

## Special Topics in REA Modeling

### Learning Objectives

After studying this chapter, you should be able to:

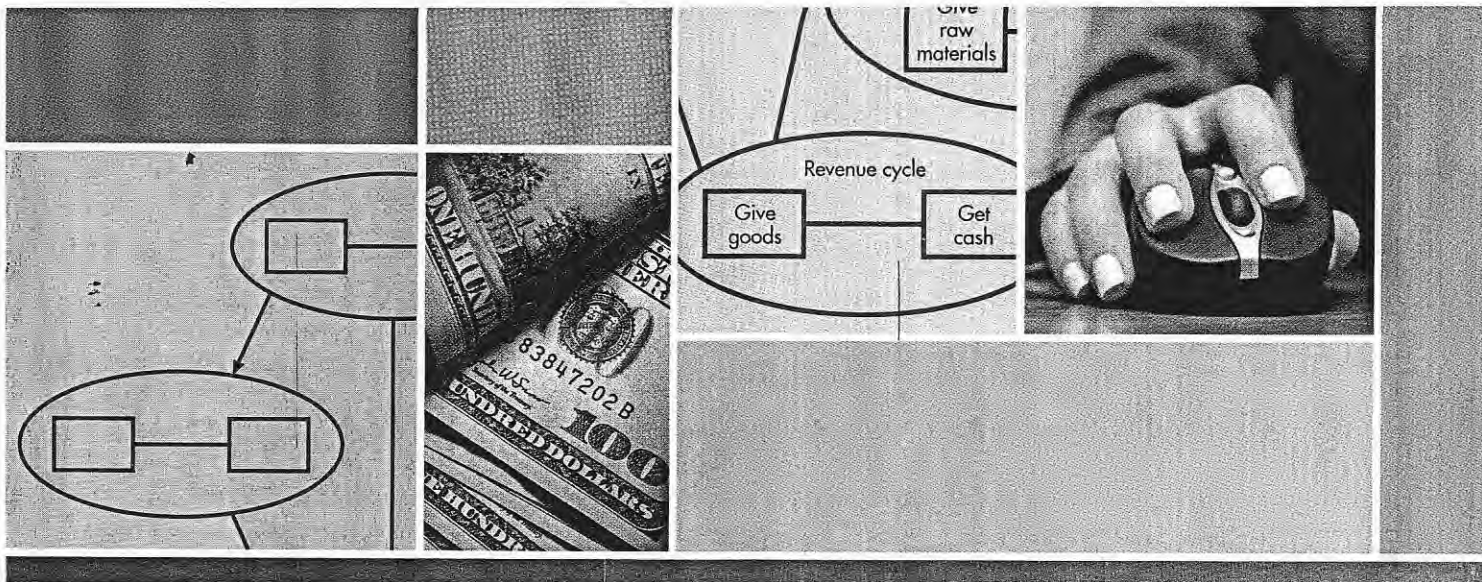
1. Develop REA data models for a variety of organizations besides retail stores.
2. Develop REA data models for the HR/payroll, manufacturing, and capital assets business cycles.

### INTEGRATIVE CASE PAUL STONE, CONSULTING

Paul Stone has enjoyed designing a database for Fred's Train Shop so much that he decides he wants to do similar work for other local businesses. First, however, he realizes that he needs to acquire some additional skills. Although he feels confident of his ability to model the activities of retail businesses like Fred's Train Shop, Paul knows that he needs to learn more about how to model other types of businesses, such as manufacturing businesses and businesses that provide services.

Paul begins searching the Internet for information about data modeling and database design. He finds a link to a workshop on REA data modeling that is being offered by the American Accounting Association. After reading about it, Paul is certain that it is exactly what he is looking for. He registers for the class. He then prepares a list of questions about the situations that he wants to learn how to model:

1. How do you model the revenue cycle activities of a business that provides services, such as computer or automotive repairs? What about a business that rents items instead of selling them?
2. How do you model the production cycle activities of a manufacturer?
3. How do you integrate payroll activities with other HR processes, such as hiring and training employees?
4. How do you model financing transactions, such as the issuance of stock or debt?



## Introduction

The previous two chapters introduced the topic of REA data modeling and explained how to implement an REA model in a relational database. Both chapters focused primarily on the revenue and expenditure cycle activities for a typical retail organization. This chapter extends those basic concepts to a variety of other types of businesses and business cycles. We begin by examining more complex models of the revenue and expenditure cycles, including some additional activities typically performed by manufacturers and distributors and other special situations. Then we discuss several additions to the basic REA model. Next we explain how to model basic business activities in the production, HR, and financing cycles. We conclude by presenting a comprehensive integrated REA model that incorporates many of the topics presented in this chapter.

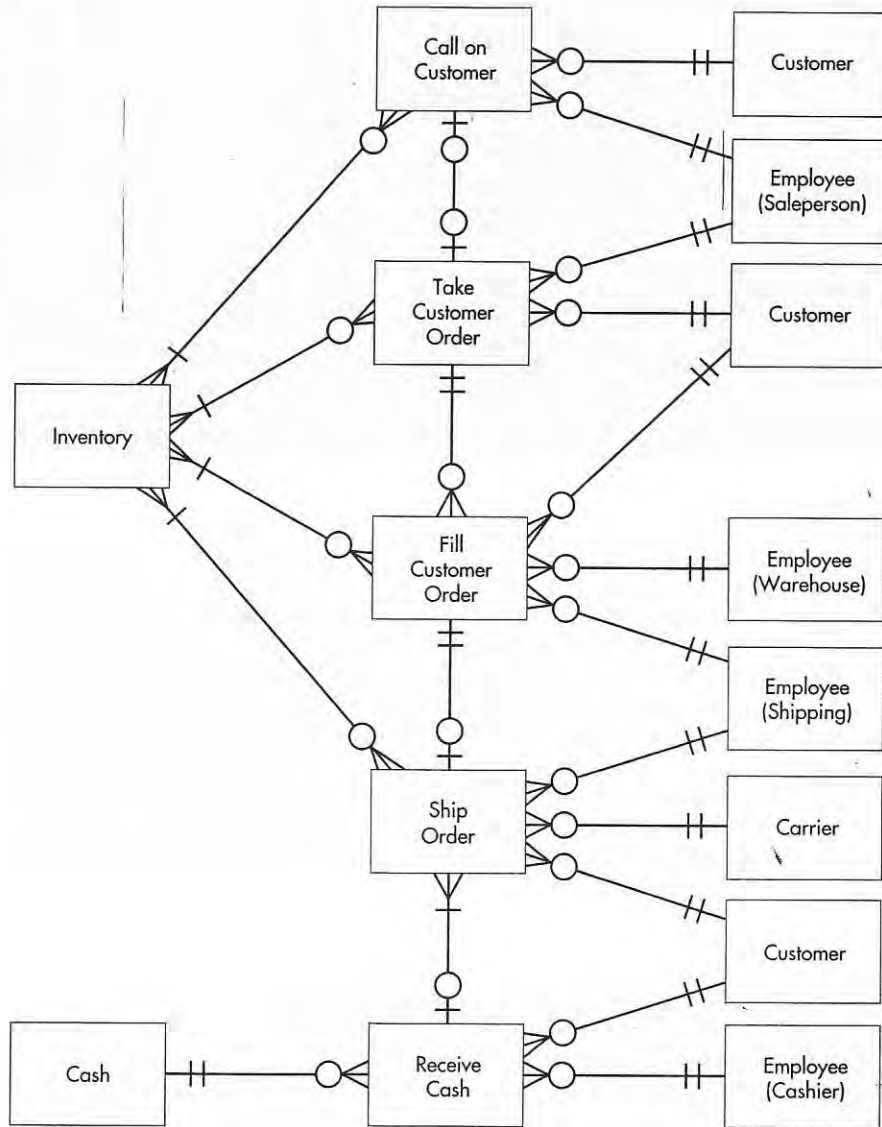
## Additional Revenue and Expenditure Cycle Modeling Topics

Figures 19-1 and 19-2 present REA diagrams that include additional events for the revenue and expenditure cycles, respectively. Tables 19-1 and 19-2 show how to implement these models in a relational database.

### Additional Revenue Cycle Events and Attribute Placement

Many of the entities and relationships depicted in Figure 19-1 have already been discussed in previous chapters, so we will focus only on those aspects that are new. Figure 19-1 separates the warehouse activity of filling an order from the activity of actually shipping or delivering that order to the customer. Thus, each instance of the Fill Customer Order event represents the picking and packing of an order by a warehouse employee. The meaning of the cardinality pairs between that event and the inventory resource and participating agents should be understood from discussions in the previous two chapters. The relationship between the Take Customer Order and Fill Customer Order events is represented as being one-to-many (1:N). The minimum cardinalities reflect the fact that two events occur sequentially. The maximum cardinalities reflect the fact that sometimes the company may be out of stock of one or more items that were ordered. Therefore, it may take multiple warehouse activities to completely fill a particular order. Each customer order has to be individually picked and packed, however. The relationship between the Fill Customer Order and Ship Order events is 1:1. The minimum cardinalities reflect the fact that the two events are sequential. The maximum cardinalities are typical best practices followed by most companies. Once all the items that were ordered and in stock have been picked

**FIGURE 19-1**  
**Extended Partial**  
**Revenue Cycle REA**  
**Diagram**



and packed, that entire package is shipped intact to the customer. Note that the Ship Order event occurs when the merchandise is given to the customer (i.e., it is the Sale event). Thus, if formal sales invoices are prepared, there would be a separate invoice for each filled order. For proper accountability each Ship Order event is linked to one, and only one, Fill Customer Order event. It is true that oftentimes many different orders are placed on the same truck or railroad car. However, producing accurate financial records requires tracking each individual “shipment” (sale) on that truckload/carload separately.

Table 19-1 shows that the primary key of the Ship Order event is the shipment number. The bill of lading number is another attribute, but it is not the primary key because it may be null for deliveries made using the company’s own trucks. Sales invoice number is another attribute of the shipment event. It is not the primary key, however, because as discussed in Chapters 12 and 13, many companies are moving to eliminate the printing of paper invoices and even the creation of electronic ones. Moreover, even when invoices are still used, they may not be generated at the time the merchandise is shipped. Therefore, if invoice number were the primary key, information about the shipment could not be recorded until the invoice was generated. For companies that do still use invoices, however, the invoice number attribute serves an important internal control function: Examination of the value of this attribute provides an easy means of verifying whether

**TABLE 19-1** Attributes for Relational Tables in Figure 19-1

Table Name	Primary Key	Foreign Keys	Other Attributes
Inventory	Product number		Description, unit standard cost, unit list price, weight, reorder point, beginning quantity-on-hand
Cash	General ledger account number		Name, beginning balance
Call on customer	Call number	Customer number, salesperson employee number	Date, time, purpose
Take customer order	Sales order number	Customer number, salesperson employee number, call number	Date, time, terms, desired delivery date
Fill customer order	Picking ticket number	Sales order number, customer number, warehouse employee number, shipping employee number	Date, time, comments
Ship order	Shipment number	Picking ticket number, customer number, shipping employee number, carrier number, remittance number	Date, time, bill-of-lading number, invoice number
Receive cash	Remittance number	Customer number, employee number, cash account number	Date, time, amount received
Employees	Employee number		Name, date hired, date of birth, number of dependents, pay rate, other tax/withholding information, job title
Customers	Customer number		Name, address, credit limit, beginning balance
Carriers	Carrier number		Name, contact phone
Inventory– Call on Customers	Product number, call number		Comments
Inventory– Take Customer Order	Product number, sales order number		Quantity ordered, price per unit
Inventory Fill Order	Product number, picking ticket number		Quantity picked
Inventory–Ship Order	Product number, shipment number		Quantity shipped

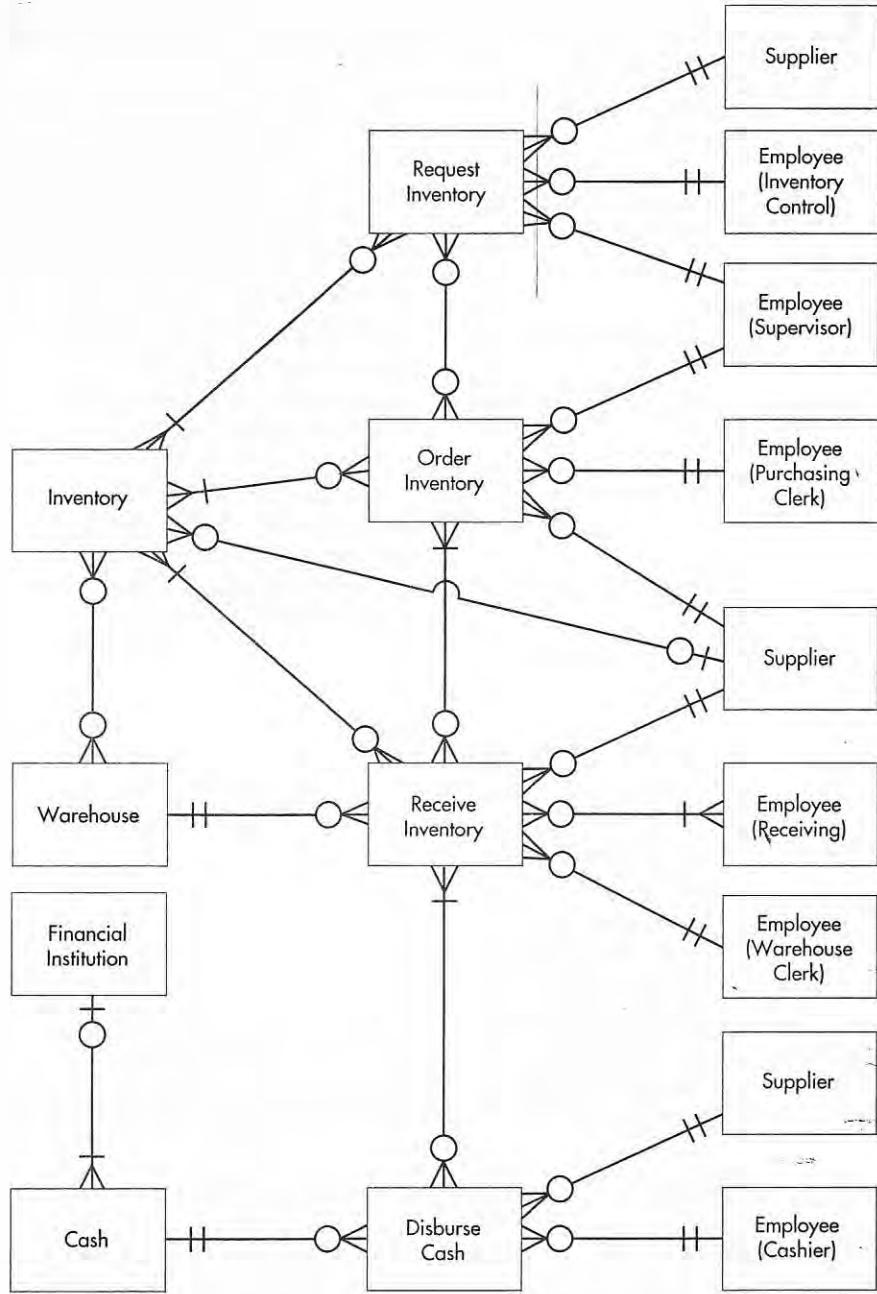
all shipments have indeed been billed and recorded (a null value means that an invoice has not yet been prepared).

Also notice that Table 19-1 shows that information about prices and costs is stored in several places. The Inventory table contains information about the standard (list) price and standard cost of each item because those values are typically constant for the entire fiscal year. The Inventory–Take Customer Order table, however, contains information about not only the quantity ordered but also the actual price and accounting cost assigned to each item. This reflects the fact that companies may change prices several times during the year. Thus, although the list price is constant, the actual sales price depends on when the sale occurs. Similarly, although the standard cost for each item is constant during the year, the calculated cost of goods sold (which may be determined using either FIFO, LIFO, weighted-average, or specific identification) will vary throughout the year, especially if a perpetual inventory system is used.

### Additional Expenditure Cycle Events and Attribute Placement

Most of the entities and relationships depicted in Figure 19-2 have been explained in the previous two chapters. The one new entity is the Request Inventory event. Many larger organizations want to formally approve requests to purchase goods; the Request Inventory event provides a way to collect data about such activities. Each instance of this event represents a request to

**FIGURE 19-2**  
**Extended REA Diagram**  
**for Expenditure Cycle**



purchase one or more items. The M:N relationship between the Request Inventory and the Order Inventory events has a minimum cardinality of 0 in both directions. The 0 minimum associated with the Order Inventory event reflects the fact that requests occur before actual orders; in addition, some requests are denied and thus are never linked to an order. The 0 minimum associated with the Request Inventory event reflects the fact that some orders are generated automatically by the inventory control system, rather than as a result of a specific request. The maximum associated with the Order Inventory event is many because some requests may be for several different items, each of which may be normally obtained from different sources. Separate purchase orders are needed for each different supplier. Therefore, an approved request may be linked to several different orders. The maximum cardinality associated with the Request Inventory event is many to reflect the common practice of combining different requests for items provided by the same supplier into one larger order to obtain better terms.

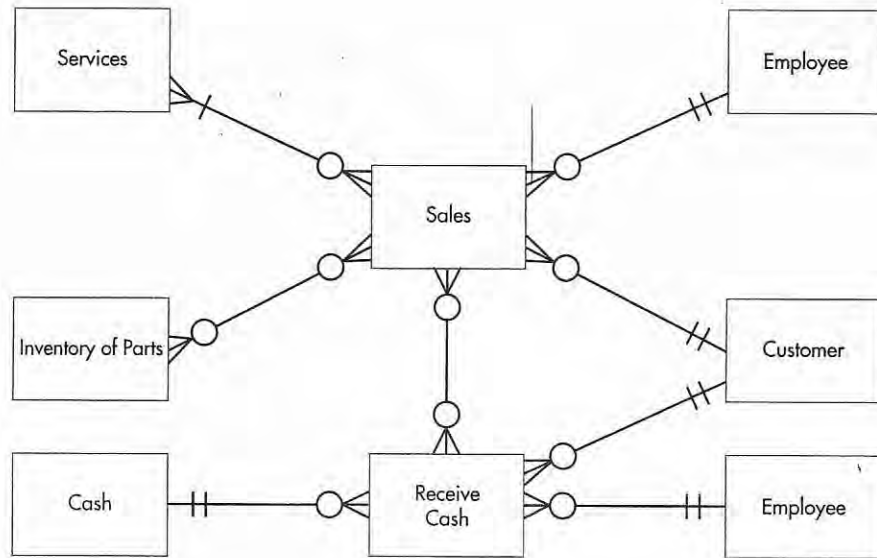
Table 19-2 shows that cost information is stored in several tables. Standard cost is stored as an attribute of the Inventory table because it is the same for all units of a given inventory

**TABLE 19-2 Attributes for Relational Tables in Figure 19-2**

Table Name (Entity)	Primary Key	Foreign Keys	Other Attributes
Inventory	Product number		Description, unit standard cost, unit list price, weight, reorder point, beginning quantity-on-hand
Warehouse	Warehouse number		Name, address, capacity
Financial institution	Institution number		Name, contact phone
Cash	General ledger account number	Financial institution number	Name, beginning balance
Request inventory	Purchase requisition number	Supplier number, inventory control employee number, supervisor employee number	Date, reason
Order inventory	Purchase order number	Supplier number, purchasing clerk employee number, supervisor employee number	Date, comments
Receive inventory	Receiving report number	Warehouse number, supplier number, warehouse employee number	Date, time, remarks, vendor's invoice number
Disburse cash	Check number	Supplier number, employee number, cash account number	Date, amount, memo
Suppliers	Supplier number		Name, contact phone, rating, beginning balance
Employees	Employee number		Name, date hired, date of birth, number of dependents, pay rate, other tax/withholding information, job title
Inventory-Request_Inventory	Product number, purchase requisition number		Quantity requested
Inventory-Order_Inventory	Product number, purchase order number		Quantity ordered, cost per unit
Inventory-Receive_Inventory	Product number, receiving report number		Quantity received, condition
Inventory-Warehouse	Product number, warehouse number		Quantity stored
Request_Inventory-Order_Inventory	Purchase requisition number, purchase order number		
Order_Inventory-Receive_Inventory	Purchase order number, receiving report number		
Receive_Inventory-Disburse_Cash	Receiving report number, check number		Amount applied to invoice
Receive_Inventory-Employee	Receiving report number, employee number		
Inventory-Supplier	Product number, supplier number		Type (preferred, alternate)

item for a fiscal year. In contrast, the actual cost of inventory is stored in the Inventory-Order\_Inventory table. This reflects the fact that purchase prices can vary over time. By storing the cost of each order with the quantity purchased, the system can calculate the actual cost of ending inventory and the cost of goods sold according to any accepted inventory valuation method (LIFO, FIFO, weighted-average, or specific identification). If, on the other hand, actual cost were stored as an attribute of the Inventory table, it would necessitate using the weighted-average method because all units of a given inventory item would be assigned the same cost. In addition, cost data would be available only in this format; it would be impossible to

**FIGURE 19-3**  
**Partial Revenue Cycle for**  
**Sale of Services**



compute alternative values for inventory because the detailed data about the cost associated with each purchase would not be stored in the database.

### Sale of Services

Thus far, all our modeling examples have focused on businesses that sell tangible inventory. Businesses like automotive repair shops, however, generate revenue from both the sale of products and the provision of services. Figure 19-3 presents a partial REA model of the revenue cycle for such a company.

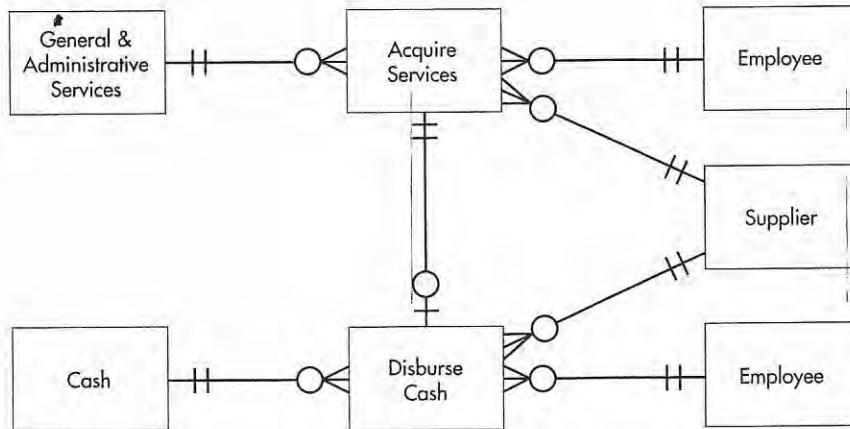
The Services entity in Figure 19-3 contains information about the organization's revenue-generating activities. Each row identifies a specific type of service the company provides. For example, the Services table for an automotive repair shop might include individual rows for oil changes and brake replacement. Each row would include information about the standard ("book") time it should take to complete the service and the standard (regular) price charged for that type of repair.

Figure 19-3 includes relationships between the Sales event and both the Services and Inventory Resource entities. The nature of the cardinality of those relationships depends on the specific business, but usually both relationships will be modeled as being M:N because most businesses provide the same types of services to many different customers, using standard mass-produced parts. The minimum and maximum cardinalities in Figure 19-3 are typical for businesses like automotive and appliance repairs. For such businesses, every sales transaction must involve at least one specific type of service but may include several services (e.g., a customer may require an oil change and brake repairs). However, some repair services, such as fixing a flat tire, may not involve the use of any identifiable inventory parts, requiring only labor.

### Acquisition of Intangible Services

In addition to purchasing inventory, equipment, and buildings, organizations also acquire various intangible services, such as Internet access, telephone service, and utilities. Figure 19-4 shows how to model such activities.

The basic give-to-get economic exchange involves acquiring various services and paying for them. Payments for those services are included in the Disburse Cash table. A separate event, Acquire Services, is used to collect data about the acquisition of those services. This event entity stores information about the actual amount of the service consumed and the actual price charged. In Figure 19-4, this event is linked to a resource labeled "General and Administrative Services" that reflects the financial accounting treatment for these items. That



**FIGURE 19-4**  
Partial Expenditure Cycle  
for Acquisition of  
Services

resource entity includes information about the intangible resource, such as the length of the contract, if any, its starting date, the budgeted cost for that service, the budgeted or standard amount to be provided each period, and a description of any limitations or special requirements associated with its use.

The relationship between the acquisition event and the resource entity is modeled as 1:N in Figure 19-4 because in most cases each service (telephone, electricity, etc.) is acquired separately, usually from a different supplier. The relationship between the Acquire Services and Disburse Cash events is modeled as 1:1 to reflect the common situation in which the organization obtains the use of a specific service for a particular period of time and makes a payment each month for the services it acquired and used that month.

### Digital Assets

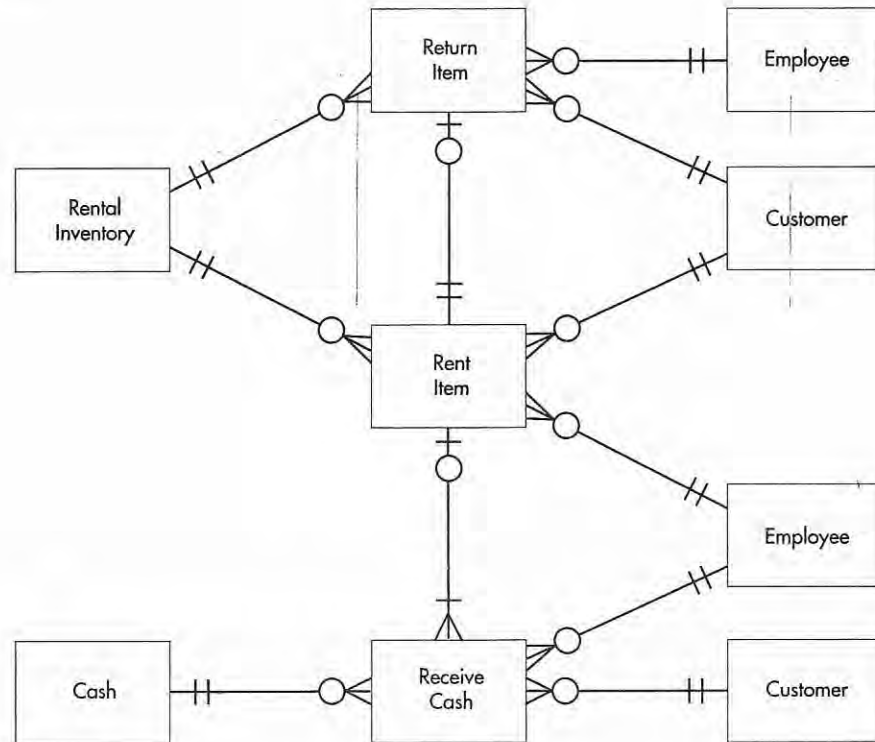
What about digital assets? Companies that sell software, music, or digital photographs over the Internet give up a digital copy of those resources, but not the actual resource itself. How does this affect the REA models of the revenue and expenditure cycles? It doesn't. Such companies still need to collect information about their purchase of and payment for those digital assets, as well as tracking orders for and delivery of those digital assets, along with receipt of payments from their customers. Those companies also need an Inventory table so that customers can see what digital products are available for sale. The structure of that Inventory table is almost identical to that of mass-produced merchandise. The only difference is that because sales involve only a digital copy of the resource, there is no need for attributes such as quantity-on-hand, quantity-available, reorder point, and standard reorder quantity. However, the Inventory table will still include information about the standard list price of each item and its description.

### Rental Transactions

Some businesses generate revenue through rental transactions, rather than sales. Thus, the basic give-to-get economic exchange involves the temporary use of a resource in return for both the receipt of cash and the subsequent return of the resource being rented. Figure 19-5 shows how to model such transactions.

Businesses that rent equipment or other resources want to track each physical item separately. Therefore, the primary key for the Rental Inventory table is some kind of unique serial number, rather than a part number. Each Rent Item event records information about the rental of one specific item, such as the date and time it was rented, the rental price, and any specific terms of the agreement. If a customer rents multiple items, the system treats this as a set of rental events, each for one particular inventory item. This facilitates tracking the status of each piece of Rental Inventory. For example, a query to determine whether an item is still outstanding needs to reference only the Rental and Return events; in contrast, if the rental of five items had been recorded as one event, then the preceding query would also have to include the M:N relationship table linking the Rental event and Rental Inventory entity. (Note: This is transparent to the

**FIGURE 19-5**  
**Partial Revenue Cycle for**  
**Rental Transactions**



customer. The customer simply completes the required paperwork and pays the specified amount and neither knows, nor cares, that the system created several rows in the database, instead of one, to record the transaction.)

Figure 19-5 shows that the Rent Item event is linked to both the Receive Cash and Return Item events. Examine the relationship from the Rent Item to the Receive Cash event. The minimum cardinality of 1 reflects the fact that customers typically pay first, prior to taking possession of the item. The maximum cardinality is many because there may be additional charges imposed when the item is returned. The cardinality pair associated with the Rent Item event has a 0 minimum and 1 maximum because the Receive Cash event occurs first and is linked to one, and only one, specific rental event. The relationship between the Rent Item and Return Item events is 1:1 to reflect the fact that the rental of each specific item is individually tracked, as is its return; moreover, each item rented can be returned at most one time. The minimum cardinalities on each side of the relationship reflect the temporal sequence of the two events (i.e., an item is rented before it is returned).

Organizations sometimes rent, rather than purchase, resources. For example, many organizations rent office spaces and warehouses. The basic economic give-to-get exchange involves payments to the supplier for the right to use a resource for a specific period of time. Information about the Payment event is included in the Disburse Cash table. A separate Rent Resource event may be created to represent the acquisition of the resource, because that event will probably collect information about different attributes than those that are relevant to the receipt of inventory. Although it is rented and not owned, the resource itself would also be included in the model as a separate entity because organizations will likely need to maintain much of the same kind of information (e.g., location, description, etc.) about rented resources as they do for resources that are owned. Rented and owned resources may be represented in separate entities, however, because each may contain a number of attributes not relevant to the other (e.g., information about rental contract terms, acquisition cost, depreciation method, etc.). In addition, if the rented resource must be returned (e.g., rental of equipment), then another event will need to be included in the REA diagram to record that activity. In that case, the Rent Resource event would be linked to two events: Disburse Cash and the Return of the resource, forming a mirror image of the REA model of the renting organization's revenue cycle activities discussed earlier.

## Additional REA Features

Figures 19-1 and 19-2 depict several new additional elements of REA data models not discussed in the prior two chapters: employee roles, M:N agent–event relationships, locations, and relationships between resources and agents.

### Employee Roles

Figure 19-1 and 19-2 identified the role played by an employee (e.g., salesperson, warehouse clerk, etc.). This information enriches the REA diagram and can be used to verify whether job functions are properly segregated. However, Tables 19-1 and 19-2 still show that there is only one employee entity. Information about job roles is simply another attribute (job title) in the employee table.

### M:N Agent–Event Relationships

Figure 19-2 depicts the relationship between the Receive Inventory event and employees as being M:N. This reflects the fact that many deliveries are so large that several employees must work together to unload and store the items. M:N agent–event relationships occur whenever an activity is performed by more than one employee, yet management wants to retain the ability to monitor each individual's performance.

### Locations

Figure 19-2 introduces two new entities: Warehouses and Financial Institutions. These entities store information about the location where resources are stored and where certain events take place. Many companies have multiple warehouses. The cardinality pairs linking the Warehouse and Inventory entities reflect several common situations. A warehouse can, occasionally, be empty but usually stores many different inventory items. Conversely, the same inventory items may be stored in several different warehouses. Sometimes companies may also want to maintain information about inventory that they do not normally carry.

Note also that linking the Receive Inventory event to the Warehouse entity makes it possible to evaluate performance at different locations. Events, such as Receive Inventory, can only occur at a specific location; conversely, many events can occur at the same location. Therefore, Figure 19-2 depicts the relationship between Warehouses and Receive Inventory as 1:N.

Examination of Table 19-2 shows that the Financial Institution entity clarifies the nature of the Cash entity. Each row in the Cash table corresponds to a specific general ledger account that is aggregated in the balance sheet under the heading “Cash and Cash equivalents.” The cardinality pairs associated with the Financial Institution and Cash entities reflect common business practices. A specific cash account can only be located at one financial institution and some accounts, such as “Petty Cash,” are not on deposit anywhere. Companies also typically only keep information about financial institutions with which they have accounts but may have more than one account at the same financial institution.

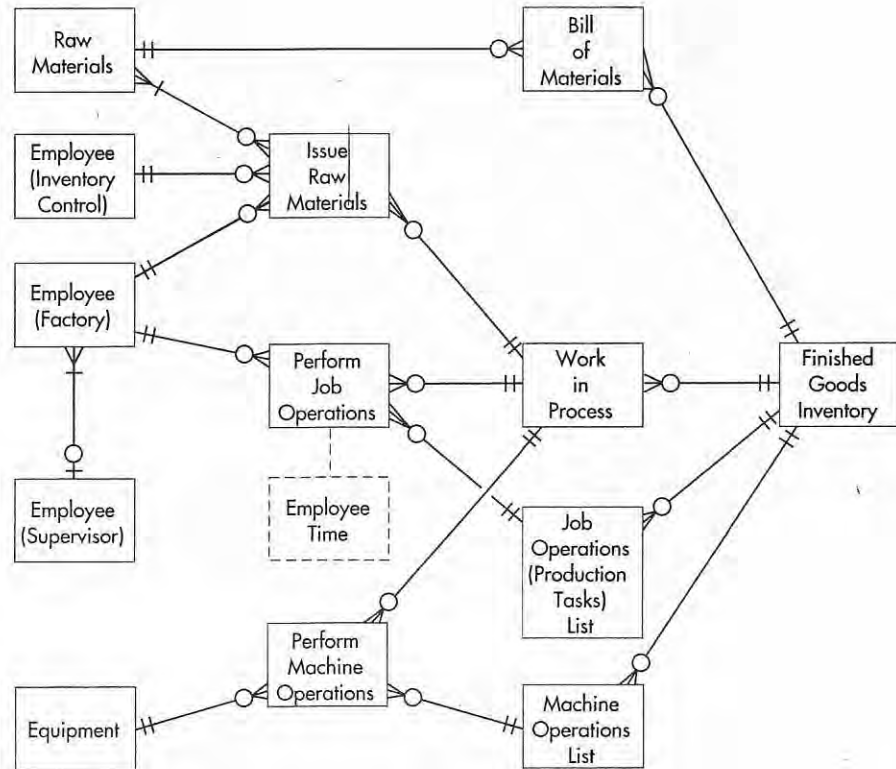
### Relationships Between Resources and Agents

Figure 19-2 also includes a M:N relationship between the Inventory entity (a Resource) and the Supplier entity (an Agent). This relationship reflects the common best practice of identifying preferred and alternative suppliers for specific inventory items. Similar relationships between resources and employees can be used to model responsibility and accountability.

## Production Cycle REA Model

Figure 19-6 is a data model for the basic production cycle activities of a manufacturing company and Table 19-3 lists the tables required to implement that model in a relational database, along with the placement of various attributes. Accurate product cost management and performance evaluation of production cycle activities requires collecting detailed information about the use of

**FIGURE 19-6**  
**Partial REA Diagram for**  
**Production Cycle**



raw materials, labor, and machinery to produce finished products. Thus, there are four main events of interest included in a typical production cycle REA diagram:

1. Issuance of raw materials
2. Use of labor in production
3. Use of machinery and equipment in production
4. Production of new finished products, represented by the work-in-process event

### Additional Entities—Intellectual Property

Figure 19-6 includes three special types of entities—the Bill of Materials, the Job Operations List, and the Machine Operations List—that store important portions of a manufacturing company's intellectual property. The Bill of Materials entity contains information about the raw materials used to make a finished product. As Table 19-3 shows, this includes data about the *standard* quantity of each raw material that should be used to make that product. Thus, the bill of materials can be thought of as the list of ingredients in a recipe. By itself, however, such a list is not sufficient to manufacture a product—instructions concerning how to combine those components, including the proper sequence of steps, are also needed. The Job Operations List entity stores the instructions concerning labor activities, and the Machine Operations List entity stores the instructions for actions to be performed using various pieces of equipment. Both entities also store data about the *standard* time it should take to perform those operations.

Figure 19-6 shows 1:N relationships between the Bill of Materials entity and both the Raw Materials and Finished Goods inventory entities. Each row in the Bill of Materials entity specifies how much of a specific raw material is needed to make a particular finished good; thus, each row represents the information that would be found on one line of a Bill of Materials list. This reflects the fact that the same raw material (e.g., 12-gauge wire) may be used in five different products, with a different amount used to make each product. The relationship between the Raw Materials entity and the Issue Raw Materials event is M:N because the same raw materials can be related to many different events of issuing that raw material; conversely, often all of the different materials needed to manufacture a product are issued at the same time; hence, one Issue Raw Materials event can be linked to many different lines in the Raw Materials table.

**TABLE 19-3 Attributes for Relational Tables in Figure 19-6**

Table Name (Entity)	Primary Key	Foreign Keys	Other Attributes
Raw materials <sup>a</sup>	RM item number		Description, standard unit cost, reorder point, beginning quantity on hand
Employees	Employee number		Name, date hired, date of birth, number of dependents, pay rate, other tax/withholding informatio, job title
Equipment	Equipment ID number		Description, acquisition cost, depreciation method, depreciation life, salvage value
Issue raw materials	RM issue number	Inventory control employee number, factory employee number, WIP job number	Date, time, comments
Perform job operations	Job operation number	Employee number, WIP job number, job operations list number	Date, time started, time finished
Perform machine operations	Machine operation number	Equipment ID number, WIP job number, machine operations list number	Date, time started, time finished
Bill of materials	Bill of materials number	Finished good product number, raw materials item number	Standard quantity needed
Work in process	WIP job number	Finished good product number	Date/time started, date/time completed, target completion date, quantity ordered, quantity produced, production order number
Job operations list	Job operations list number	Finished good product number	Instructions, standard time for operation
Machine operations list	Machine operations list number	Finished good product number	Instructions, standard time for operation
Finished goods inventory <sup>a</sup>	Product number		Description, unit standard cost, unit list price, weight, beginning quantity-on-hand
Raw materials-issue raw materials	RM item number, RM issue number		Quantity issued

<sup>a</sup>Some organizations may combine Finished Goods and Raw Materials into one inventory table.

The relationships between the Finished Goods Inventory resource and both the Job Operations List and Machine Operations List entities are 1:N. This reflects the fact that each row in the list entities represents information about a specific activity required to make a specific product. For example, there would be separate rows for polishing brass for each product that included brass parts; each row would store information about the standard time it should take to polish the brass when making a particular product. Often, multiple steps are required to make a single product. Thus, one finished good would be linked to many different rows in the Job Operations List and Machine Operations List entity tables.

Figure 19-6 also includes an entity labeled “Employee Time”. As explained in Chapter 18, this entity is seldom instantiated as a table in a relational database. Hence, it is represented with dashed lines in Figure 19-6.

### Production Cycle Events

Data about *actual* raw materials used in production is stored in the Issue Raw Materials entity. Similarly, information about the *actual* labor and machine operations performed, including the actual amount of time each activity took, is stored in the Perform Job Operations and Perform Machine Operations entities, respectively. Performance can be evaluated by comparing the data in these three event entities with the information about standards that is stored in the corresponding information entities (Bill of Materials, Job Operations List, and Machine Operations List).

The Perform Job Operations event entity is an example of a Give Resource event: It records the use of employee time. Each row in that table records information about how much time an employee spent working on a particular job. Thus, there can be many rows in this table for each employee every day. For example, on July 7, employee 727 may spend three hours on WIP job 2234, two hours on WIP job 2235, and three hours on WIP job 2236. Collecting this kind of detailed information about how factory employees use their time enables manufacturing companies to accurately assign labor costs to different production batches and product lines.

The Perform Machine Operations event is similar to the Perform Job Operations event, except that it records information about the use of a specific piece of machinery or equipment. This information is useful not only to assign costs to products, but also for scheduling maintenance. Note that the Perform Machine Operations event is *not* used to record depreciation. Depreciation expenses seldom correspond to actual use of the equipment. Depreciation is not modeled as an event in the REA diagram because it is an accounting concept that arbitrarily allocates the cost of an acquired resource to different fiscal periods. Periodic depreciation is simply a calculation based on a formula (depreciation method) and a set of assumptions (estimated useful life, salvage value, etc.). Information about the formula and assumptions is stored in the resource entity for use in calculating periodic depreciation charges, but the calculation process itself is not an event, just as the processes of calculating the total amount of a particular sales transaction or the amount of an employee's paycheck are not modeled as events.

Figure 19-6 models the relationships between the Perform Job Operations event and the Job Operations List entity, and between the Perform Machine Operations event and the Machine Operations List entity, as being 1:N. The list entities store information about the standard time it should take to perform each individually identifiable activity; the operations events record the actual time used to perform that activity. Thus, each actual event can be linked to only one entry in the standards table, but each entry in the standards table is likely to be linked to many actual performances of that activity.

The Work-in-Process entity is used to collect and summarize data about the raw materials, labor, and machine operations used to produce a batch of goods. The relationships between Work-in-Process and those three event entities are all 1:N, reflecting the fact that each production run may involve a number of raw materials issuances, labor operations, and machine operations. Each of those activities, however, is linked to a specific production run. These links reflect an internal give-to-get exchange that is the essence of the production cycle: Raw materials, labor, and equipment are all used in order to produce finished goods inventory. Thus, three Give Resource events are related to one Get Resource event.

### New REA Feature

Notice that Figure 19-6 differs from previous REA diagrams in that it shows only one agent associated with the Perform Job Operations (and Perform Machine Operations) events. These internal events differ from the other events discussed throughout this book in that they do not involve an exchange or transfer of resources. Instead, they represent the consumption or use of individual resources, such as a specific employee's time or the use of a specific piece of equipment. Therefore, the event is linked to that agent (employee or piece of machinery) for which management wants to collect information for product costing and performance evaluation purposes.

Figure 19-6 also depicts a 1:N relationship between employees and supervisors. This reflects the typical situation where each employee is assigned to a specific supervisor, but each supervisor is responsible for many employees. In contrast, a matrix style of organization, where each employee reports to several supervisors, would be modeled as an M:N relationship between factory employees and supervisors. Relationships between internal agents may be created to model lines of responsibility. Relationships between internal and external agents can also occur. For example, some organizations that primarily provide services, such as banks and insurance companies, may assign customers to specific employees who are responsible for effectively managing the overall quality of the ongoing association with each customer. Relationships between external agents are rare but may sometimes be implemented to satisfy the requirements for a well-structured database. For example, if an insurance company needed to collect and maintain detailed information about each of a customer's dependents, it could do so by creating a separate entity called "Dependents" and establishing a 1:N relationship between that entity and the Customer entity.

## Combined HR/Payroll Data Model

Figure 19-7 integrates payroll and HR activities. The Time Worked event is necessary to calculate payroll. The Time Used event is used for cost accounting, to properly assign labor costs (in manufacturing companies, this event entity is often called “Job Operations”). All of the other events represent important HR activities.

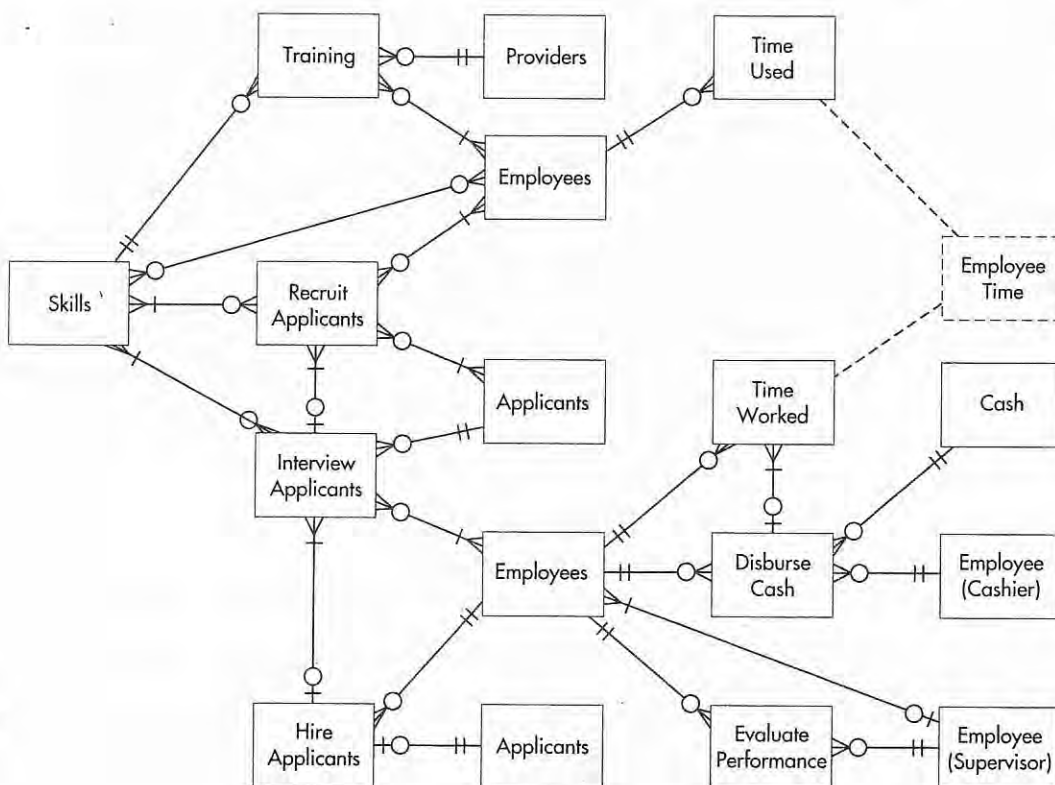
### HR Cycle Entities

Notice that in Figure 19-7 the Employee entity is linked to almost every other entity in the diagram, reflecting the importance of employees to the organization. The Employee entity stores much of the data typically found in the employee (payroll) master file: name, date hired, date of birth, pay rate, job title, supervisor, number of dependents, withholding allowances, and information about any voluntary deductions, such as 401(k) plans.

The Skills entity contains data about the different job skills of interest to the organization. There would be a row in this table for each major job skill. For example, a software developer may list different programming languages and application programs in this table. The relationship between Skills and Employees is modeled as being M:N because one employee may possess a number of job skills (i.e., one programmer may be proficient in several different languages) and, conversely, several employees may possess the same skill.

The Training event entity represents the various workshops, training programs, and other opportunities provided for employees to develop and maintain their skills. Thus, this entity stores data that can be used to evaluate the effectiveness and cost of training and development efforts. The relationship between the Employees and Training entities is M:N, because a given employee will, over time, attend numerous training courses and, conversely, several employees may attend the same specific training class. The relationship between the Skills and Training entities is 1:N, because each course is designed to develop a specific skill, but each skill may be taught many different times.

The Recruiting event entity stores data about activities performed to notify the public of job openings. The data recorded in this entity are useful for documenting compliance with employment laws and also for evaluating the effectiveness of various methods used to announce job opportunities.



**FIGURE 19-7**  
Integrated REA  
Diagram for  
HRM/Payroll Cycles

The M:N relationship between Skills and Recruiting reflects the fact that each advertisement may seek several specific skills and that, over time, there may be several advertisements for a given skill. The relationship between the Recruiting event and Job Applicants is modeled as being M:N because many people typically apply for each job opening, but a given individual may also respond to more than one recruiting event. Also, more than one employee may participate in each recruiting event, and, over time, a given employee may participate in many such events.

The Interview event stores detailed data about each job interview. It is linked to the Hire Employees event in a 1:N relationship. This reflects the fact that the Hiring event occurs only once but may result from either one or a number of preceding interviews.

### Tracking Employees' Time

The section on the Production Cycle discussed the use of a Perform Job Operations event to track how factory workers spent their time so that labor costs can be allocated to products. Professional services firms, such as law firms, consulting organizations, and accounting firms, similarly need to track how their members use their time in order to accurately bill each client. Figure 19-7 uses the Time Used event for this purpose. The structure of this table is similar to that of the Perform Job Operations table described earlier (we use a different name here because "perform job operations" has a manufacturing connotation). Thus, each row in this table includes the following attributes: the employee, the job (client) to which that employee's time should be charged, a description of the task performed (e.g., prepare will, telephone consultation, court appearance, etc.), and the time when that task was started and ended. Information about the nature of the task needs to be collected in order to evaluate performance and because sometimes the rate billed for a particular employee may vary depending on the task being performed.

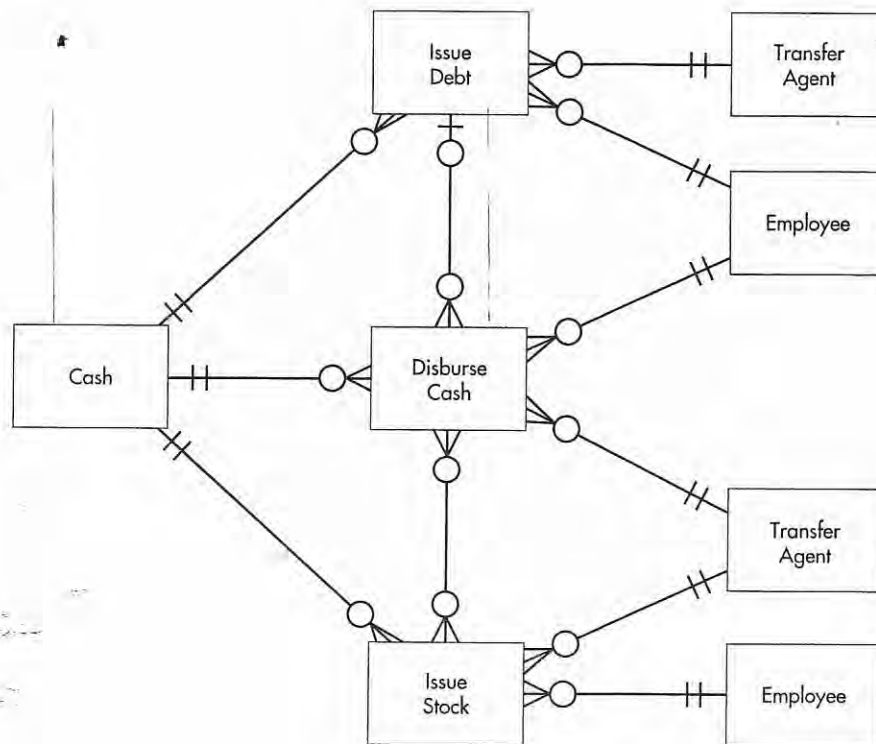
It is instructive to compare the information provided by the Time Used event to that provided by linking specific business events to the employee agent who performed that task. Regular event-agent relationships, such as that between sales and employees, collect data that can be used to answer such questions as "How much did salesperson X sell this week?" or "How many sales did each salesperson make?" In contrast, the Time Used event provides the information needed to answer such questions as "How much time did a particular salesperson spend calling on customers, as opposed to providing customer service support via the telephone?" Each instance of a regular event entity (e.g., each row in the Call on Customer, Sales, or Provide Customer Support tables) captures data about discrete activities, such as a particular sales transaction. In contrast, each row in the Time Used event captures data about what an employee did during a block of time. Hence, each row in the Time Used table can, and often is, linked to many rows in a Business Event table. For example, employee 007 may spend five hours making sales calls to customers, during which time she visited five customers. That would be represented as one row in the Track Time Used table, but five separate rows in the call on customer table. Thus, there is a 1:N relationship between the two types of events. It is not necessary to link the Time Used entity to specific business events, however, but doing so facilitates evaluating performance at a very detailed level (i.e., to answer questions such as during which block of time on which days of the week is a particular salesperson most effective).

Not every organization collects detailed data about their employees' use of time, in which case there is no need for a Time Used entity. Moreover, even when such an event is included, the resource that is used (Employee Time) is seldom implemented as a table in the database because there are no meaningful attributes to describe it. Hence, the resource entity "Employee Time" is depicted with dashed lines in Figure 19-7.

## Financing Activities Data Model

Most organizations issue stock and debt to finance their operations. Figure 19-8 is an REA diagram of these two financing activities.

The event Issue Debt is a special kind of cash receipt; hence, it is connected to the Cash resource entity. It is often modeled as a separate event entity distinct from "Receive Cash" because it contains different attributes from those associated with cash receipts that arise from



**FIGURE 19-8**  
Partial Financing  
Activities Diagram

the Sales event, such as the face amount of debt issued, total amount received, date issued, maturity date, and interest rate. Usually, most companies do not deal directly with individual creditors. Instead, they sell their debt instruments through a financial intermediary, which is depicted in Figure 19-8 as the Transfer Agent. The transfer agent maintains the necessary information about individual creditors, to properly direct both the periodic interest payments and eventual repayment of principal. Therefore, each occurrence of an Issue Debt event contains data about the *aggregate* amount received from issuing a set of debt instruments. For example, the issuance of \$10,000,000 of 5% bonds, which were ultimately purchased by several thousand different individuals for a total of \$9,954,000, constitutes one Issue Debt event.

Debt-related payments (whether periodic interest payments or repayment of principal at maturity) are cash disbursements. Usually, the organization writes one check for the total amount of interest owed for a particular bond or note and sends that to the transfer agent, who then handles the distribution of individual checks to each creditor. Thus, to continue our example, the company would send \$125,000 to the transfer agent to make the first quarterly payment on that \$10,000,000 of bonds. The transfer of funds would be recorded as *one* row in the Disburse Cash table. Note that if a company has issued different series of bonds at different points in time, it would normally make separate transfers of funds to the transfer agent for payments linked to each debt issue. Thus, Figure 19-8 shows each Disburse Cash event linked to a maximum of 1 Issue Debt events. The minimum cardinality is 0 because a particular Disburse Cash event may be linked to either an Issue Debt event or an Issue Stock event.

Equity transactions are modeled in a manner similar to debt transactions. The Issue Stock event is a special kind of cash receipt associated with the issuance of stock, and the dividend payments are another type of cash disbursement. As with debt, most companies do not deal directly with individual stockholders. Thus, Figure 19-8 shows that both types of equity transactions involve participation by an employee (the treasurer) and the external transfer agent. The relationship between the Disburse Cash and Issue Stock events is modeled as being M:N because each stock issuance may be linked to many dividend payments and, conversely, a particular dividend payment may be related to multiple different issuances of stock (i.e., *all* shareholders, regardless of which issue they bought, will receive a portion of each dividend). The minimum cardinalities are 0 in both directions because there is a temporal sequence between the two events and because a given Disburse Cash event might be linked to an Issue Debt event instead of to an Issue Stock event.

The issuance of stock and debt does not occur very often. Moreover, the information associated with these events (par value, actual cash received, etc.) needs to be retained for years in order to track equity and debt accounts to prepare financial statements. Therefore, information about these two events is maintained indefinitely, rather than being erased at the end of the fiscal period as are other events.

## Summary and Case Conclusion

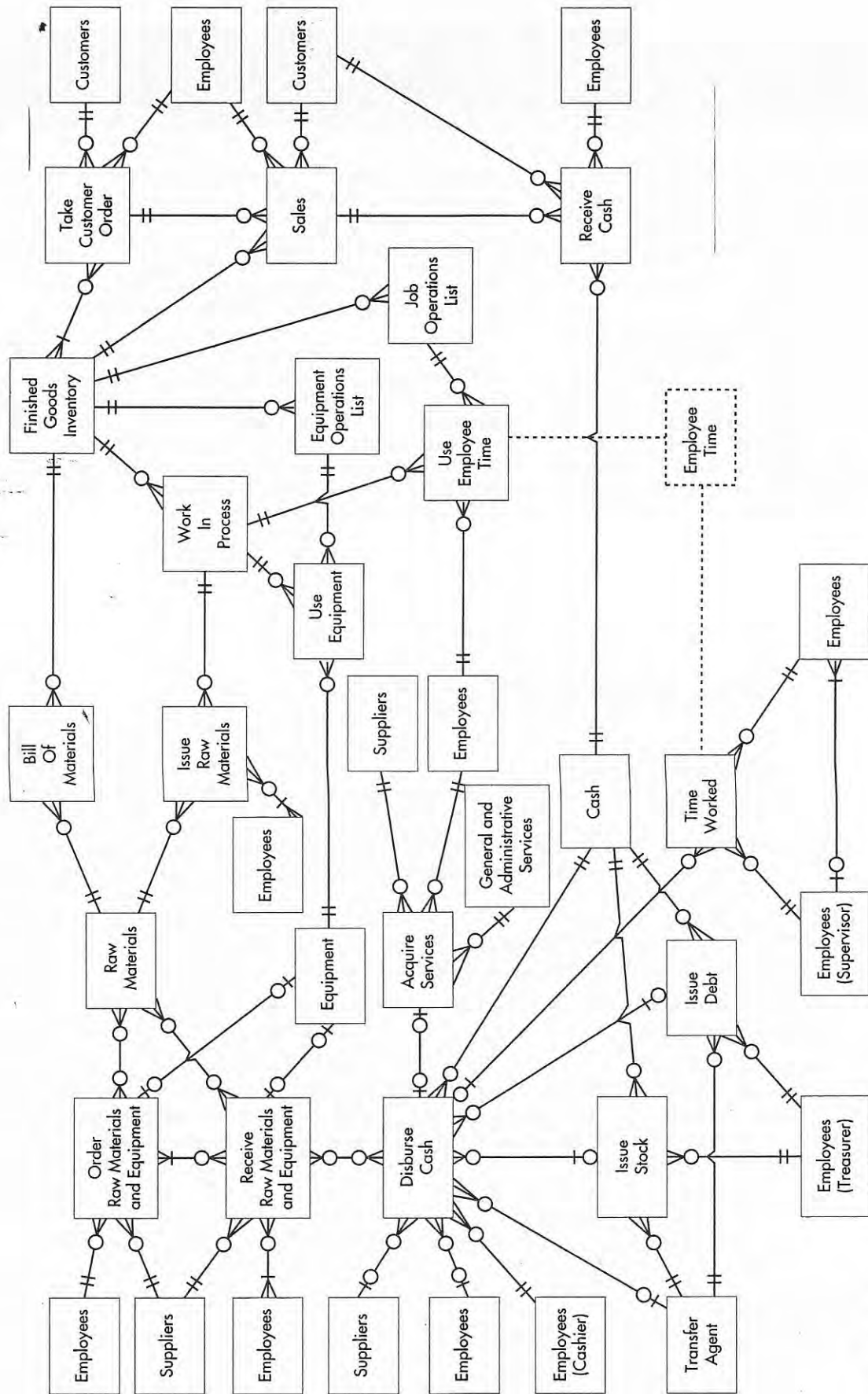
Figure 19-9 presents an integrated enterprise-wide data model that includes most of the situations discussed in this and the previous two chapters. Note how the figure shows the linkages among different subsystems of the organization's AIS. For example, a customer order for finished goods may, if there is insufficient inventory on hand to fill the order, trigger the scheduling of a production run to produce those goods. In turn, this production run may necessitate ordering additional raw materials. Enterprise Resource Planning (ERP) systems are designed to automatically trigger these types of related actions across subsystems by linking each subsystem to a common enterprise-wide database. Thus, even though the databases used in many ERP systems may not be explicitly based on the REA data model, a model like that depicted in Figure 19-9 provides useful documentation about the business activities supported by the ERP system.

Indeed, one of the benefits of an integrated enterprise-wide data model like Figure 19-9 is that auditors can use it to guide the development of queries to validate the completeness and accuracy of transaction processing. To illustrate the possibilities, let us examine the process for validating the updates to the sales account in the general ledger. Referring to Figure 19-9, the first step would be writing queries against the data model for the revenue cycle. One such query would sum the amount of all sales during the time period of interest. Other queries would link the Sales and Take Customer Order tables to verify the completeness and validity of all recorded sales. Additional queries could be written to trace sales to specific customers and sales staff. In fact, the number of such cross-table links that can be easily generated is limited only by the auditor's imagination. In addition, the system can be configured to create extensive log files that make it possible to identify who authorized a transaction. Thus, integrated data models make it possible to write a set of queries that creates a rich, complex audit trail of an organization's business activities.

An integrated enterprise-wide data model like that depicted in Figure 19-9 can also significantly improve the support provided for managerial decision making. Managers can write queries to assess operational efficiency. For example, queries that link the "Use Employee Time" event to various other events can provide information about the relative productivity of various employees. Moreover, the REA model's inherent flexibility makes it easy to collect new information items to evaluate performance, often simply by adding new attributes to existing tables. As Focus 19-1 explains, this flexibility not only facilitates managerial decisions, but can also provide tax benefits.

Creating an integrated, enterprise-wide data model also facilitates the amalgamation of financial and nonfinancial information in the same database, which can improve internal reporting. Traditionally, internal reports have focused primarily on financial performance measures. Effective management of an organization, however, requires measuring performance on multiple dimensions because no single measure is sufficient. Instead, top management must have reports that provide a multidimensional perspective on performance. An integrated, enterprise-wide data model like that depicted in Figure 19-9 facilitates the development of multidimensional performance reports, such as the balanced scorecard discussed in Chapter 16.

Paul Stone reflects on what he has learned at the REA workshop. He realizes that although a number of different types of businesses and transactions were covered, he is likely to encounter clients with yet other situations. Nevertheless, he feels confident that he now understands a wide enough variety of situations that he can use that knowledge to develop solutions to enable him to model almost any type of business activity he is likely to encounter. After all, as a CPA, Paul's entire career has involved continuous learning and refinement of his skills.



**FIGURE 19-9**  
Integrated, Enterprise-wide REA Diagram


**FOCUS**  
19-1

**Tax Benefits of Well-Designed Databases**

A well-designed database efficiently and effectively supports an organization's transaction processing requirements while also providing management with easy access to the information it needs to plan, control, and evaluate performance. A properly designed database can also yield tax benefits. This can be illustrated easily when considering business travel and entertainment expenses.

The IRS generally allows organizations to deduct 50% of the meals and entertainment expenses incurred when dealing with customers or prospective customers. Many organizations simply accumulate all meal and entertainment expenses in one general ledger account. This makes it easy to calculate the tax deduction at the end of the year: Just multiply the total amount in the meals and entertainment account by 50%. Although this approach is simple, efficient, and logical, it can cause an organization to miss out on

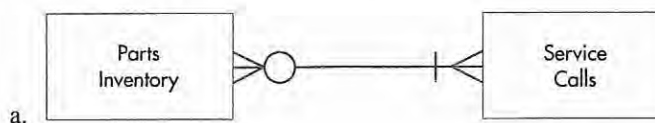
additional tax deductions. The IRS has established several exceptions in which meals and entertainment expenses are 100% deductible. To take advantage of these exceptions, organizations need to design their databases to be able to identify tax-relevant characteristics of specific meals and entertainment expenses. This can be as simple as adding another attribute to the table used to record those expenses.

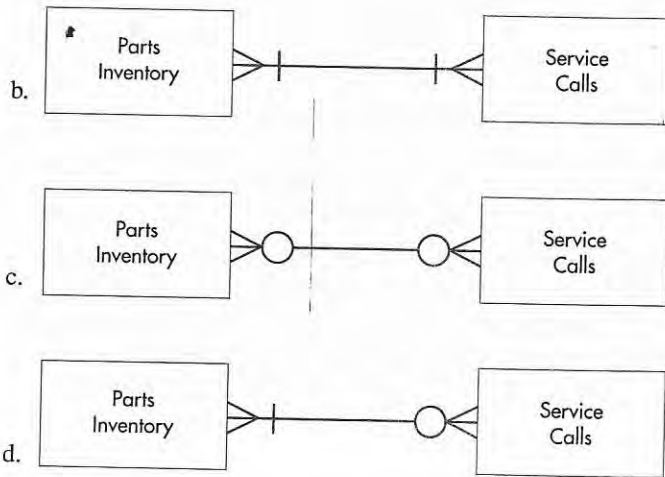
Is it worth the effort? Consider the following examples: (a) Four tickets to an NBA game, plus refreshments, can cost over \$400; (b) four tickets to a concert by a major symphony with dessert and coffee afterwards can cost over \$300. When you multiply such examples by the number of times your sales staff entertains clients during the course of a year, the potential tax benefits of deducting an additional 50% of such costs can be huge.

## AIS IN ACTION

### Chapter Quiz

- Which of the following represents the "get" side of the basic give-to-get economic exchange for a business that rents equipment and machinery for use by others?
  - Rent Equipment
  - Receive Cash
  - Return Rented Equipment
  - Return Rented Equipment and Receive Cash
- Which resource in the HR/payroll cycle is seldom implemented in a database?
  - skills
  - employee time
  - applicants
  - cash disbursements
- Joe's Computers makes service calls to repair computer equipment. Some calls involve only labor charges, and others involve both labor and parts. Which of the following correctly models the relationship between the Service Calls event and Parts Inventory?





4. Which entity contains information about the components used to manufacture a particular product?
  - a. Inventory
  - b. Job Operations List
  - c. Bill of Materials
  - d. Machine Operations List
5. Which of the following production cycle events involves the *acquisition* of a resource (i.e., is a Get event)?
  - a. Perform Machine Operations
  - b. Perform Job Operations
  - c. Work in Process
  - d. Issue Raw Materials
6. Acme Manufacturing tracks information about customer calls by sales representative. Although many calls involve demonstrations of products, some are purely to build relationships. What is the correct way to model the relationship between Inventory and the Call on Customers event?
  - a.
  - b.
  - c.
  - d.

7. Which production cycle event collects the data used to calculate payroll?
  - a. Perform Job Operations
  - b. Time Worked
  - c. Time Used
  - d. Disburse Cash
8. The give-to-get economic exchange associated with debt financing involves which two events?
  - a. Issue Debt and Receive Cash
  - b. Issue Debt and Disburse Cash
  - c. Receive Cash and Disburse Cash
  - d. none of the above
9. Acme manufacturing wants to track post-sales customer service by collecting information about each customer service call: who called, when the call happened, which customer service representative handled the call, how long the call lasted, which sales transaction prompted the call, and which inventory items were discussed. The relationship between the Sales and Post-sales Service Call events should most likely be modeled as which of the following?
  - a. 1:1
  - b. 1:N
  - c. M:N
  - d. 0:N
10. Which of the following additions to the basic REA template are sometimes needed?
  - a. relationships between two resources
  - b. relationships between two agents
  - c. relationships between a resource and an agent
  - d. all of the above

## Discussion Questions

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- 19.1. Often it takes several sales calls to obtain the first order from a new customer. Why then does Figure 19-1 depict the relationship between the Call on Customer and Take Customer Orders events as being 1:1?
- 19.2. How could an automobile dealer model the use of loaner cars, which it gives to customers for free whenever they drop off a vehicle for maintenance that will take longer than one day to complete?
- 19.3. In what situations would you expect to model a relationship between an agent and a resource?
- 19.4. Why is depreciation not represented as an event in the REA data model?
- 19.5. How would you model the acquisition of a digital asset, such as the purchase of software online (the software is downloaded and then installed on the purchaser's computer)?
- 19.6. How are the similarities and differences between the purchase of services, such as telephone service, and the purchase of raw materials reflected in an REA data model?
- 19.7. How would you modify the expenditure cycle REA diagram depicted in Figure 19-4 to include the return of defective products to suppliers for credit?

## Problems

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- 19.1. We-Fix-Computers, Inc., provides spare parts and service for a wide variety of computers. Customers may purchase parts to take home for do-it-yourself repairs, or they may bring their systems in for repair, in which case they pay for both the parts and the labor associated with the type of service required. Some services do not include any new parts, just a labor charge for that service. Individual customers must pay for all parts purchases in full at the time of sale. Individual customers must pay 50% down when they bring their computers in

for servicing and pay the balance at pickup. Corporate customers, however, are billed monthly for all sales (parts or service). Although We-Fix-Computers, Inc., has several different banking accounts, all sales are deposited intact into its main checking account.

We-Fix-Computers, Inc. purchases its inventory of parts from more than a dozen different vendors. Orders are usually delivered the next day; sometimes, however, suppliers ship only partial orders. We-Fix-Computers pays for some of its purchases COD, but usually pays by the 10th of the month for all purchases made the prior month. None of its suppliers allows it to make installment payments.

### Required

Draw an integrated REA diagram for We-Fix-Computers' revenue and expenditure cycles.

- 19.2. The Mesa Veterinary Hospital is run by Dr. Brigitte Roosevelt. She has two employees in the office and has asked you to develop a database to help better track her data. Dr. Roosevelt currently uses her personal computer only for word processing, but she is interested in also using it to maintain pet histories and accounting information. She is excited about the transition and is counting on you to help her through the process. She describes her daily activities as follows:



*When new customers come to Mesa Veterinary Hospital, the "owners" of the pets are required to complete an introductory form. This form includes the following:*

- Owner name
- Address
- Day phone
- Night phone

*They are also required to provide the following information about each pet, as some people own many pets:*

- Pet name
- Breed
- Color
- Birth date

*Dr. Roosevelt would like to enter this information once, and then have the system retrieve it for all subsequent visits.*

*When customers call to make appointments, one of the office clerks asks what kind of services they require (e.g., is it a routine exam, a surgery, etc.). Dr. Roosevelt sees only one pet during each appointment. If she is going to see one owner's two pets, then two separate appointments are necessary (but scheduled back-to-back). For each appointment, Dr. Roosevelt records the pet's weight, notes the reason for the appointment, and records her diagnosis. Depending on the diagnosis, the doctor will possibly prescribe any number of medications to cure the pet. Owners are charged \$25 for each appointment and must pay additionally for any medications prescribed for their pets. Dr. Roosevelt requires all pets to be brought back for another examination prior to refilling any prescriptions. Customers must pay for services and medication in full at the conclusion of their visits.*

You also learn that Dr. Roosevelt orders drugs and medications from several different suppliers. She places orders weekly, on Fridays. Suppliers usually make one shipment to fill each order, but sometimes have to make additional shipments if they are currently out of stock of one or more items. In such cases, they always ship the back-ordered item as soon as they receive it from the manufacturer; they never combine such back orders with subsequent orders by Dr. Roosevelt. Suppliers bill Dr. Roosevelt monthly and expect payment in full by the 15th of the following month. A few suppliers do permit Dr. Roosevelt to make installment payments. The prices charged by suppliers for a given product may change several times during the year, so it is important to accurately store the cost of each item each time it is purchased.

Dr. Roosevelt concludes the interview by requesting that in addition to the facts mentioned, she wants the system to store the following attributes:

- Number of pets owned by each customer
- Total charge for the appointment
- Prescription price
- Drug name
- Length of appointment
- Diagnosis
- Date of appointment
- Service requested

### Required

- a. Given this brief overview, draw an integrated REA diagram for the Mesa Veterinary Hospital and include cardinalities.
- b. As directed by your instructor, either draw the tables necessary to implement the integrated REA diagram you developed for the Mesa Veterinary Hospital or build the tables in a relational DBMS to which you have access. Be sure to include all attributes from the narrative plus the additional ones explicitly listed by Dr. Roosevelt at the conclusion of the interview. Create additional attributes only if necessary.

*(This problem is adapted from one created by Dr. Julie Smith David for classroom use at Arizona State University.)*



- 19.3. Your university hires you to implement a database system for the library network. You have interviewed several librarians, and the following summarizes these discussions:

- The library's main goal is to provide students and professors with access to books and other publications. The library, therefore, maintains an extensive collection of materials that are available to anyone with a valid university identification card.
- The standard procedure for lending materials is that the student or faculty member comes to one of the three campus libraries and locates the book or journal on the shelves.
- Each book is assigned three unique numbers. First, the book is assigned a number by the publisher, called the International Standard Book Number (ISBN). This number allows the publishers to track each title and the number changes with each new edition. The second number is the Dewey decimal number, which is assigned to the title and written on the outside spine of the book. This number is used to organize the library shelves and is thus helpful to the students and faculty. It is therefore critical that this number be available to users on the online inquiry screens. The last number is a university book ID number. A different number is assigned to every book that is received so the library can track all copies of each book. This number is different from the other two numbers such that if the library has three copies of one book, each will have a unique university book ID number.
- When students or faculty check out books, the system must be able to track the specific copy that is being borrowed. Each book has a magnetic strip inserted in its spine, which is used as a security measure. If someone tries to take a book without checking it out, an alarm sounds.
- In general, students and faculty have equal clout in the library. Both are able to check out most books and to check out several books at one time. No one is allowed to remove periodicals from any library. The length of time that the book may be borrowed varies, however, depending on who checks it out. Students are allowed to check out a book for several weeks; faculty may borrow books for several months.
- When patrons check out books, they take their materials to the circulation desk. At that time, the librarian scans in each item's university book ID number and the borrower's ID number. The system records a separate loan event for each book being checked out, assigning each a separate loan number. At this time, each book's due date is calculated and marked on a slip located inside each book's front cover. Simultaneously, the magnetic strip is deactivated so the book may be removed from the library.
- After borrowers check out a book, they are expected to return it by its due date. In reality, everyone is allowed 30 days after the due date recorded on the checkout slip before the book is officially overdue. At that point, the book must be returned, and the borrower is assessed a \$10 fine. If the book is permanently lost, then the borrower is

fined \$75 for the book's replacement. All fines must be paid in cash, in full. Students are not allowed to enroll for subsequent semesters until all library fines are paid; they also do not receive a diploma until all library fines are paid. Faculty must pay all outstanding fines by June 30 of each year.

- When a book is returned, the return must be entered into the system, and a unique return number is used to log the transaction. At that time, the loan record is updated to show that the book has been returned.

The following attributes have been identified as critical for the new system:

University book ID	Borrower phone number	Type of borrower (faculty or student)
Book publisher	Cash account number	Librarian college degree
Due date	Librarian name	Actual return date
Loan number	Book status (on the shelf or checked out)	Borrower ID
Checkout date	Borrower's fine balance owed	Library borrowed from
Borrower name	ISBN number	Librarian number
Book title	Book return number	Account balance
Fine receipt number	Dewey decimal number	Total number of books in a specific library
Amount received	Borrower address	Loan status (still out- standing, or returned)
Library name	Book copyright date	Author name
Amount of fine	Borrower e-mail address	
Default library where book is shelved		

**Required**

- Draw an REA diagram for the library system. Remember to include cardinalities.
- As directed by your instructor, either create the tables on paper that would be required to implement your REA diagram or actually build those tables in a relational DBMS to which you have access. Only use the attributes listed, unless others are absolutely necessary.

*(This problem is adapted from one developed by Dr. Julie Smith David for classroom use at Arizona State University.)*

19.4. The XYZ Company sells tools and parts to automotive repair shops. Shops call in orders; all orders received by noon are delivered the same day. Between 12:00 and 1:00, the system prints out schedules. From 1:00 to 5:00, drivers make deliveries according to the printed schedules. Typically, each driver makes between 25 and 30 deliveries each day. Each delivery is signed for by a repair shop manager; the portable laptop then uses wireless communications to transmit information about the delivery back to the XYZ company and the information is recorded as another row in the sales event table. The XYZ Company uses its own trucks to make local deliveries to its customers. It wants to track information about the use of those trucks: which employee drove which truck, to which customers did a particular truck make deliveries, which deliveries are made on which days, what was the starting and stopping mileage each day?



**Required**

- Draw a partial REA diagram of the XYZ Company's revenue cycle to model these events: Taking Customer Orders, Deliveries, and the Use of Vehicles. Be sure to include cardinalities.
- Create a set of tables (either on paper or in a relational DBMS to which you have access) to implement the REA model you developed for the XYZ Company.

19.5. Assume that Stained Glass Artistry, a new shop that specializes in making stained glass artwork, has hired you to design an integrated database that will provide the owners with the accounting information they need to effectively manage the business. Stained Glass Artistry makes a wide variety of stained glass windows for sale in its store.



A unique job order is assigned to each production run, which includes creating multiple copies of the same basic design. When raw materials are issued to employees, the issuance is documented on a prenumbered raw material issue form. The different kinds of glass needed for the product, and other materials such as copper foil or lead, are issued at one time, so that employees can efficiently produce the design.

Creating a piece of stained glass art involves several different steps, including cutting, foiling, and soldering. The owners want to track how much time each employee spends each day performing each of those various tasks.

The owners have developed raw material and direct labor standards for each design they offer. They want their AIS to track actual costs and standard costs so that they can generate reports that provide price and quantity variance information.

The owners also have provided you with the following list of facts that they want stored in the database. (*Note:* You must create appropriate primary keys for each table; this is the list of other attributes.)

#### Attributes in Standard Glass Artistry AIS

Date hired	Time started task	Time completed task
Style of glass (name or description)	Quantity on hand	Color of glass
Design name	Quantity to be produced	Actual cost of design
Standard hours to make design	Standard quantity of glass to use in design	Quantity issued
Wage rate	Date design produced	Standard cost of design
	Employee name	Date of birth
		Standard cost of glass

#### Required

- Draw an integrated REA diagram for Stained Glass Artistry. Include both minimum and maximum cardinalities.
  - Create the set of relational tables required to implement your REA diagram for Stained Glass Artistry in a relational database.
- 19.6. Bernie's Pet Store sells pet food, toys, and supplies. Bernie, the owner, is the only person who places orders with suppliers. He is also the only person who writes checks. Suppliers ship each order individually; if they are out of an item, they back order it and ship it separately as soon as it arrives. Bernie pays each supplier monthly for all purchases made the previous month. Suppliers do not allow him to make installment payments.

Bernie has eight employees, each of whom can check in materials received from suppliers and sell merchandise to customers. Bernie pays his employees weekly from a separate checking account used only for payroll purposes.

All sales are made in-store and are paid for immediately by cash, check, or credit card.

When employees are not working the cash register or checking in merchandise, they restock shelves and clean up the premises. Bernie does not want to track each *individual* restock or clean-up event, but does want to know how much time each employee spends each day doing those tasks. He also wants to track how much time each employee spends each day receiving inventory and how much time they spend working at the cash register. He wants to be able to write queries that would show time spent by job task (restocking, cleaning, receiving, or sales) for each employee. It is not practical, however, to try to measure the time spent on individual tasks (e.g., Bernie does not want employees to track the time they start and finished unloading a shipment from supplier X, then repeat for supplier Y; similarly, he does not want to track how long it takes to ring up each individual customer at the cash register). All he wants is to know how much time each day (e.g., 3.75 hours) each employee spent performing each different type of job.

#### Required

Draw an integrated REA diagram for Bernie's Pet Shop. Be sure to include both payroll processing and the ability to track how employees use their time.

- 19.7. At Big Time University (BTU) students are allowed to purchase two basketball tickets for each home game. Each ticket contains the date of the game, and the seat information, such as section, row, and individual seat number. Students pay for each game individually; that is, student sporting event passes are not used at BTU. BTU deposits the proceeds from each game into its bank.



**Required**

- a. Prepare an REA diagram with cardinalities for the revenue cycle for BTU's basketball games. State any assumptions you may have to make concerning BTU's business policies and practices.
  - b. Implement your model in a set of relational tables. Be sure to specify primary keys, foreign keys, and identify at least one other attribute that should be included in each table.
- 19.8. Small contractors often rent special equipment for specific jobs. They need to track the equipment that is rented, when it is returned, and payments made to the rental company.



**Required**

- a. Draw a partial REA diagram for the acquisition, payment, and return of rental equipment. Be sure to include cardinalities and state any assumptions you made when specifying those cardinalities.
- b. Create a set of tables (either on paper or in a relational DBMS to which you have access) to implement the REA model you developed.

### Case 19-1 Practical Database Assignment

This case involves creating a database from an integrated REA diagram and then using the REA diagram to guide the writing of queries to prepare financial statements.

**Required**

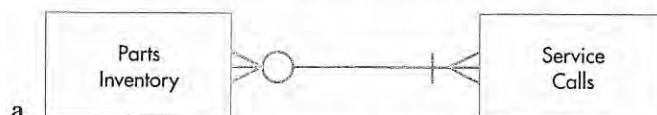
- a. Create the tables necessary to implement Figure 19-9 in a relational database. Be sure to include primary keys and other relevant attributes in each table.
- b. Write the query, or set of queries, necessary to generate as many elements of financial statements as possible. For example, write the query or set of queries that would be used to calculate the amount of cash on hand, the total of accounts receivable, the total value of raw materials inventory on hand, etc.

## AIS IN ACTION SOLUTIONS

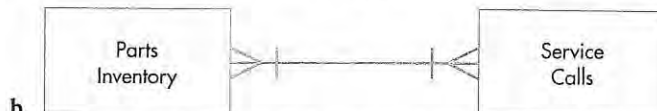
### Quiz Key

1. Which of the following represents the "get" side of the basic give-to-get economic exchange for a business that rents equipment and machinery?
  - a. Rent Equipment (Incorrect. The Give event (Rent Equipment) is linked to two Get events: Return Rented Equipment and Receive Cash.)
  - b. Receive Cash (Incorrect. The Give event (Rent Equipment) is linked to two Get events: Return Rented Equipment and Receive Cash.)

- c. Receive Cash (Incorrect. The Give event (Rent Equipment) is linked to two Get events: Return Rented Equipment and Receive Cash.)
- ▶ d. Return Rented Equipment and Receive Cash (Correct. The Give event (Rent Equipment) is linked to two Get events: Return Rented Equipment and Receive Cash.)
2. Which resource in the HR/payroll cycle is seldom implemented in a database?
- a. skills (Incorrect. Information about skills is important to record.)
- ▶ b. employee time (Correct. The employee time represents the right to use an employee's time—but time is a noninventoriable asset and is consumed when it is acquired, so this resource is seldom if ever implemented as a table in a database.)
- c. applicants (Incorrect. Applicants are agents and information about them must be recorded.)
- d. cash disbursements (Incorrect. Cash disbursements is an event about which information must be recorded.)
3. Joe's Computers makes service calls to repair computer equipment. Some calls involve only labor charges, and others involve both labor and parts. Which of the following correctly models the relationship between the Service Calls event and Parts Inventory?



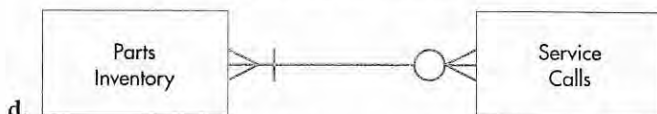
(Incorrect. This shows that every part must be linked to use on at least one service call.)



(Incorrect. This shows that every part must be linked to at least one service call and that every service call must involve use of at least one part.)



(Correct. This shows that some parts may not be linked to any service call, but others could be linked to many service calls. It also shows that some service calls do not involve the use of any parts, although other service calls may involve the use of multiple parts.)



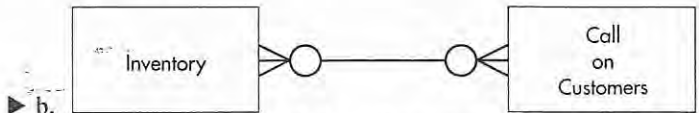
(Incorrect. This shows that every service call must involve the use of at least one part.)

4. Which entity contains information about the components used to manufacture a particular product?
- a. Inventory (Incorrect. The Bill of Materials entity stores the list of ingredients (components) used to manufacture a given product.)
- b. Job Operations List (Incorrect. The Job Operations list entity identifies the steps required to manufacture the product, but the list of components used is stored in the Bill of Materials entity.)
- ▶ c. Bill of Materials (Correct. The Bill of Materials entity stores the list of components used to manufacture a given product.)
- d. Machine Operations List (Incorrect. The Machine Operations List entity stores the steps and processes involving machinery used to manufacture a product.)
5. Which of the following production cycle events involves the *acquisition* of a resource (i.e., is a Get event)?
- a. Perform Machine Operations (Incorrect. The Perform Machine Operations event records information about the use of machinery and equipment; i.e., it is a Give event.)

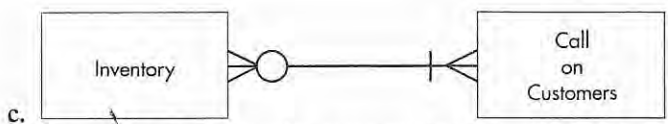
- b. Perform Job Operations (Incorrect. The Perform Job Operations event records information about the use of labor to manufacture a product; i.e., it is a Give event.)
  - ▶ c. Work in Process (Correct. The Work in Process event collects and aggregates all the costs associated with creating a finished product.)
  - d. Issue Raw Materials (Incorrect. The Issue Raw Materials event records information about the raw materials used to manufacture a product; it is an example of a Give event.)
6. Acme manufacturing tracks information about customer calls by sales representative. Although many calls involve demonstrations of products, some are purely to build relationships. What is the correct way to model the relationship between Inventory and the Call on Customer event?



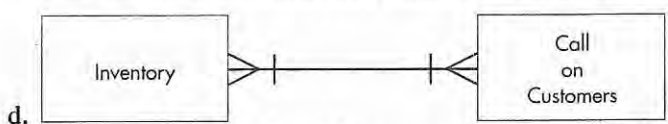
(Incorrect. This shows that every call must involve demonstration of at least one product.)



(Correct. This shows that a call may not involve the demonstration of any products, although it could demonstrate multiple products. At the same time, it correctly shows that some products may not be linked to any sales calls, whereas others may be linked to many different sales calls.)



(Incorrect. This shows that every product must be linked to a sales call.)



(Incorrect. This both shows that every product must be linked to a sales call and that every sales call must involve the demonstration of at least one product.)

7. Which production cycle event collects data used to calculate payroll?
- a. Perform Job Operations (Incorrect. The Perform Job Operations event collects data about the use of labor; it is used to calculate product costs.)
  - ▶ b. Time Worked (Correct. This event captures the acquisition of time from employees, in return for which they must be paid.)
  - c. Time Used (Incorrect. This event collects data about the use of labor; it is used to calculate product costs.)
  - d. Disburse Cash (Incorrect. This event records the paying of wages, but not their calculation.)
8. The give-to-get economic exchange associated with debt financing involves which two events?
- a. Issue Debt and Receive Cash (Incorrect. The Issue Debt is a special instance of the Receive Cash Event.)
  - ▶ b. Issue Debt and Disburse Cash (Correct. Issuing debt results in receipt of cash and subsequent repayments of that debt.)
  - c. Receive Cash and Disburse Cash (Incorrect. The Issue Debt event is used to record the facts about borrowing events, which differ from the facts collected about cash receipts for sales.)
  - d. none of the above (Incorrect.)

9. Acme manufacturing wants to track post-sales customer service by collecting information about each customer service call: who called, when the call happened, which customer service representative handled the call, how long the call lasted, which sales transaction prompted the call, and which inventory items were discussed. The relationship between the Sales and Post-sales Service Call events should most likely be modeled as which of the following?
- a. 1:1 (Incorrect. Some customers may make more than one service call related to a specific sales transaction and they may also discuss several sales transactions during the same service call.)
  - b. 1:N (Incorrect. Some customers may make more than one service call related to a specific sales transaction and they may also discuss several sales transactions during the same service call.)
  - ▶ c. M:N (Correct. Some customers may make more than one service call related to a specific sales transaction and they may also discuss several sales transactions during the same service call.)
  - d. 0:N (Incorrect. There is no such thing as a 0:N relationship).
10. Which of the following additions to the basic REA template are sometimes needed?
- a. relationships between two resources (Incorrect. This chapter introduced an example of this to model location information, but it also introduced examples of relationships between two agents and between a resource and an agent).
  - b. The relationship between two agents (Incorrect. This chapter introduced an example of this to model information about supervisors, but it also introduced examples of relationships between two resources and between a resource and an agent).
  - c. The relationship between a resource and an agent (Incorrect. This chapter introduced an example of this to model responsibility for a resource, but it also introduced examples of relationships between two resources and between two agents).
  - ▶ d. All of the above (Correct. Examples of each of the above were introduced in this chapter.)

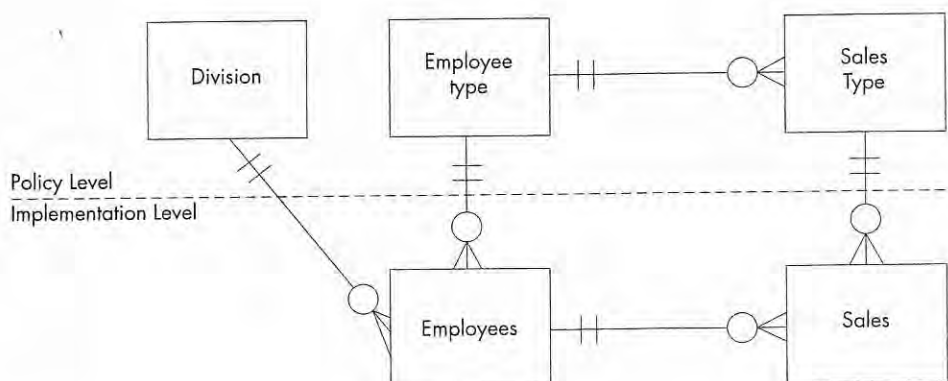
## Appendix: Extending the REA Model to Include Information About Policies<sup>1</sup>

Chapters 17–19 have explained how the REA model can be used to describe the contents of a database used to support an organization's transaction processing requirements. The various REA diagrams presented in those three chapters depicted the actual resources, events, and agents involved in carrying out the organization's business processes. The basic rules presented for developing an REA diagram are designed to ensure the accurate recording of things that exist, the events that occurred, and the specific agents who participated in those events. The REA model can be extended to also explicitly represent information about an organization's business policies. Doing so provides the opportunity to model information about such things as standards and internal controls. This Appendix provides a brief introduction to this topic.

Extending the REA model to incorporate information about policies that represent what should, could, or must happen involves the use of two new data modeling concepts: Type and Group entities. Type entities are used to depict "is-a-kind-of" relationships and Group entities are used to represent "is-a-member-of" relationships. Figure 19A-1 shows that both kinds of entities exist at the policy level and that they are mapped to entities at the operational level. For example, each individual sales transaction represents a specific type of sale (Internet, In-store, Mail Order, etc.). Similarly, each individual employee is linked to one, and only one, specific class of employees (buyers, cashiers, salespeople, etc.); in other words, each individual employee is a type of employee. In addition, Figure 19A-1 shows that employees are also assigned to (members of) specific divisions in the organization.

Type and Group entities are similar in that both are abstractions that represent sets of objects. They differ in terms of semantics and attributes. Type entities contain attributes that apply to every individual entity of that type. For example, Figure 19A-1 shows that the Employee Type entity contains the attributes Role, Base Pay, and Salary Range and the Sales Type entity contains attributes about whether to charge for shipping, sales tax, etc. In contrast, Group entities contain attributes that apply to the set as a whole and are often derived values. Thus, Table 19A-1 shows that the Group entity called Division contains attributes such as average salary and the number of employees, which represent properties of the entire set that are calculated from the values of every entity that belongs to that group.

The attributes of Type entities provide a way to specify policy information (e.g., valid salary ranges, shipping charges, etc.) so that the system can enforce and validate adherence to the organization's business policies. For example, an individual employee's salary can be compared to the permissible salary range for that class of employee. Similarly, the system can decide whether to collect sales tax on a particular sales transaction by checking the stated policy for that type of



**FIGURE 19A-1**  
Extending the REA  
Model to Include Policy-  
Level Information

<sup>1</sup>The material in this Appendix is based on the article, "Policy-Level Specification in REA Enterprise Information Systems" by Guido L. Geerts and William E. McCarthy, in the *Journal of Information Systems* 20:2 (Fall 2006): 37–63.

**TABLE 19A-1 Policy-Level Entities and Relationships**

Policy Level Entities	Primary Key	Foreign Keys	Other Attributes
Division	Division number		Budgeted sales this period
Employee type	Employee type number		Role description, permissible salary range
Sales type	Sales type number	Employee type number	Venue (Internet, mail-order, in-store, etc.), collect sales tax (Y/N)
Operational Level Entities	Primary Key	Foreign Keys	Other Attributes
Employees	Employee number	Division number, employee type number	Name, date hired, salary, etc.
Sales	Invoice number	Employee number, sales type number	Date, time, comments

sale. The attributes of Group entities provide a way to represent budgetary information, such as sales goals for each division, in a manner that facilitates creating reports that compare actual results (data stored in the operational-level entities) with plans (data stored in the policy-level entities).

Finally, Figure 19A-1 also shows that there can be relationships among Type entities. This provides another means to specify business policies and internal controls. For example, including Employee Type as an attribute in the Sales Type entity provides a mechanism for specifying that only sales staff can make sales to customers; similar linkages can be used to specify that only buyers can order inventory from suppliers, that only cashiers can write checks, and so on.

The objective of this Appendix was to provide an introduction to how the REA model can be extended to incorporate information about organizational policies and internal controls. If you take a database course, you will learn more about abstractions like Type and Group entities and the concepts of typification, generalization, and aggregation. You may also learn more about policy-level REA issues on your own, by reading the article cited as the reference source for this Appendix.