Appendix B

The University Lab: Conceptual Design

Preview

The pieces of the database design puzzle come together in this appendix and Appendix C, The University Lab: Conceptual Design Verification, Logical Design, and Implementation. You will develop a conceptual database design by using the ideas and techniques presented in Chapter 4, Entity Relationship (ER) Modeling; Chapter 5, Advanced Data Modeling; Chapter 6, Normalization of Database Tables; and Chapter 9, Database Design.

You will see the evolution of a database system, starting with the results of the database initial study and moving through a conceptual design's initial ER diagram. In Appendix D, Converting an ER Model into a Database Structure, you will see how a conceptual design is evaluated and transformed into a logical design that can be implemented in any relational DBMS environment.

Data Files and Available Formats

MS Access | Oracle | MS SQL | My SQL

MS Access | Oracle | MS SQL | My SQL

There are no data files for this appendix.

Data Files Available on cengagebrain.com

Many years of teaching database design have taught the authors a valuable lesson: If you have never stepped through a complete example of database design, chances are that you will not be able to successfully design and implement a database system.

"**I hear it and I forget it, I see it and I remember it, I do it and I learn it.**"
—Old Chinese proverb

The example will be the automation of a large university computer lab. Because the design detailed in this appendix is based on a real project, you will confront a few real-world problems and develop some important analytical skills.

A well-functioning system represents the culmination of several small steps. To follow the steps, but avoid getting lost in details, use Table B.1 as your map. Table B.1 shows that this appendix will take you through the first phase of a conceptual database design, through its initial ER model. The remaining database design tasks outlined in Table B.1 will be completed in Appendix C.

TABLE B.1

DATABASE DESIGN MAP FOR THE UNIVERSITY COMPUTER LAB (UCL)

DATABASE LIFE CYCLE PHASE	OUTPUT	SECTION
Database initial study	UCL objectives	B-1a
	Organizational structure	B-1b
	Description of operations[1]	B-1c
	Problems and constraints	B-1d
	System objectives	B-1e
	Scope and boundaries	B-1f
Database design		
Conceptual design	Information sources and users	B-2a
	Information needs: user requirements	B-2b
	The initial ER model	B-2c
	Defining attributes and domains	B-1–B-2
Continued in Appendix C	**Continued in Appendix C**	
Logical design	Normalization	C-2
	ER model verification	C-3
Physical design	Tables	C-4a
	Indexes and views	C-4b
	Access methods	C-5
Implementation		
	Creation of databases	C-6a
	Database loading and conversion	C-6b
	System procedures	C-6c
Testing and evaluation		
	Performance measures	C-7a
	Security measures	C-7b
	Backup and recovery procedures	C-7c
Operation		
	Database is operational	C-8a
	Operational procedures	C-8b

[1] The term *description of operations* is sometimes used as a synonym for the database initial study. However, the use of that synonym is appropriate only when the "operations" encompass the organization's entire data environment, rather than just the transaction component of the data environment. This appendix will use the label "description of operations" in its more restrictive sense.

Many of the small steps in Table B.1 might appear to be trivial at first glance. Don't be tempted to overlook or rush through them. Those little details may make the difference between design success and failure. Later, it will be much easier to discard unnecessary details than to address omissions.

Database design is "detail" work. The details in this example should give you a better grasp of a design process that sometimes appears to be disorganized.

B-1 The Database Initial Study

The database initial study is basically a detailed description of an organization's current and proposed database system environments. Therefore, the database initial study must include a careful accounting of the organization's objectives, its structure, its operations, its problems and constraints, the system's objectives, the system's scope and boundaries, the information sources and users, and the end-user requirements.

A real-world database initial study is likely to have hundreds of pages because detail and accuracy are essential. The need for such detail and accuracy is obvious when you realize that the database design is based on the business rules derived from the database initial study. If the database initial study lacks detail and/or accuracy, the business rules are likely to be incomplete or inaccurate. It follows that the database design based on such business rules is destined to fail.

The information contained in the database initial study is, to a large extent, the product of interviews with key end users. Those people are the system's main beneficiaries and must be identified carefully. The key users of the University Computer Lab application developed in this appendix are:

- The assistant dean (dean) of the College of Business.
- The computer lab director (CLD), who is charged with the Lab's operational management.
- The computer lab assistants (LAs), who are charged with the Lab's daily operations.
- The computer lab secretary (CLS), who assists in the Lab's general administrative functions.
- The computer lab's graduate assistants (GAs), who work under the lab director to provide technical support and training to faculty and staff using the College of Business resources.

In the interest of brevity, only a few excerpts of the numerous interviews that were undertaken for this project will be shown.

B-1a UCL Objectives

The University Computer Lab (UCL) is in a central location on campus and is accessible by all university students regardless of major. The UCL provides access to many resources, including 200 computers, laser printers, and scanners, to all university members. The UCL provides service and support to a group of users composed of faculty, staff, and students. The Lab's objectives are to:

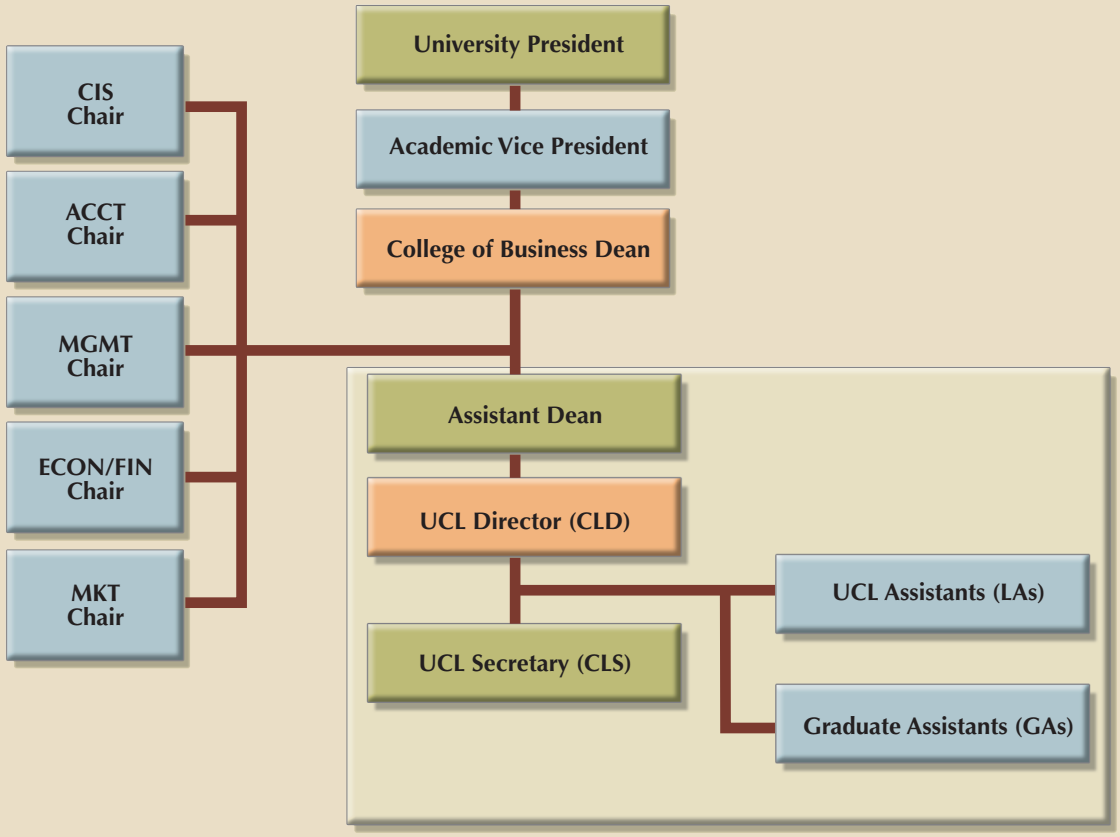
- Provide users with controlled access to the UCL's assets, such as computers, printers, supplies, application software, and software documentation.
- Guide users working with the UCL's assets and provide general problem-solving services. Those services are primarily designed to help users with basic computing operations, such as disk formatting, file copying, (approved), software installation, and basic startup and shutdown procedures.

B-1b Organizational Structure

Understanding the UCL's organizational structure helps the designer define the organization's lines of communication and establish appropriate reporting requirements. (See Figure B.1.)

The computer lab director (CLD) manages all of the UCL's operational functions. The CLD is assisted by the computer lab secretary (CLS). Graduate assistants (GAs) and undergraduate students work in the Lab as lab assistants (LAs). The CLD reports to the assistant dean of the College of Business, who reports to the College of Business dean, who, in turn, reports to the university's academic vice president, who reports to the university president. Although most of the university's chain of command for the College of Business is shown in Figure B.1, the design will focus exclusively on the UCL operations. However, because the other four department chairs receive periodic lab usage summaries, provide feedback to the UCL's director, and contribute to the UCL's funding based on lab usage, they are included in Figure B.1.

FIGURE B.1 THE UCL'S ORGANIZATIONAL STRUCTURE



CIS = Computer Information Systems
ACCT = Accounting
MGMT = Marketing/Management
MKT = Marketing
UCL = University Computer Lab

Note

The structure shown in Figure B.1 omits details that do not affect the UCL's database design. For example, neither the purchasing department nor the other university colleges and their departments have been shown within the organizational structure because they are not within the UCL's reporting channels. For the same reason, other components of the university's organizational structure are not included in Figure B.1.

Figure B.1 is useful in these ways:

- It facilitates communication between the system's end user(s) and the system's designer(s). Knowledge of the organizational structure helps you define information requirements. (Who needs what information, in what form, and when?)
- It helps system end users specify and clarify areas of responsibility. (Where do I fit into the picture? What is my job?)

Knowing the complete organizational structure is important even when a system is designed for only one component because the system might be expanded later to include other parts of the structure. The designer must keep in mind that different departments might have different, and sometimes conflicting, views of the data and/or the system requirements. The job of the database designer is to develop a common and shared view of data within the organization.

B-1c Description of Operations

Once the UCL's objectives and organizational structure are defined, it is time to study the operations. The UCL has six types of operations. They are organized as inventory/storage/order management, equipment maintenance and repair management, equipment check-out and check-in management, lab assistant payroll management, lab reservations management, and lab access management.

Inventory/Storage/Order Management The UCL's items are classified as hardware, software, literature, and supplies.

- *Hardware* includes computers, terminals, printers, and so on.
- *Software* includes all application programs, such as spreadsheets, word-processing software, statistical software, and database software.
- *Literature* includes reference texts and software manuals.
- *Supplies* include all consumables, such as printer ribbons and paper.

Each inventory item is classified by inventory type, and inventory type is used to group all similar items. The inventory type defines a four-part hierarchy: the inventory category, the class, the type, and the subtype. Table B.2 illustrates the hierarchy.

TABLE B.2

INVENTORY TYPE HIERARCHY

ITEM	CATEGORY	CLASS	TYPE	SUBTYPE
Computer, Intel i5, 2.3 GHz	Hardware	Computer	Desktop	Dual core
Laser printer paper, 8.5" x 11"	Supply	Paper	Laser	8.5" x 11"
CDs, blank rewritable	Supply	CD	Blank	R/W

The database designer(s) and the end users must work together to develop a complete and implementable definition of the appropriate inventory type hierarchy. That collaboration also yields appropriate identification codes and descriptions for each inventory type.

The inventory type also plays an important role in the way inventory items and quantities are recorded. For example, some inventory items do not require individual component tracking. Those inventory items, called **nonserialized items**, include laser printer paper, CDs, and other nondurable supplies. The term *nonserialized* means that the items do not require tracking by an assigned serial number or code. (Keeping track of individual reams of laser printer paper hardly seems appropriate.) On the other hand, durable inventory items, such as computers and printers, require careful tracking with serial numbers or other codes. Therefore, durable inventory items are referred to as **serialized items**.

nonserialized items
Items for which the attributes describe a generalized view of the that kind of item, without identifying each individual instance of the item.

serialized items
Items for which each instance of the item must be tracked as an individually identifiable item.

The assignment of serial numbers or codes enables end users to track an item's location, user, status, and other relevant information. Keep in mind that although hardware is *usually* considered to be a serialized item, the end users and organizational policies create the business rules that define the extent of the serialized and nonserialized classifications.

The inventory's items are updated when:

- An ordered item is received.
- An item is checked out of inventory or checked into inventory by a lab user.
- A consumable item (such as paper or an ink cartridge) is withdrawn from inventory for use.
- The CLD must adjust the inventory. For example, if a physical inventory check reveals that a box of paper is missing, the quantity on hand for that item must be adjusted.

University regulations specify that if a requisition is issued for an amount exceeding $500, a university-wide committee must approve the purchase. Once approved, the requisition is sent to the purchasing department for bidding and purchasing.

Note

Generic Rule

The university-wide committee requires the CLD to request items without specifying a specific brand and/or vendor unless the CLD can document compatibility problems. You will discover later that such a generic requirement has an effect on the entity attribute selection. For example, you must define equipment by inventory type, as follows:

- Category: Hardware
- Class: Computer
- Type: Desktop
- Subtype: Dual Core

A sample requisition for the proposed purchase of five computers would be written this way: Five (5) computers with the following characteristics: latest generation Intel processor, 19" LCD monitor, minimum 500 GB hard disk, Gigabyte Ethernet card, latest Windows operating system, and MS Office suite.

An exception to the generic rule is made only when an item is purchased under state contract. Approved items not purchased under the state contract are sent out for bids. The purchasing department sends a purchase order to the vendor who makes the winning bid. A copy of the purchase order is sent to the UCL. After receiving the item, the UCL issues a payment authorization to the university accounts payable department for payment of the purchase order.

When the item is received, it might be placed in the UCL to be used or it might be stored. There are several storage locations; each can contain many different kinds of items, and each type of item can be stored in several different locations. For example, three printers might be distributed by storing one in location A and placing the other two in the UCL for immediate use. Supplies are withdrawn from storage as needed.

Equipment Maintenance and Repair Management Computer equipment occasionally malfunctions. Defective equipment is usually repaired by the CLB. If the problem cannot be solved in-house, the equipment is sent to the vendor for repair.

If a piece of equipment requires maintenance, the CLD generates an entry in the Bad Equipment Log. If the equipment must be returned to the vendor for repair, the CLD makes an entry in the Hardware Returned for Service Log.

Equipment Check-Out and Check-In Management Although the Lab's budget and the general administrative responsibility are assigned to the College of Business, any university student, professor, or staff member can use the Lab's facilities. The designer asks the following questions to identify constraints:

Q&A

DESIGNER:

"May equipment be borrowed from the Lab?"

END USER:

"Only professors or staff members may borrow equipment from the Lab. In order to keep a record of equipment location and use, the CLD must check out the equipment. The professor who wants to borrow the equipment must fill out the appropriate form before removing any equipment. The check-out form requires the user to supply a date-out and an estimated date-in. If the equipment has not been returned by the date-in deadline, a notice is sent to the professor whose name appears on the check-out form. Student manuals and data disks may not be borrowed; they are for use only in the Lab."

Lab Assistant Payroll Management The UCL pays lab assistants (LAs) on an hourly basis and keeps track of the total hours worked by each LA during each 14-day pay period. Each LA is assigned a work schedule (the dates and times each LA must work) and must submit a time sheet (showing the hours actually worked) before a paycheck can be issued. The CLD reviews the time sheets and sends them to the payroll department for further processing. Graduate assistants (GAs) are paid a monthly stipend and work a fixed number of hours per week; they are not included in payroll calculations.

Lab Reservations Management The UCL can be reserved by faculty members for teaching purposes. A faculty member fills out a reservation form to reserve the Lab, specifying the date, time, department, and course number of the class to be taught. If an

instructor reserves the Lab for a small class, students not enrolled in that class may use the remaining unoccupied computers *at the instructor's discretion*. Appropriate questions here would be as follows:

Q&A

DESIGNER:

"Are limits placed on how often a faculty member can reserve the Lab?"

END USER:

"No, but given the Lab's limited resources, this may be the time to define limits."

Q&A

DESIGNER:

"How far ahead of time must the Lab be reserved?"

END USER:

"A faculty member must reserve the Lab at least one calendar week ahead of time."

Q&A

DESIGNER:

"Is the lead time OK?"

END USER:

"Yes."

Each reservation covers only one class; the Lab can be used by only one class during its reservation period. Reservations are handled on a first-come, first-served basis and must be approved by the CLD.

Q&A

DESIGNER:

"Is there a daily limit on the number of reserved hours?"

END USER:

"There is currently no policy governing the number of daily Lab reservations. Given the heavy student demand for Lab time, especially during periods when class Lab projects are due, we should place limits on the amount of reserved time. We propose to limit reserved time to one hour in the morning and one hour in the afternoon."

Computer Lab Access Management The UCL is used by students, faculty, and staff members. Upon entering the UCL, the user signs the users' log, located at the LA's desk, and leaves a (valid) University ID card with the LA. When the user leaves the UCL, the LA makes sure that all items checked out by the user (for example, manuals and instructors' data disks) have been returned. If all items have been returned, the LA returns the ID to the user and the user signs out in the log. As long as the UCL is open, there are no time restrictions placed on the user, except when the UCL is reserved for a class.

As you start to understand the operations taking place, you begin to create a Volume of Information Log that estimates the amount of data the system will manage. Table B.3 is an example of such a log. It shows the types of information and the number of entries you expect in designated periods of time.

TABLE B.3

A SAMPLE VOLUME OF INFORMATION LOG

TYPE OF INFORMATION	EXPECTED NUMBER OF ENTRIES PER PERIOD
Lab assistants	14 per semester
Work schedule	8 hours per workday per lab assistant
Hours worked	1 (total hours summary) entry per pay period per lab assistant
Users Faculty Students Staff	 300 15,000 650
Reservations	4 per week
Daily lab users	570 per day
Orders	20 per month
Items ordered	3 per order
Inventory types	15
Locations	5
Repairs	20 per month
Vendors	40

B-1d Problems and Constraints

Once you understand the UCL's operations, you must take stock of the current system's shortcomings. Detailed interviews with key users are likely to reveal operational problems. As you catalog the problems, you should also begin to examine possible causes: poor, inadequate, or absent operational procedures; lack of operational controls; or improper application of existing procedures. Problem-source identification helps the designer develop adequate solutions to problems.

Problems can be *common* (systemwide) or *specific* (pertaining only to portions of the system). The following common problems are identified by UCL key users:

- The manual system is never up to date and yields a constant stream of errors, especially in inventory.
- There is too much data duplication and data inconsistency.
- The manual system does not generate useful information. It's too impractical (time-consuming) to generate reports.

- The system does not allow ad hoc queries.
- The CLD spends too much time manually processing data.
- The lack of a computerized inventory system makes data management difficult. Those data management shortcomings lead to lack of control and restrict the CLD's ability to manage the UCL equipment effectively.

Specific problem areas must be targeted. In the case of the UCL, the following operational problems are identified:

Inventory/Storage/Order Management

- The CLD does not have ready access to crucial inventory management data; for example, what items have been ordered, from what vendor they were ordered, and what items have been ordered but have not been received.
- The UCL needs to know the available stock and average use of supplies, such as paper and printer ink cartridges, to effectively manage the supply inventory, to determine optimal order quantities, and to place necessary orders.
- The CLD does not always know the actual location of an item at any given time. The current system hinders the CLD's ability to track inventory by category, by location, or by manufacturer.

Equipment Maintenance and Repair Management

- The CLD cannot easily generate a repair and maintenance history for each piece of equipment.
- The CLD cannot easily determine the status of items currently subject to maintenance procedures.

Equipment Check-Out/Check-In Management

- The CLD lacks timely and correct information about the Lab's assets: what equipment is checked out, to whom it was checked out, when it was checked out, and so on. Item activity summaries are not available.

Lab Assistant Payroll Management

- The CLD spends too much time reconstructing summaries of hours worked by each LA. The summaries are useful in determining work assignments. The summaries are also necessary to adjust the UCL budget.
- The CLD cannot easily estimate student workloads. Such estimates are necessary to help the CLD distribute work schedules more equitably among the LAs.

Lab Reservations Management

- The manual reservation system is inadequate; it takes too long to check whether desired dates and times are available and to complete the required paperwork.
- The current system does not provide statistical information useful for scheduling Lab reservations.

Computer Lab Access Management

- The user log is not properly maintained.
- Some students do not return certain items. Given inadequate user log entries, too often the LAs do not detect this problem. Items have been lost from the Lab as a result of this lack of control.

- Security problems, ranging from unauthorized network access and unauthorized software installation/deletion to the disappearance of manuals, are also a major concern, and they appear to be increasing.

Given the large number of documented problems, the conclusion is that the current manual system is inadequate. The paperwork tends to be overwhelming, and although reams of data are collected, the data are not readily available. What's more, transforming the data into useful information is usually too time-consuming to be practical.

Problems are solved within two sets of constraints: *operational constraints* imposed by organizational policy and *economic constraints* imposed by the organization's finances.

A well-designed database system should be able to address most of the Lab's stated problems. Consequently, the constraints within which the system is to be designed must be carefully defined.

Time Frame

- The College of Business wants the new system to be fully operational within three months.

Hardware and Software

- The new system must be developed (to the extent possible) with existing UCL hardware and software. The system must be operated on the UCL's existing local area network.

Distributed Aspects and Expandability

- The new system must operate within a multiuser environment.
- The system's operation will be independent of existing administrative systems on campus.

Cost

- The development costs of the new system must be minimal. To reduce expenses and to provide CIS majors with an educational bonus, the system must be developed by CIS majors. To minimize development costs, the design and implementation will be undertaken as a class project under the direction of a faculty member.
- The new system will use no more than two additional terminals to enable the UCL secretary and the CLD to access the system.
- The system must operate without requiring additional personnel in the department.
- Considering budgetary constraints, the College of Business has set aside $9,500 for the new system's unavoidable expenses.

B-1e System Objectives

After identifying the problems and constraints, the designer and end users cooperate to establish the proposed new system's objectives, giving priority to problems that key users deem most significant. Two sets of objectives are defined for the UCL. First are *general objectives*, which define the overall system requirements. They are as follows:

- Improve operational efficiency, thereby increasing the UCL's capacity and the UCL's ability to expand its operations.
- Provide useful information for planning, control, and security.

Second are *specific objectives*, which define the system component requirements. They are described below.

Inventory/Storage/Order Management

- Provide better control of purchase orders, allowing the CLD to check open orders and purchases.
- Monitor the stock of supply items.
- Control inventory by type (group) as well as by individual item.
- Provide quick and efficient information about the location and status of individual items.
- Provide timely information about the use of supplies and generate the statistical information required to guide the timing and extent of future purchases.

Equipment Maintenance and Repair Management

- Monitor the maintenance history of each item.
- Keep track of items that have been returned to the vendor for repair or replacement.

Equipment Check-Out/Check-In Management

- Keep track of the items that are checked out.
- Monitor the items' check-out time.
- Generate usage statistics for reference purposes.

Lab Assistant Payroll Management

- Provide scheduling and workload information.
- Provide work summaries for each LA.

Lab Reservations Management

- Decrease the time spent processing a reservation.
- Produce reservation schedules.
- Generate statistical summaries by department, faculty, staff member, and date (to be used for planning purposes).

Computer Lab Access Management

- Provide tighter control over users and resources in the Lab.
- Reduce the sign-in time.
- Provide information about peak use times (to be used for scheduling purposes).

B-1f Scope and Boundaries

For legal and practical design reasons, the database designer (and, indeed, the entire development team) cannot work on a system whose operational extent has not been carefully defined and limited—that is, the designer must not work on an unbounded system. If the system limits have not been defined, the designer may be legally required to expand the system indefinitely. In addition, an unbounded system environment will not contain the built-in constraints that make its use practical in a real-world environment.

To define the UCL's database scope and boundaries, the designer must answer the following questions:

1. *What will be the extent of the system?* The database design will cover only the UCL portion of the organizational chart presented in Figure B.1. It will be independent of other database systems currently used on campus.
2. *What operational areas will be covered by the system?* The University Computer Lab system will cover six operational areas (see Section B-1c) and will address the specific objectives listed in Section B-1e. In other words, the system will be limited to addressing the following operational areas:
   a. Inventory/storage/order management.
   b. Equipment maintenance and repair management.
   c. Equipment check-out/check-in management.
   d. Lab assistant payroll management.
   e. Lab reservations management.
   f. Computer lab access management.
3. *What design and implementation strategy should be adopted to bring the system online within the specified time constraints?* To maximize the system's design efficiency, the operational areas should be organized into system modules. A **module** is a design segment that can be implemented as an autonomous unit. Modules may be linked to produce a system. Modules are especially useful because their existence makes it possible to implement and test the system in stages.
4. *What modules must be included in the system?* The operational areas discussed in Question 2 can be classified under two headings: Lab management and inventory management. Therefore, the two modules shown in Table B.4 are appropriate. Note that each module is composed of named processes. For example, the Lab Management System module contains the ACCESS, RESERVATION, and PERSONNEL processes.

module
A design segment that can be implemented as an autonomous unit.

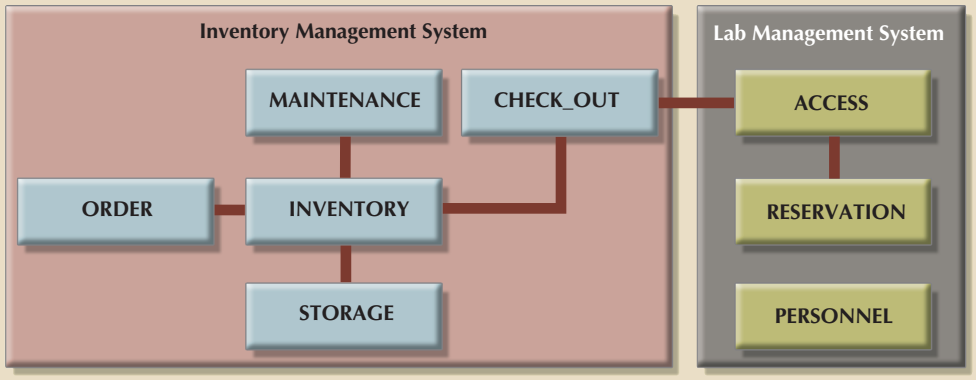
TABLE B.4

REQUIRED UCL SYSTEM MODULES

MODULE	OPERATIONAL AREA	PROCESS NAME
Lab Management System	Computer lab access Reservations Lab assistants' payroll	ACCESS RESERVATION PERSONNEL
Inventory Management System	Inventory Order Storage Equipment maintenance and repair Equipment check-out and check-in	Inventory ORDER STORAGE MAINTENANCE CHECK_OUT

5. *How do the modules interface?* The Inventory Management System module's INVENTORY process is the system's key component; its existence enhances the CLD's ability to monitor the Lab's operation and to control the Lab's administrative functions. Figure B.2 shows that the Inventory Management System module interfaces with the Lab Management System module through the CHECK_OUT process.

FIGURE B.2 THE UNIVERSITY COMPUTER LAB MANAGEMENT SYSTEM



Although the INVENTORY process will be independent of other special-purpose inventory systems used on campus, it will use the purchasing department's inventory item classifications. Those classifications facilitate item referencing and querying when users are communicating with purchasing. In addition, using the classifications makes it easy to integrate with a campuswide inventory control system in the future.

The INVENTORY process must permit:

- Registering new inventory types and individual items.
- Keeping track of an item's location, classification, and usage.

The INVENTORY process will interface with the ORDER, STORAGE, MAINTENANCE, and CHECK_OUT processes.

The ORDER process tracks types of inventory items that are ordered from vendors. The system will be designed to track the purchase orders and requisitions placed by the UCL. The ORDER process will interface with the INVENTORY process.

The MAINTENANCE process will track the in-house repairs performed on items, as well as track items returned to the vendor for repair. The MAINTENANCE process also interfaces with the INVENTORY process because items found in inventory may have a repair history.

The CHECK_OUT process will track the items that are checked out by the Lab's users: faculty, staff, and students.

The ACCESS process will help the CLD track the Lab's users. The ACCESS process will interface with the CHECK_OUT process because some items are checked out by students, faculty, or staff members.

The RESERVATION process will track Lab reservations made by faculty or staff members. The process interfaces with:

- ACCESS (because faculty members reserve the Lab).
- PERSONNEL (because an LA records the reservation).

The PERSONNEL process will facilitate the CLD's ability to monitor the LAs' work schedules and actual hours worked. This process interfaces with the RESERVATION process because LAs record Lab reservations.

B-2 Database Design Phase: Conceptual Design

To develop a good conceptual design, you must be able to gather information that lets you accurately identify the entities and describe their attributes and relationships. The entity relationships must accurately reflect real-world relationships.

B-2a Information Sources and Users

The initial study phase generated much useful information from the system's key users. The conceptual design phase must be begun by confirming good information sources. The confirmation process recertifies key users and carefully catalogs all current and prospective end users. In addition, the confirmation process targets the current system's paper flow and documentation, including data and report forms. No document in the paper trail is considered irrelevant at this stage. If the paper exists, somebody must have thought it was important at some point. For the UCL, the following have been confirmed:

- Assistant dean.
- Computer lab director (CLD).
- Computer lab secretary (CLS).
- Computer lab assistants (LA) and graduate assistants (GA).
- Students, faculty, and staff who use the Lab's resources.
- All currently used computer lab forms, file folders, and report forms.

It is not surprising that a list of prospective system users tends to be a duplicate of at least a portion of the list of information sources:

- The CLD (who is also the UCL system administrator) will manage the system, enter data into the database, and define reporting requirements.
- The LA and the GA are the primary UCL system users and will enter data into the database.
- The CLS is a system user and will query and update the database.

You should create a summary table to identify all system sources and users. You can use that table for cross-checking, thereby enabling you to audit sources and users more easily. The UCL system summary is shown in Table B.5. Note that the summary table also identifies the proposed system modules, processes, and interfaces discussed in the previous section.

TABLE B.5

DATA SOURCES AND USERS

MODULE	PROCESS	SOURCES	USERS	INTERFACE
Inventory Management System	**INVENTORY**			
	Inventory data	Inventory forms, CLD	CLD, CLS, Dean*	Order
	Item data	Inventory forms	CLD, CLS, Dean	Maintenance
	Withdrawal	Inventory forms	CLD, CLS, Dean	Check-out
	Repairs	Bad equipment log	CLD, CLS, Dean	Maintenance
	Check-out	Check-out forms	CLD, CLS, Dean	Check-out
	Location	Inventory forms	CLD, CLS, Dean	Storage
	ORDER			
	Order data	Order forms	CLD, CLS, Dean	Inventory
	Items ordered	Order forms	CLD, CLS, Dean	Inventory
	Items received	Order forms, Inventory	CLD, CLS, Dean	Inventory
	Inventory type	Inventory forms, CLD	CLD, CLS, Dean	Inventory
	Vendors	Order forms	CLD, CLS, Dean	Inventory
	STORAGE			
	Location data	Inventory forms	CLD, CLS	Inventory
	Item data	Inventory forms	CLD, CLS	Inventory
	MAINTENANCE			
	Repair	Bad equipment log	CLD, CLS, GA	Inventory
	Item data	Inventory forms	CLD, CLS, GA	Inventory
	Vendor data	Inventory forms	CLD, CLS, GA	Inventory
	CHECK-OUT			
	Item data	Inventory forms	CLD, CLS, LA, GA	Inventory
	Users	Check-out log	CLD, CLS, LA, GA	Access
Lab Management System	**ACCESS**			
	User	Lab usage log	CLD, LA	Reservation, Check-out
	RESERVATION			
	Reservation data	Lab reservation forms	CLD, CLS, LA	Access
	PERSONNEL			
	Lab assistants	Lab assistants form	CLD, CLS	Personnel
	Work schedule	Work schedule form	CLD, CLS, LA	Personnel
	Hours worked	Time sheet forms	CLD, CLS, LA	Personnel

CLD = Computer lab director CLS = Computer lab secretary LA = Lab assistant GA = Graduate assistant
* Although the dean is not an active system user, (s)he uses the system reports for decision making.

B-2b Information Needs: User Requirements

A design must match relevant user requirements. *Relevant requirements* are based on the proposed level of information-generating efficiency. The summary of all relevant UCL user requirements yields a general *systems requirements* description, as follows:

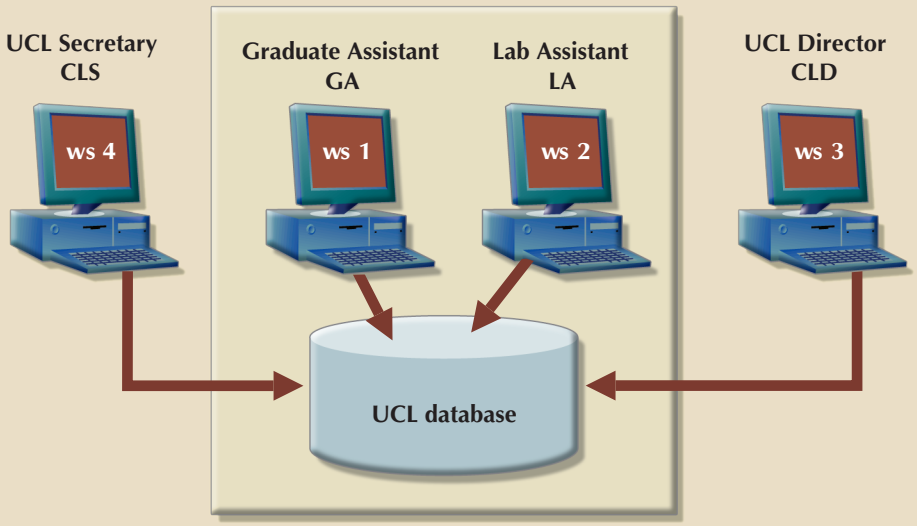
1. *The system must be easy to use.* A menu-driven interface might be most appropriate.
2. *The system must provide security measures* by using passwords and access rights.
3. *The system must be fully integrated*, thus eliminating redundant data entry and redundant updates. The system must ensure database integrity.
4. *Users must be able to access the system concurrently from several workstations*. The workstation location and use must conform to the setup shown in Table B.6. Figure B.3 depicts the University Computer Lab Management System (UCLMS) setup.

TABLE B.6

WORKSTATION ASSIGNMENTS: USES AND USERS

USER	PROCESSES ACCESSED	USE	STATION ID
UCL director (CLD)	All	System administration	WS3
UCL secretary (CLS)	INVENTORY ORDER STORAGE MAINTENANCE CHECK_OUT RESERVATION PERSONNEL	Updates and queries	WS4
Lab assistants (LAs) and Graduate assistants (GAs)	ACCESS RESERVATION CHECK_OUT MAINTENANCE PERSONNEL *	Updates and queries	WS1, WS2
* Restricted access			

FIGURE B.3 UCL MANAGEMENT SYSTEM SETUP SUMMARY



5. *The system processes must perform the following functions:*

   a. *PERSONNEL process*. Maintains data for all LAs, their schedules, and their hours worked.
   b. *INVENTORY and storage process*. Controls the stock of items by location as well as by inventory type. The system must also track consumable items by recording their usage (withdrawal). The system must track nonserialized and serialized items.
   c. *ORDER process*. Integrates with the inventory module to establish the relationship between orders and inventory types. The system must generate information about the total orders placed and the total cost of orders by vendor, by order, and by inventory type. It also must be able to generate a grand total cost to be used for budgeting.

d. *MAINTENANCE process*. Tracks the equipment maintenance history for all hardware. The process must also report items that have been returned to the vendor for replacement or maintenance.
e. *RESERVATION process*. Allows the CLD to schedule Lab reservations easily. The system must enable professors and staff to request a reservation online. The system must automatically show the schedule of reservations for the requested day, and it must accept reservations according to the departmental and/or UCL policy.
f. *CHECK_OUT process*. Enables the user to track items that are checked out by faculty or staff members for their temporary use.
g. *ACCESS process*. Tracks the UCL's usage rate. The system enables LAs to register students who want to use the Lab facilities. The system will retrieve the user identification number (ID) from bar code readers installed on the LAs' main desk computers. The system must also allow students to check out instructors' data disks and software manuals.

6. The system's *input* requirements are, to a major extent, driven by its output requirements—that is, its desired query and reporting capabilities. The reports required by the UCL are shown in Table B.7. The reporting requirements help define appropriate attributes within the entities. Precise report format specifications are a crucial part of the conceptual design process.

TABLE B.7

UCLMS REPORTS

NUMBER	REPORT	DESCRIPTION	USERS
1	Inventory movements	Inventory movements by date and type	CLD, CLS
2	Inventory	Inventory by inventory type	CLD, CLS
3	Location inventory	Inventory of items by location	CLD, CLS
4	Orders	Orders by date, vendor, and status	Dean, CLD
5	Open orders	Open orders by date and vendor	Dean, CLD
6	Orders payable	Orders received but not paid	Dean, CLD
7	Payment history	Orders paid by date and vendor	Dean, CLD
8	Maintenance	Maintenance history by date and item	CLD, GA, LA
9	Check-out	Items checked out by date and user	CLD, CLS
10	LA schedule	Lab assistants schedule	CLD, CLS, GA, LA
11	LA hours worked	Hours worked by lab assistants	CLD, CLS, GA, LA
12	Reservation schedule	Reservations by date and user	CLD, CLS, LA
13	UCL usage statistics	Computer lab usage statistics	Dean, CLD, chairs

B-2c Developing the Initial Entity Relationship Model

From the database initial study and conceptual design preparations, you can identify an initial set of entities. Those entities represent the most important information system objects as viewed by the end user and the designer. Some of the entities represent real-world objects, such as user, lab assistant, item, location, or vendor. Others represent information about entities, such as work schedule, hours worked, repairs, Lab use log, or reservations. The UCL will use the entities shown in Table B.8.

TABLE B.8

INITIAL UCL ENTITIES BASED ON THE INITIAL STUDY

ENTITY NAME	ENTITY DESCRIPTION	ENTITY TYPE
USER	User data: includes administration, faculty, and students	
LAB_ASSISTANT	Lab assistant data: includes graduate assistants	
WORK_SCHEDULE	Lab assistant work schedule data: hours each lab assistant is assigned to work	
HOURS_WORKED	Lab assistant hours worked data: actual hours worked per each pay period for each lab assistant	Weak
LOG	Daily users of the UCL: one entry for each visitor	
RESERVATION	Lab reservation details	
INV_TYPE	Inventory types	
ITEM	Item details	
LOCATION	Storage locations	
REPAIR	Repair data by item	
VENDOR	Vendor details	
ORDER	Order details	

The designer and the end user must agree on the entities. The designer then defines the relationships among the entities, basing them generally on the description of operations (Section B-1c). More specifically, the entity relationships are based on business rules that have been derived from the careful description of operational procedures.

Business rules must be both identified and verified. The UCL database designer conducts a series of interviews with key system users: the University Computer Lab director, who is responsible for the operational administration, and the assistant dean of the computer information systems department, who is responsible for the system's general administration. After the appropriate business rules are identified and incorporated into the ER model, the designer "reads" the model to those individuals to verify its accurate portrayal of the actual and/or proposed operations. The designer also "reads" the ER model to end users to verify that it accurately describes their actions and activities. The verification process may yield additional entities and relationships.

The UCL ER modeling process yields the following summary of business rules, entities, and relationships:

Business Rule 1 Each item belongs to only one inventory type, and each inventory type may have zero, one, or many items belonging to it.

To clarify this business rule, look at the sample data shown in Table B.9. Note that an inventory type is a classification that includes all items within a given category. For example, the Dell Dimension and the Toshiba are both personal computers.

TABLE B.9

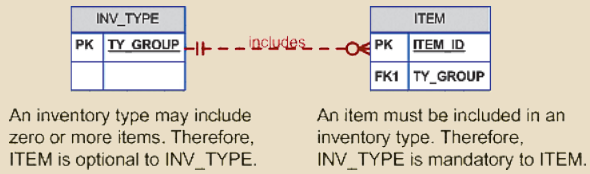
EXAMPLES OF INVENTORY TYPES

INVENTORY TYPE				ITEM	
CATEGORY	CLASS	TYPE	SUBTYPE	ITEM ID	DESCRIPTION
Hardware	Personal computer	Desktop	Dual Processor	3233452	Dell Dimension, 2048 MB RAM, 200 GB hard drive
Hardware	Personal computer	Laptop	Pentium	3312455	Toshiba 1024 MB RAM, 160 GB hard drive
Hardware	Printer	Laser	BW	312246	HP LaserJet IV
Hardware	Printer	Ink-jet	Color	313225	HP 592e color printer
Hardware	Printer	Laser	Color	316757	Xerox Network printer
Supply	Paper	Single sheet	8.5 x 11		Laser printer paper
Supply	CD	Blank	R/W		Recordable CD
Supply	Cartridge	Ink-jet	Color		Color ink-jet cartridge

As you examine the entries in Table B.9, note that each individual item belongs to only one inventory type.

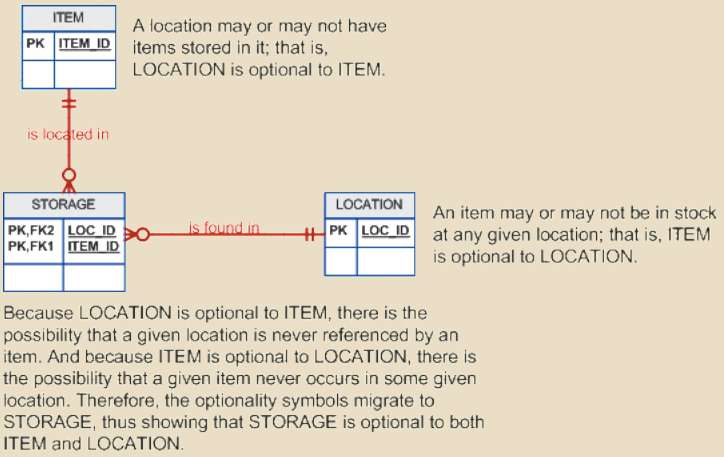
The first business rule leads to the ER model segment shown in Figure B.4.

FIGURE B.4 THE ER MODEL SEGMENT FOR BUSINESS RULE 1



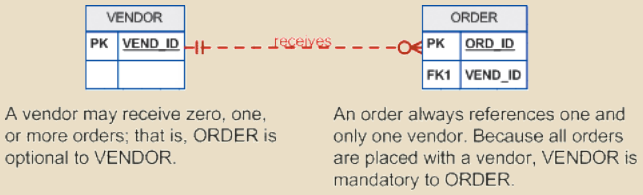
Business Rule 2 An item may be put in use upon its arrival, or it may be stored. In other words, an item might not be stored at all. Some items, such as printer cartridges, are part of a generic grouping and may be stored in more than one location. Therefore, some items could be stored in zero, one, or more locations. Each storage location might store zero, one, or many items. (See Figure B.5.)

FIGURE B.5 THE ER MODEL SEGMENT FOR BUSINESS RULE 2



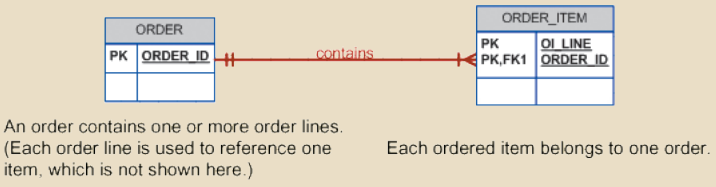
Business Rule 3 An order references only one vendor, and each vendor may have zero, one, or many orders. (See Figure B.6.)

FIGURE B.6 THE ER MODEL SEGMENT FOR BUSINESS RULE 3



Business Rule 4 Each order contains one or many ordered items, and each ordered item line belongs to only one order. (See Figure B.7.)

FIGURE B.7 THE ER MODEL SEGMENT FOR BUSINESS RULE 4

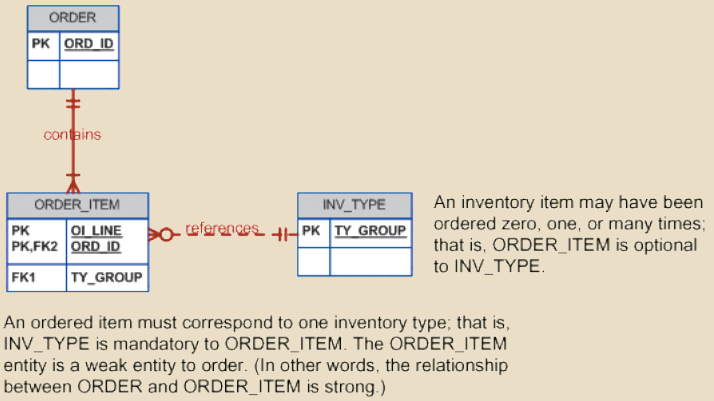


Business Rule 5 Each ordered item line corresponds to one *inventory* type, and each inventory type can be referenced by one or many order item lines. (See Figure B.8.)

Example:

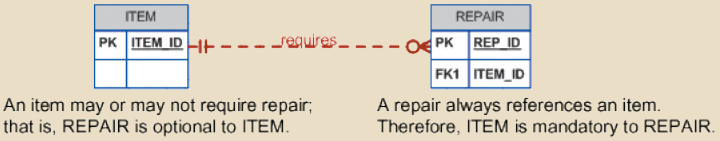
ORDERED ITEM	PENTIUM COMPUTER	
Inventory type	Category:	Hardware
	Class:	Computer
	Type:	Desktop
	Subtype:	Dual Processor
Item	3233452	Serial number
		Dell

FIGURE B.8 THE ER MODEL SEGMENT FOR BUSINESS RULE 5



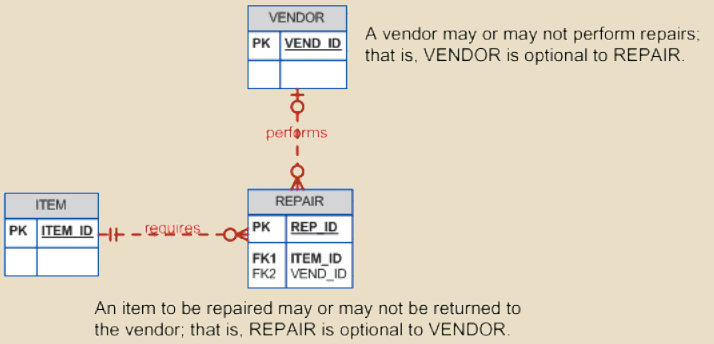
Business Rule 6 Each item may require zero, one, or many repairs, and each repair entry refers to only one item. (See Figure B.9.)

FIGURE B.9 THE ER MODEL SEGMENT FOR BUSINESS RULE 6



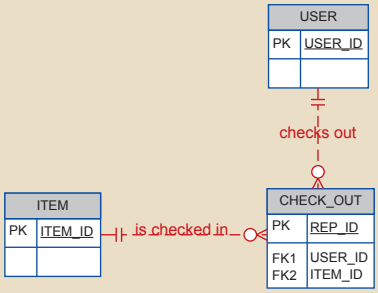
Business Rule 7 Each item to be repaired may or may not be returned to the vendor (the CLD repairs some of them), and each vendor may have zero, one, or many repair items returned. (See Figure B.10.)

FIGURE B.10 THE ER MODEL SEGMENT FOR BUSINESS RULE 7



Business Rule 8 Each user may check out zero, one, or many items, and each item may be checked out by zero, one, or many users during the semester. (See Figure B.11.)

FIGURE B.11 THE ER MODEL SEGMENT FOR BUSINESS RULE 8



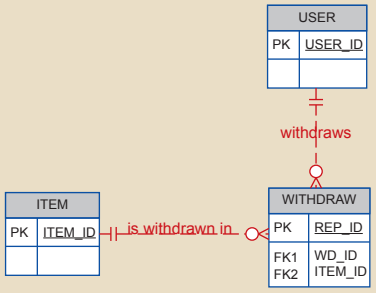
A user may or may not check out an item; that is, ITEM is optional to USER.

Because USER is optional to ITEM. there is a possibility that a given user never checks out an item. And because ITEM is optional to USER, there is the possibility that a given item is never checked out by a user. Therefore, the optionality symbols migrate to CHECK_OUT. thus indicating that CHECK_OUT is optional to both ITEM and USER.

An item may or may not be checked out by a user; that is, USER is optional to ITEM.

Business Rule 9 Each (faculty or staff) user may withdraw zero, one, or many items, and each item may be withdrawn by zero, one, or many users during the semester. (See Figure B.12.)

FIGURE B.12 THE ER MODEL SEGMENT FOR BUSINESS RULE 9



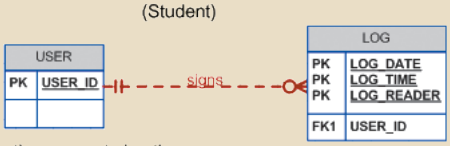
A user may or may not withdraw an item; that is, ITEM is optional to USER.

Because USER is optional to ITEM. there is a possibility that a given user never Withdraws an item. And because ITEM is optional to USER, there is the possibility that a given item is never withdrawn by a user. Therefore, the optionality symbols migrate to WITHDRAW. thus indicating that WITHDRAW is optional to both ITEM and USER.

An item may or may not be withdrawn by a user; that is, USER is optional to ITEM.

Business Rule 10 Each (student) user may sign into the user log many times during the semester, and each user log entry is made by only one (student) user. (See Figure B.13.)

FIGURE B.13 THE ER MODEL SEGMENT FOR BUSINESS RULE 10

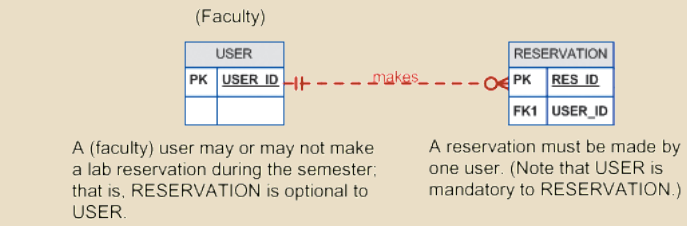


A (student) user must sign the lab use log to register. However, because some students do not use the lab facilities, they do not make log entries. Therefore, LOG is optional to USER.

Each lab use log entry requires a (student) user to sign in. Therefore, USER is mandatory to LOG.

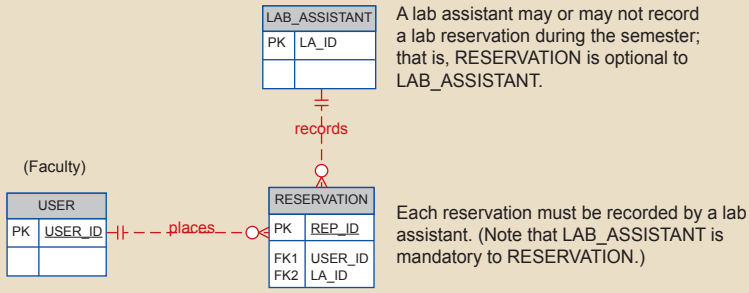
Business Rule 11 Each (faculty) user may place zero, one, or many reservations during the semester, and each reservation is placed by one faculty member. (See Figure B.14.)

FIGURE B.14 THE ER MODEL SEGMENT FOR BUSINESS RULE 11



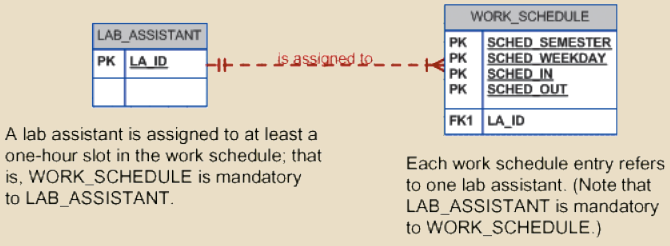
Business Rule 12 Each reservation is recorded by an LA, and each LA may record zero, one, or many reservations during the semester. (See Figure B.15.)

FIGURE B.15 THE ER MODEL SEGMENT FOR BUSINESS RULE 12



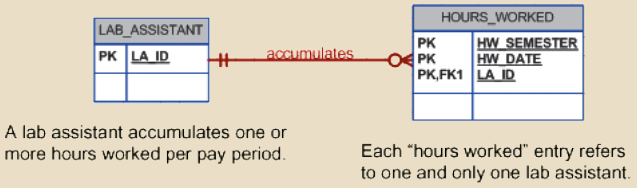
Business Rule 13 Each LA is assigned to work at least one day in each week's work schedule, and each work schedule assignment is made for one LA. (See Figure B.16.)

FIGURE B.16 THE ER MODEL SEGMENT FOR BUSINESS RULE 13



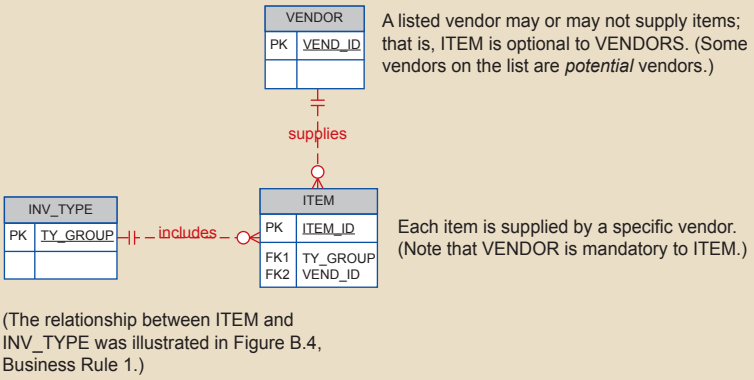
Business Rule 14 Each LA accumulates hours worked during each two-week pay period, and each "hours worked" entry is associated with one LA. (See Figure B.17.)

FIGURE B.17 THE ER MODEL SEGMENT FOR BUSINESS RULE 14



Business Rule 15 Each item is supplied by a specific vendor, and each vendor may supply several different items. (See Figure B.18.)

FIGURE B.18 THE ER MODEL SEGMENT FOR BUSINESS RULE 15



Note

Remember that a student can check out items only while (s)he is in the Lab. While such a constraint is written as a business rule, this restriction cannot be represented in the ER diagram; instead, it must be reflected in the program code to conform to the UCL's operational procedures.

Although Tables B.8 and B.10 contain similar information, they reflect different stages in the entity relationship modeling process. Table B.8 shows the initial entity information that is derived from the UCL description of operations. That description is the source of the UCL's business rules. Business rules often generate questions that cause additional entities, relationships, and attributes to be identified. In addition, as the entities and their relationships generate ERD segments, the modeling process may uncover the need for additional entities and/or relationships. The entity information presented in Table B.10 reflects the results of this dynamic modeling process.

Table B.10 summarizes the proposed UCL management system's entities. The ER components identified thus far come together in an ER diagram. Figure B.19 represents the database as seen by the end users and designer at this point.

TABLE B.10

UCL ENTITIES BASED ON THE BUSINESS RULES

ENTITY NAME	ENTITY DESCRIPTION	ENTITY TYPE
USER	User data	
LAB_ASSISTANT	Lab assistant data	
WORK_SCHEDULE	Lab assistant work schedule data	
HOURS_WORKED	Lab assistant hours worked data	Weak
LOG	Daily users of the UCL	
RESERVATION	Lab reservations data	
INV_TYPE	Inventory type data	
ITEM	Items data	
CHECK_OUT	Item check-out data	
WITHDRAW	Supply withdrawal data	
LOCATION	Location in which item is stored	
STORAGE	Item storage data	Composite
REPAIR	Repair data	
VENDOR	Vendor data	
ORDER	Order data	
ORDER_ITEM	Items ordered data	Weak

Note

Business rules are generated from many sources, such as multiple end users, forms, and manuals. Therefore, business rules are not generated in any particular order. For example, you began this appendix's business rule summary by specifying the inventory business rules, you shifted to the end users and their Lab activities, and then you returned to inventory business rules. Those business rules were then converted into ER segments, which were then placed in the framework shown in Figure B.19. If necessary, you can start anywhere in the ER diagram and organize the business rules to match a path you trace through the design. Or you can group the business rules to match the processes. Although this business rule rearrangement may appeal to your desire for organization, it is not required.

Also keep in mind that different end users tend to view data relationships at different levels. For example, note that the M:N relationship between ITEM and LOCATION is represented by a composite entity named STORAGE. (Note that the STORAGE entity's PK consists of the PKs of the related tables, thus making STORAGE a composite entity.) Compare that relationship implementation with one for the M:N relationship between ORDER and INV_TYPB. In the latter case, the ORDER_ITEM entity's PK is composed of OI_LINE and ORD_ID, thereby making the ORDER_ITEM entity weak. Note that the original business rule expressing the M:N relationship between ITEM and LOCATION may be written as:

An ITEM may be stored in many LOCATIONs, and each LOCATION may be used to store many ITEMs.

However, that M:N relationship gives rise to two 1:M relationships that are expressed by these two business rules:

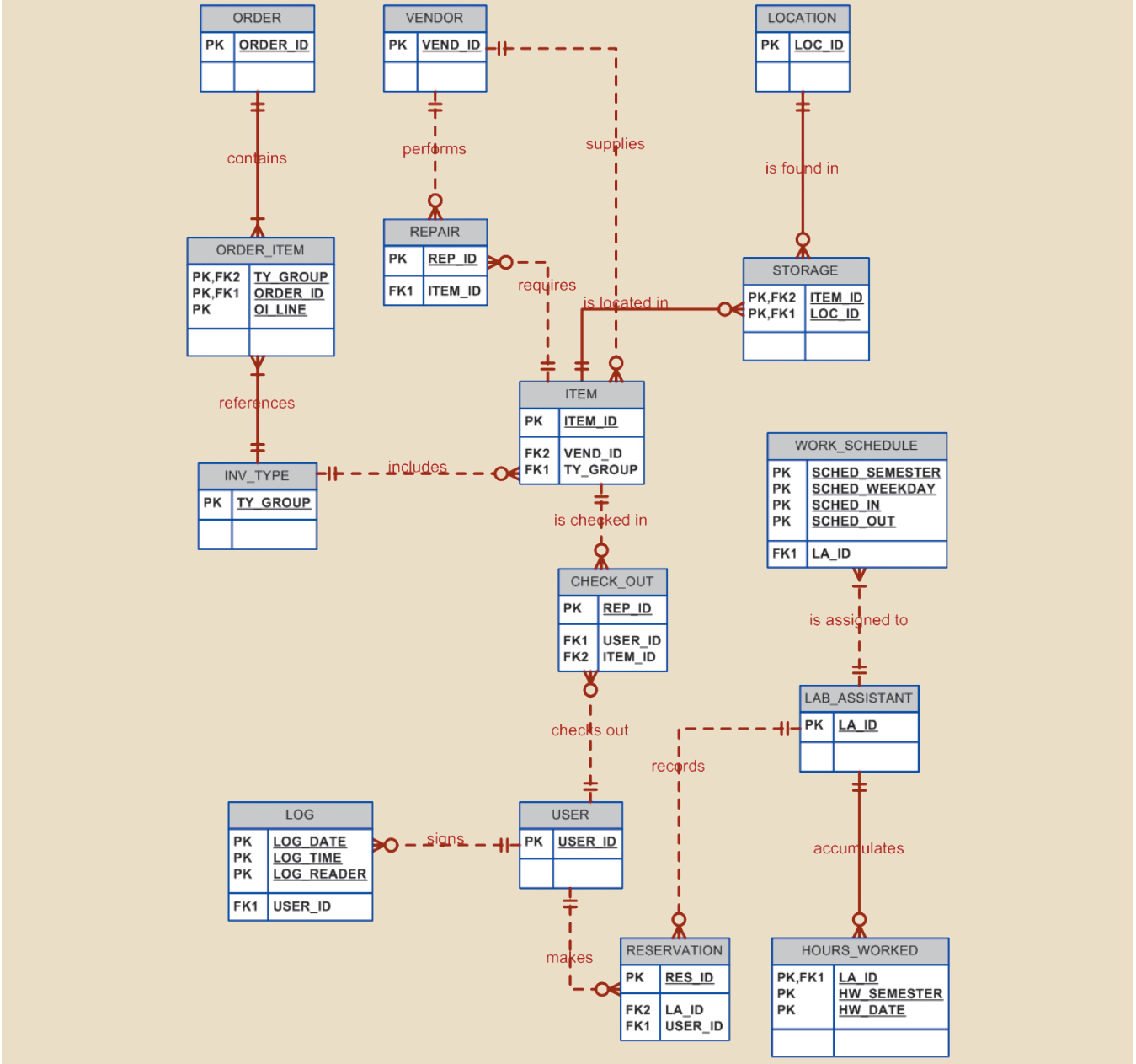
1. Each ITEM may be found one or more times in STORAGE, and each STORAGE (location) *may* contain many ITEMs.

2. Each LOCATION may be referenced one or more times in STORAGE, and each STORAGE entry references one and only one LOCATION.

In short, the database designer must integrate the design components while keeping in mind the following:

- The design is based on multiple information sources.
- The order in which the business rules are developed and yield ER segments is immaterial.
- Different end users view relationships from different perspectives. Thus, the designer must make professional judgments about the way in which those perspectives are reflected in the database design.

FIGURE B.19 THE UCL MANAGEMENT SYSTEM'S INITIAL ERD



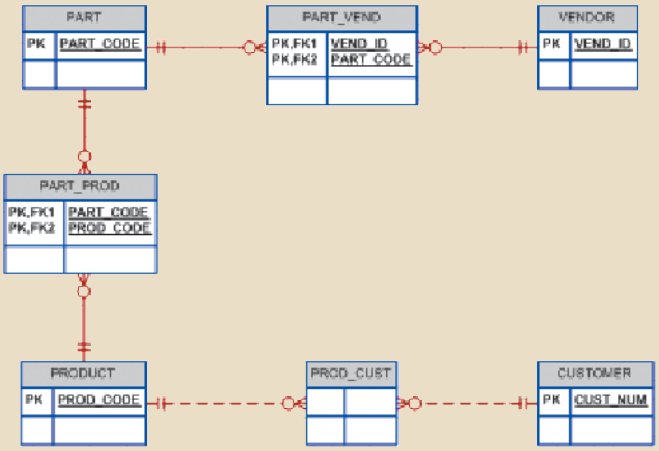
Key Terms

module, B-13 nonserialized items, B-6 serialized items, B-6

Review Questions

1. What factors relevant to database design are revealed during the initial study phase?
2. Why is the organizational structure relevant to the database designer?
3. What is the difference between the database design scope and its boundaries? Why is the scope and boundary statement so important to the database designer?
4. What business rule(s) and relationships can be described for the ERD shown in Figure QB.4?

FIGURE QB.4 THE ERD FOR QUESTION 4



5. Write the connectivity and cardinality for each of the entities shown in Question 4.
6. What is a module, and what role does a module play within the system?
7. What is a module interface, and what does it accomplish?

Problems

1. Modify the initial ER diagram presented in Figure B.19 to include the following entity supertype and subtypes: The University Computer Lab USER may be a *student* or a *faculty member*.
2. Using an ER diagram, illustrate how the change you made in Problem 1 affects the relationship of the USER entity to the following entities:
   a. LOG
   b. RESERVATION
   c. CHECK_OUT
   d. WITHDRAW

3. Create the initial ER diagram for a car dealership. The dealership sells both new and used cars, and it operates a service facility. Base your design on the following business rules:

   a. A salesperson can sell many cars, but each car is sold by only one salesperson.
   b. A customer can buy many cars, but each car is sold to only one customer.
   c. A salesperson writes a single invoice for each car sold.
   d. A customer gets an invoice for each car (s)he buys.
   e. A customer might come in only to have a car serviced; that is, one need not buy a car to be classified as a customer.
   f. When a customer takes in one or more cars for repair or service, one service ticket is written for each car.
   g. The car dealership maintains a service history for each car serviced. The service records are referenced by the car's serial number.
   h. A car brought in for service can be worked on by many mechanics, and each mechanic can work on many cars.
   i. A car that is serviced may or may not need parts. (For example, parts are not necessary to adjust a carburetor or to clean a fuel injector nozzle.)

4. Create the initial ER diagram for a video rental shop. Use (at least) the following description of operations on which to base your business rules.

   The video rental shop classifies movie titles according to their type: comedy, western, classical, science fiction, cartoon, action, musical, or new release. Each type contains many possible titles, and most titles within a type are available in multiple copies. For example, note the summary in the following table of the relationship between video rental type and title.

TYPE	TITLE	COPY
Musical	My Fair Lady My Fair Lady Oklahoma! Oklahoma! Oklahoma!	1 2 1 2 3
Cartoon	Dilly Dally & Chit Chat Cat Dilly Dally & Chit Chat Cat Dilly Dally & Chit Chat Cat	1 2 3
Action	Amazon Journey Amazon Journey	1 2

   Keep the following conditions in mind as you design the video rental database:

   - The movie type classification is standard; not all types are necessarily in stock.
   - The movie list is updated as necessary; however, a movie on that list might not be ordered if the video shop owner decides that the movie is not desirable for some reason.
   - The video rental shop does not necessarily order movies from all vendors on the vendor list; some vendors on the vendor list are merely potential vendors from whom movies may be ordered in the future.
   - Movies classified as new releases are reclassified to an appropriate type after they have been in stock for more than 30 days. The video shop manager wants to have an end-of-period (week, month, year) report for the number of rentals by type.

- If a customer requests a title, the clerk must be able to find it quickly. When a customer selects one or more titles, an invoice is written. Each invoice can contain charges for one or more titles. All customers pay in cash.
- When a customer checks out a title, a record is kept of the check-out date and time and the expected return date and time. When rented titles are returned, the clerk must be able to check quickly whether the return is late and to assess the appropriate late return fee.
- The video store owner wants to generate periodic revenue reports by title and by type. The owner also wants to generate periodic inventory reports and track titles on order.
- The video store owner, who employs two (salaried) full-time and three (hourly) part-time employees, wants to keep track of all employee work time and payroll data. Part-time employees must arrange entries in a work schedule, while all employees sign in and out on a work log.

5. Suppose a manufacturer produces three high-cost, low-volume products: P1, P2, and P3. Product P1 is assembled with components C1 and C2; product P2 is assembled with components Cl, C3, and C4; and product P3 is assembled with components C2 and C3. Components may be purchased from several vendors, as shown in the following table.

VENDOR	COMPONENT SUPPLIED
V1	C1, C2
V2	C1, C2, C3, C4
V3	C1, C2, C4

Each product has a unique serial number, as does each component. To track product performance, careful records are kept to ensure that each product's components can be traced to the component supplier.

Products are sold directly to final customers; that is, no wholesale operations are permitted. The sales records include the customer identification and the product serial number. Using the preceding information, do the following:

a. Write the business rules governing the production and sale of the products.
b. Create an ER diagram capable of supporting the manufacturer's product/component tracking requirements.

6. Create an ER diagram for a hardware store. Make sure you cover (at least) store transactions, inventory, and personnel. Base your ER diagram on an appropriate set of business rules that you develop. (*Note*: It would be useful to visit a hardware store and conduct interviews to discover the type and extent of the store's operations.)

7. Use the following brief description of operations as the source for the next database design.

All aircraft owned by ROBCOR require periodic maintenance. When maintenance is required, a maintenance log form is used to enter the aircraft's identification number, the general nature of the maintenance, and the maintenance starting date. A sample maintenance log form is shown in Figure PB.7A.

FIGURE PB.7A THE MAINTENANCE LOG FORM

ROBCOR Aircraft Service

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Log #: 2155 **Aircraft: 2155W** **Date in: 18-Jan-2016**
Checked in by: George D. Ramsey (115)

Squawk summary

1. Left mag rough on run-up_____
2. Nose gear shimmies at taxi speeds_____
3. Left main gear door does not close flush with wing panel_____
4. Gear struts do not maintain proper pressure_____
5. Left engine vibrates when power is pulled back to 20 in. manifold pressure_____
6. _____
7. _____
8. _____
9. _____
10. _____

Aircraft release date: 19-Jan-2016 **Released by: Bea L. Patterson (109)**

Note that the maintenance log form contains a space used to enter the aircraft release date and a signature space for the supervising mechanic who releases the aircraft into service. Each maintenance log form is numbered sequentially. *Note*: A supervising mechanic is one who holds a special Federal Aviation Administration (FAA) Inspection Authorization (IA). Three of ROBCOR's ten mechanics hold such an IA.

Once the maintenance log form is initiated, the maintenance log form's number is written on a *maintenance specification sheet*, also known as a *maintenance line form*. When completed, the specification sheet contains the details of each maintenance action, the time required to complete the maintenance, parts (if any) used in the maintenance action, and the identification of the mechanic who performed the maintenance action. The maintenance specification sheet is the billing source (time and parts for each of the maintenance actions), and it is one of the sources through which parts use may be audited. A sample maintenance specification sheet (line form) is shown in Figure PB.7B.

FIGURE PB.7B THE MAINTENANCE LINE FORM

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Log #: 2155

Item	Action Description	Time	Part	Units	Mechanic
1	Performed run-up Rough mag reset	0.8	None	0	112
2	Cleaned #2 bottom plug, left engine	0.9	None	0	112
3	Replaced nose gear shimmy dampener	1.3	P-213342A	1	103
4	Replaced left main gear door oleo strut seal	1.7	GR/311109S	1	112
5	Cleaned and checked gear strut seals	1.7	None	0	116
6					
7					
8					

Parts used in any maintenance action must be signed out by the mechanic who used them, thus allowing ROBCOR to track its parts inventory. Each sign-out form contains a listing of all parts associated with a given maintenance log entry. Therefore, a parts sign-out form contains the maintenance log number against which the parts are charged. In addition, the parts sign-out procedure is used to update the ROBCOR parts inventory. A sample parts sign-out form is shown in Figure PB.7C.

Mechanics are highly specialized ROBCOR employees, and their qualifications are quite different from those of an accountant or a secretary, for example.

Given this brief description of operations and using the Chen ER methodology, draw the fully labeled ER diagram. Make sure you include all appropriate relationships, connectivities, and cardinalities.

8. You have just been employed by the ROBCOR Trucking Company to develop a database. To gain a sense of the database's intended functions, you spent some time talking to ROBCOR's employees and you examined some of the forms used to track driver assignments and truck maintenance. Your notes include the following observations:

   - Some drivers are qualified to drive more than one type of truck operated by ROBCOR. A driver may, therefore, be assigned to drive more than one truck type during some period of time. ROBCOR operates several trucks of a given type. For example, ROBCOR operates two panel trucks, four half-ton pick-up trucks, two single-axle dump trucks, one double-axle truck, and one 16-wheel truck. A driver with a chauffeur's license is qualified to drive only a panel truck and a half-ton pick-up truck and, thus, may be assigned to drive any one of six trucks. A driver with a commercial license with an appropriate heavy equipment endorsement may be assigned to drive any of the nine trucks in the ROBCOR fleet. Each time a driver is assigned to drive a truck, an entry is made in a log containing

the employee number, the truck identification, and the sign-out (departure) date. Upon the driver's return, the log is updated to include the sign-in (return) date and the number of driver duty hours.

FIGURE PB.7C THE PARTS SIGN-OUT FORM

ROBCOR Aircraft Service

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Log #: 2155

Form sequence #: 24226

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Part	Description	Units	Unit Price	Mechanic
P-213342A	Nose gear shimmy dampener, PA31-350/1973	1	$189.45	112
GR/311109S	Left main gear door oleo strut seal, PA31-350/1973	1	$59.76	103

- If trucks require maintenance, a maintenance log is filled out. The maintenance log includes the date the truck was received by the maintenance crew. The truck cannot be released for service until the maintenance log release date has been entered and the log has been signed off by an inspector.
- All inspectors are qualified mechanics, but not all mechanics are qualified inspectors.
- Once the maintenance log entry has been made, the maintenance log number is transferred to a service log in which all service log transactions are entered. A single maintenance log entry can give rise to multiple service log entries. For example, a truck might need an oil change as well as a fuel injector replacement, a brake adjustment, and a fender repair.
- Each service log entry is signed off by the mechanic who performed the work. To track the maintenance costs for each truck, the service log entries include the parts used and the time spent to install the part or to perform the service. (Not all service transactions involve parts. For example, adjusting a throttle linkage does not require the use of a part.)
- All employees are automatically covered by a standard health insurance policy. However, ROBCOR's benefits include optional copaid term life insurance and disability insurance. Employees may select both options, one option, or no options.

Given those brief notes, create the ER diagram. Make sure you include all appropriate entities and relationships and define all connectivities and cardinalities.