes, then

$$btt = B/tr \text{ msec}$$

If we have a track size of 50 Kbytes and *p* is 3600 rpm, then the transfer rate in bytes/msec is

$$tr = (50 * 1000)/(60 * 1000/3600) = 3000 \text{ bytes/msec}$$

In this case, *btt* = *B*/3000 msec, where *B* is the block size in bytes.

The average time (*s*) needed to find and transfer a block, given its block address, is estimated by

$$(s + rd + btt) \text{ msec}$$

This holds for either reading or writing a block. The principal method of reducing this time is to transfer several blocks that are stored on one or more tracks of the same cylinder; then the seek time is required for the first block only. To transfer consecutively *k noncontiguous* blocks that are on the same cylinder, we need approximately

$$s + (k * (rd + btt)) \text{ msec}$$

In this case, we need two or more buffers in main storage because we are continuously reading or writing the *k* blocks, as we discussed in Chapter 17. The transfer time per block is reduced even further when *consecutive blocks* on the same track or cylinder are transferred. This eliminates the rotational delay for all but the first block, so the estimate for transferring *k* consecutive blocks is

$$s + rd + (k * btt) \text{ msec}$$

A more accurate estimate for transferring consecutive blocks takes into account the interblock gap (see Section 17.2.1), which includes the information that enables the read/write head to determine which block it is about to read. Usually, the disk manufacturer provides a **bulk transfer rate (*btr*)** that takes the gap size into account when reading consecutively stored blocks. If the gap size is *G* bytes, then

$$btr = (B/(B + G)) * tr \text{ bytes/msec}$$

The bulk transfer rate is the rate of transferring *useful bytes* in the data blocks. The disk read/write head must go over all bytes on a track as the disk rotates, including the bytes in the interblock gaps, which store control information but not real data. When the bulk transfer rate is used, the time needed to transfer the useful data in one block out of several consecutive blocks is *B/btr*. Hence, the estimated time to read *k* blocks consecutively stored on the same cylinder becomes

$$s + rd + (k * (B/btr)) \text{ msec}$$

Another parameter of disks is the **rewrite time**. This is useful in cases when we read a block from the disk into a main memory buffer, update the buffer, and then write the buffer back to the same disk block on which it was stored. In many cases, the time required to update the buffer in main memory is less than the time required for one disk revolution. If we know that the buffer is ready for rewriting, the system can keep the disk heads on the same track, and during the next disk revolution the updated buffer is rewritten back to the disk block. Hence, the rewrite time T_{rw} , is usually estimated to be the time needed for one disk revolution:

$$T_{rw} = 2 * rd \text{ msec} = 60000/p \text{ msec}$$

To summarize, the following is a list of the parameters we have discussed and the symbols we use for them:

Seek time:	s msec
Rotational delay:	rd msec
Block transfer time:	btt msec
Rewrite time:	T_{rw} msec
Transfer rate:	tr bytes/msec
Bulk transfer rate:	btr bytes/msec
Block size:	B bytes
Interblock gap size:	G bytes
Disk speed:	p rpm (revolutions per minute)

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Overview of the QBE Language

The Query-By-Example (QBE) language is important because it is one of the first graphical query languages with minimum syntax developed for database systems. It was developed at IBM Research and is available as an IBM commercial product as part of the QMF (Query Management Facility) interface option to DB2. The language was also implemented in the Paradox DBMS, and is related to a point-and-click type interface in the Microsoft Access DBMS. It differs from SQL in that the user does not have to explicitly specify a query using a fixed syntax; rather, the query is formulated by filling in **templates** of relations that are displayed on a monitor screen. Figure C.1 shows how these templates may look for the database of Figure 3.5. The user does not have to remember the names of attributes or relations because they are displayed as part of these templates. Additionally, the user does not have to follow rigid syntax rules for query specification; rather, constants and variables are entered in the columns of the templates to construct an **example** related to the retrieval or update request. QBE is related to the domain relational calculus, as we shall see, and its original specification has been shown to be relationally complete.

C.1 Basic Retrievals in QBE

In QBE retrieval queries are specified by filling in one or more rows in the templates of the tables. For a single relation query, we enter either constants or **example elements** (a QBE term) in the columns of the template of that relation. An example element stands for a domain variable and is specified as an example value preceded by the underscore character (). Additionally, a P. prefix (called the P dot operator) is entered in certain columns to indicate that we would like to print (or display)

EMPLOYEE

Fname	Minit	Lname	<u>Ssn</u>	Bdate	Address	Sex	Salary	Super_ssn	Dno
-------	-------	-------	------------	-------	---------	-----	--------	-----------	-----

DEPARTMENT

Dname	<u>Dnumber</u>	Mgr_ssn	Mgr_start_date
-------	----------------	---------	----------------

DEPT_LOCATIONS

<u>Dnumber</u>	<u>Dlocation</u>
----------------	------------------

PROJECT

Pname	<u>Pnumber</u>	Plocation	Dnum
-------	----------------	-----------	------

WORKS_ON

<u>Essn</u>	<u>Pno</u>	Hours
-------------	------------	-------

DEPENDENT

<u>Essn</u>	<u>Dependent_name</u>	Sex	Bdate	Relationship
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Figure C.1
The relational schema of Figure 3.5 as it may be displayed by QBE.

values in those columns for our result. The constants specify values that must be exactly matched in those columns.

For example, consider the query Q0: *Retrieve the birth date and address of John B. Smith*. In Figures C.2(a) through C.2(d) we show how this query can be specified in a progressively more terse form in QBE. In Figure C.2(a) an example of an employee is presented as the type of row that we are interested in. By leaving John B. Smith as constants in the Fname, Minit, and Lname columns, we are specifying an exact match in those columns. The rest of the columns are preceded by an underscore indicating that they are domain variables (example elements). The P. prefix is placed in the Bdate and Address columns to indicate that we would like to output value(s) in those columns.

Q0 can be abbreviated as shown in Figure C.2(b). There is no need to specify example values for columns in which we are not interested. Moreover, because example values are completely arbitrary, we can just specify variable names for them, as shown in Figure C.2(c). Finally, we can also leave out the example values entirely, as shown in Figure C.2(d), and just specify a P. under the columns to be retrieved.

To see how retrieval queries in QBE are similar to the domain relational calculus, compare Figure C.2(d) with Q0 (simplified) in domain calculus as follows:

$$Q0 : \{ uv \mid EMPLOYEE(qrstuvwxyz) \text{ and } q='John' \text{ and } r='B' \text{ and } s='Smith'\}$$

(a) EMPLOYEE

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno
John	B	Smith	_123456789	P_9/1/60	P_100 Main, Houston, TX	_M	_25000	_123456789	_3

(b) EMPLOYEE

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno
John	B	Smith		P_9/1/60	P_100 Main, Houston, TX				

(c) EMPLOYEE

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno
John	B	Smith		P_X	P_Y				

(d) EMPLOYEE

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno
John	B	Smith		P.	P.				

Figure C.2

Four ways to specify the query Q0 in QBE.

We can think of each column in a QBE template as an *implicit domain variable*; hence, Fname corresponds to the domain variable q , Minit corresponds to r , ..., and Dno corresponds to z . In the QBE query, the columns with P. correspond to variables specified to the left of the bar in domain calculus, whereas the columns with constant values correspond to tuple variables with equality selection conditions on them. The condition EMPLOYEE(qrstuvwxyz) and the existential quantifiers are implicit in the QBE query because the template corresponding to the EMPLOYEE relation is used.

In QBE, the user interface first allows the user to choose the tables (relations) needed to formulate a query by displaying a list of all relation names. Then the templates for the chosen relations are displayed. The user moves to the appropriate columns in the templates and specifies the query. Special function keys are provided to move among templates and perform certain functions.

We now give examples to illustrate basic facilities of QBE. Comparison operators other than = (such as > or \geq) may be entered in a column before typing a constant value. For example, the query Q0A: *List the social security numbers of employees who work more than 20 hours per week on project number 1* can be specified as shown in Figure C.3(a). For more complex conditions, the user can ask for a **condition box**, which is created by pressing a particular function key. The user can then type the complex condition.¹

¹Negation with the \neg symbol is not allowed in a condition box.

Figure C.3

Specifying complex conditions in QBE. (a) The query Q0A. (b) The query Q0B with a condition box. (c) The query Q0B without a condition box.

(a)

Essn	Pno	Hours
P.		> 20

WORKS_ON

(b)

Essn	Pno	Hours
P.	_PX	_HX

CONDITIONS

_HX > 20 and (PX = 1 or PX = 2)

WORKS_ON

(c)

Essn	Pno	Hours
P.	1	> 20
P.	2	> 20

For example, the query Q0B: *List the social security numbers of employees who work more than 20 hours per week on either project 1 or project 2* can be specified as shown in Figure C.3(b).

Some complex conditions can be specified without a condition box. The rule is that all conditions specified on the same row of a relation template are connected by the **and** logical connective (*all* must be satisfied by a selected tuple), whereas conditions specified on distinct rows are connected by **or** (*at least one* must be satisfied). Hence, Q0B can also be specified, as shown in Figure C.3(c), by entering two distinct rows in the template.

Now consider query Q0C: *List the social security numbers of employees who work on both project 1 and project 2*; this cannot be specified as in Figure C.4(a), which lists those who work on *either* project 1 or project 2. The example variable _ES will bind itself to Essn values in <-, 1, -> tuples *as well as* to those in <-, 2, -> tuples. Figure C.4(b) shows how to specify Q0C correctly, where the condition (_EX = _EY) in the box makes the _EX and _EY variables bind only to identical Essn values.

In general, once a query is specified, the resulting values are displayed in the template under the appropriate columns. If the result contains more rows than can be displayed on the screen, most QBE implementations have function keys to allow scrolling up and down the rows. Similarly, if a template or several templates are too wide to appear on the screen, it is possible to scroll sideways to examine all the templates.

A join operation is specified in QBE by using the *same variable*² in the columns to be joined. For example, the query Q1: *List the name and address of all employees who*

²A variable is called an **example element** in QBE manuals.

WORKS_ON			
(a)	Essn	Pno	Hours
	P._ES	1	
	P._ES	2	

WORKS_ON			
(b)	Essn	Pno	Hours
	P._EX	1	
	P._EY	2	

CONDITIONS			
	_EX	=	_EY

Figure C.4

Specifying EMPLOYEES who work on both projects. (a) Incorrect specification of an AND condition. (b) Correct specification.

work for the 'Research' department can be specified as shown in Figure C.5(a). Any number of joins can be specified in a single query. We can also specify a **result table** to display the result of the join query, as shown in Figure C.5(a); this is needed if the result includes attributes from two or more relations. If no result table is specified, the system provides the query result in the columns of the various relations, which may make it difficult to interpret. Figure C.5(a) also illustrates the feature of QBE for specifying that all attributes of a relation should be retrieved, by placing the P. operator under the relation name in the relation template.

To join a table with itself, we specify different variables to represent the different references to the table. For example, query Q8: *For each employee retrieve the employee's first and last name as well as the first and last name of his or her immediate supervisor* can be specified as shown in Figure C.5(b), where the variables starting with E refer to an employee and those starting with S refer to a supervisor.

C.2 Grouping, Aggregation, and Database Modification in QBE

Next, consider the types of queries that require grouping or aggregate functions. A grouping operator *G.* can be specified in a column to indicate that tuples should be grouped by the value of that column. Common functions can be specified, such as AVG., SUM., CNT. (count), MAX., and MIN. In QBE the functions AVG., SUM., and CNT. are applied to distinct values within a group in the default case. If we want these functions to apply to all values, we must use the prefix ALL.³ This convention is *different* in SQL, where the default is to apply a function to all values.

³ALL in QBE is unrelated to the universal quantifier.

(a) EMPLOYEE

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno
_FN		_LN			_Addr				_DX

DEPARTMENT

Dname	Dnumber	Mgrssn	Mgr_start_date
Research	_DX		

RESULT			
P.	_FN	_LN	_Addr

(b) EMPLOYEE

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno
_E1		_E2						_Xssn	
_S1		_S2	_Xssn						

RESULT				
P.	_E1	_E2	_S1	_S2

Figure C.5

Illustrating JOIN and result relations in QBE. (a) The query Q1. (b) The query Q8.

Figure C.6(a) shows query Q23, which counts the number of *distinct* salary values in the EMPLOYEE relation. Query Q23A (Figure C.6(b)) counts all salary values, which is the same as counting the number of employees. Figure C.6(c) shows Q24, which retrieves each department number and the number of employees and average salary within each department; hence, the Dno column is used for grouping as indicated by the G. function. Several of the operators G., P., and ALL can be specified in a single column. Figure C.6(d) shows query Q26, which displays each project name and the number of employees working on it for projects on which more than two employees work.

QBE has a negation symbol, \neg , which is used in a manner similar to the NOT EXISTS function in SQL. Figure C.7 shows query Q6, which lists the names of employees who have no dependents. The negation symbol \neg says that we will select values of the _SX variable from the EMPLOYEE relation only if they do not occur in the DEPENDENT relation. The same effect can be produced by placing a \neg _SX in the Essn column.

Although the QBE language as originally proposed was shown to support the equivalent of the EXISTS and NOT EXISTS functions of SQL, the QBE implementation in QMF (under the DB2 system) does *not* provide this support. Hence, the QMF version of QBE, which we discuss here, is *not relationally complete*. Queries such as Q3: *Find employees who work on all projects controlled by department 5* cannot be specified.

(a) EMPLOYEE

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno
							P.CNT.		

(b) EMPLOYEE

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno
							P.CNT.ALL		

(c) EMPLOYEE

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno
			P.CNT.ALL				P.AVG.ALL		P.G.

(d) PROJECT

Pname	Pnumber	Plocation	Dnum
P.	_PX		

WORKS_ON

Essn	Pno	Hours
P.CNT.EX	G._PX	

CONDITIONS

CNT._EX > 2

Figure C.6

Functions and grouping in QBE.

(a) The query Q23. (b) The query Q23A.

(c) The query Q24. (d) The query Q26.

EMPLOYEE

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno
P.		P.	_SX						

DEPENDENT

Essn	Dependent_name	Sex	Bdate	Relationship
_SX				

Figure C.7

Illustrating negation by the query Q6.

There are three QBE operators for modifying the database: I. for insert, D. for delete, and U. for update. The insert and delete operators are specified in the template column under the relation name, whereas the update operator is specified under the columns to be updated. Figure C.8(a) shows how to insert a new EMPLOYEE tuple. For deletion, we first enter the D. operator and then specify the tuples to be deleted by a condition (Figure C.8(b)). To update a tuple, we specify the U. operator under the attribute name, followed by the new value of the attribute. We should also select the tuple or tuples to be updated in the usual way. Figure C.8(c) shows an update

(a) EMPLOYEE

	Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno
I.	Richard	K	Marini	653298653	30-Dec-52	98 Oak Forest, Katy, TX	M	37000	987654321	4

(b) EMPLOYEE

	Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno
D.				653298653						

(c) EMPLOYEE

	Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno
	John		Smith					U_S*1.1		U.4

Figure C.8

Modifying the database in QBE. (a) Insertion. (b) Deletion. (c) Update in QBE.

request to increase the salary of 'John Smith' by 10 percent and also to reassign him to department number 4.

QBE also has data definition capabilities. The tables of a database can be specified interactively, and a table definition can also be updated by adding, renaming, or removing a column. We can also specify various characteristics for each column, such as whether it is a key of the relation, what its data type is, and whether an index should be created on that field. QBE also has facilities for view definition, authorization, storing query definitions for later use, and so on.

QBE does not use the *linear* style of SQL; rather, it is a *two-dimensional* language because users specify a query moving around the full area of the screen. Tests on users have shown that QBE is easier to learn than SQL, especially for nonspecialists. In this sense, QBE was the *first* user-friendly *visual* relational database language.

More recently, numerous other user-friendly interfaces have been developed for commercial database systems. The use of menus, graphics, and forms is now becoming quite common. Filling forms partially to issue a search request is akin to using QBE. Visual query languages, which are still not so common, are likely to be offered with commercial relational databases in the future.

Bibliography

Abbreviations Used in the Bibliography

ACM: Association for Computing Machinery
AFIPS: American Federation of Information Processing Societies
ASPLOS: Proceedings of the international Conference on Architectural Support for Programming Languages and Operating Systems
CACM: Communications of the ACM (journal)
CIKM: Proceedings of the International Conference on Information and Knowledge Management
DASFAA: Proceedings of the International Conference on Database Systems for Advanced Applications
DKE: Data and Knowledge Engineering, Elsevier Publishing (journal)
EDBT: Proceedings of the International Conference on Extending Database Technology
EDS: Proceedings of the International Conference on Expert Database Systems
ER Conference: Proceedings of the International Conference on Entity-Relationship Approach (now called International Conference on Conceptual Modeling)
ICDCS: Proceedings of the IEEE International Conference on Distributed Computing Systems
ICDE: Proceedings of the IEEE International Conference on Data Engineering
IEEE: Institute of Electrical and Electronics Engineers
IEEE Computer: Computer magazine (journal) of the IEEE CS
IEEE CS: IEEE Computer Society
IFIP: International Federation for Information Processing
JACM: Journal of the ACM
KDD: Knowledge Discovery in Databases
LNCS: Lecture Notes in Computer Science
NCC: Proceedings of the National Computer Conference (published by AFIPS)
OOPSLA: Proceedings of the ACM Conference on Object-Oriented Programming Systems, Languages, and Applications
OSDI: USENIX Symposium on Operating Systems Design and Implementation
PAMI: Pattern Analysis and Machine Intelligence
PODS: Proceedings of the ACM Symposium on Principles of Database Systems

SIGMETRICS: Proceedings of ACM International Conference on Measurement and Modeling of Computer Systems
SIGMOD: Proceedings of the ACM SIGMOD International Conference on Management of Data
SOSP: ACM Symposium on Operating System Principles
TKDE: IEEE Transactions on Knowledge and Data Engineering (journal)
TOCS: ACM Transactions on Computer Systems (journal)
TODS: ACM Transactions on Database Systems (journal)
TOIS: ACM Transactions on Information Systems (journal)
TOOIS: ACM Transactions on Office Information Systems (journal)
TPDS: IEEE Transactions of Parallel and Distributed Systems (journal)
TSE: IEEE Transactions on Software Engineering (journal)
VLDB: Proceedings of the International Conference on Very Large Data Bases (issues after 1981 available from Morgan Kaufmann, Menlo Park, California)

Format for Bibliographic Citations

Book titles are in boldface—for example, **Database Computers**. Conference proceedings names are in italics—for example, *ACM Pacific Conference*. Journal names are in boldface—for example, **TODS** or **Information Systems**. For journal citations, we give the volume number and issue number (within the volume, if any) and date of issue. For example, “**TODS**, 3:4, December 1978” refers to the December 1978 issue of *ACM Transactions on Database Systems*, which is Volume 3, Number 4. Articles that appear in books or conference proceedings that are themselves cited in the bibliography are referenced as “in” these references—for example, “in *VLDB* [1978]” or “in Rustin [1974].” Page numbers (abbreviated “pp.”) are provided with pp. at the end of the citation whenever available. For citations with more than four authors, we will give the first author only followed by et al. In the selected bibliography at the end of each chapter, we use et al. if there are more than two authors.

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