

## The REA Data Model

- Chapter 17** Database Design Using the REA Data Model
- Chapter 18** Implementing an REA Model in a Relational Database
- Chapter 19** Special Topics in REA Modeling

# Chapter 17

## Database Design Using the REA Data Model

### Learning Objectives

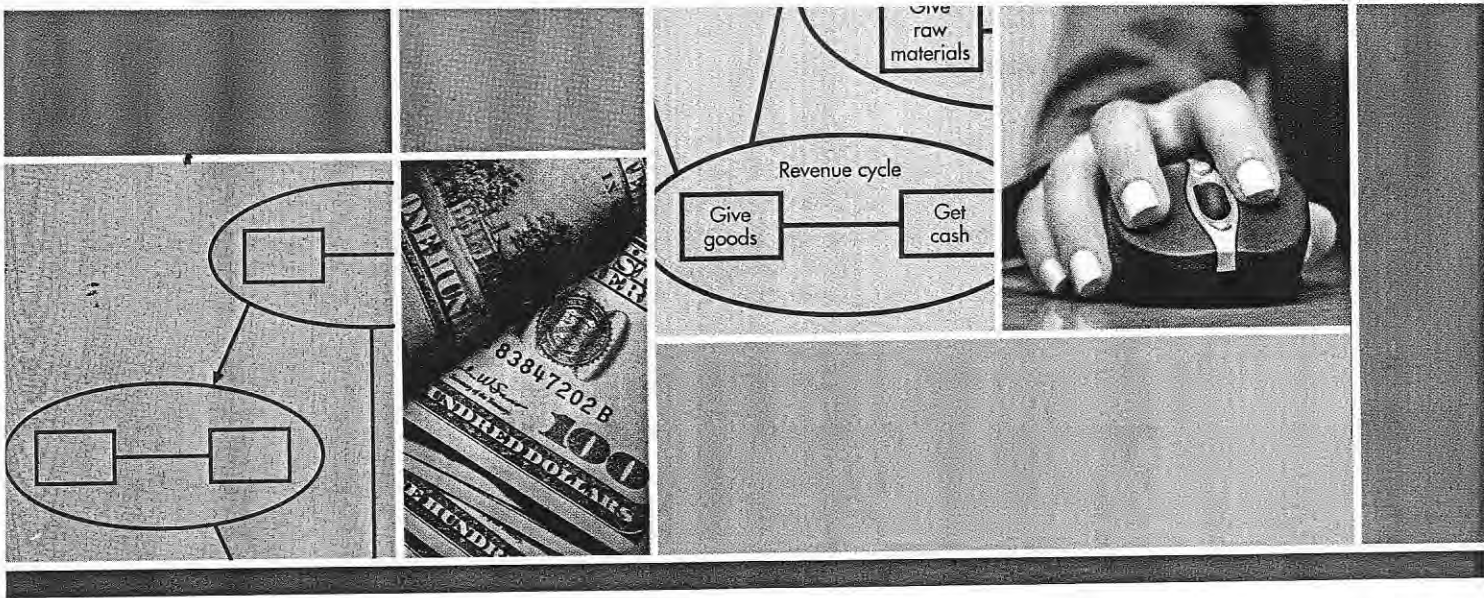
After studying this chapter, you should be able to:

1. Discuss the steps for designing and implementing a database system.
2. Use the REA data model to design an AIS database.
3. Draw an REA diagram of an AIS database.
4. Read an REA diagram and explain what it reveals about the business activities and policies of the organization being modeled.

### INTEGRATIVE CASE FRED'S TRAIN SHOP

Fred Smith is frustrated. Business in his model train shop is booming. But the simple accounting software that he uses to run the business has only limited reporting capabilities. Consequently, he often has to manually review transaction data to prepare custom reports. The process is time-consuming and prone to error. For example, Fred spent the past weekend poring over sales records for the prior three months to try to identify which combinations of items were most frequently purchased together. He plans to use the information to offer a special sales promotion but is concerned about the quality of his analysis.

At lunch, Fred explains his frustrations to his CPA, Paul Stone. Paul mentions that he has just completed a training course on database design. He suggests that he could create a relational database for Fred that would interface with his accounting software and that would provide Fred with the ability to easily design reports to analyze his business. Fred likes the idea and hires Paul to design a relational database for his train store.



## Introduction

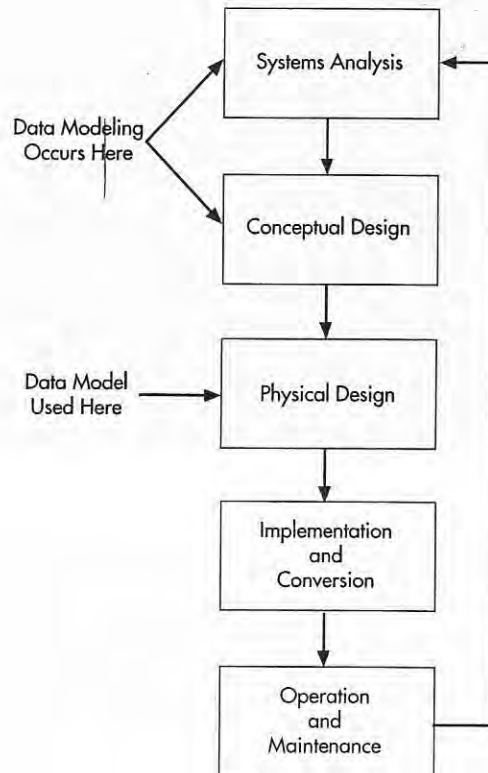
Chapter 4 covered the fundamental principles of relational databases. The three chapters in this section will teach you how to design and document a relational database for an accounting information system. You will see that there is much more to building a database than simply learning the syntax of how to use a particular database management system (DBMS). Building accurate databases requires a great deal of careful planning and design *before* you even sit down at the computer.

This chapter introduces the topic of data modeling, one aspect of database design that accountants should understand. We discuss entity-relationship (E-R) diagrams and the REA accounting model and demonstrate how to use these tools to build a data model of an AIS. Then we discuss how such REA models can also serve as a source of documentation about an organization's business activities and policies. Chapter 18 will explain how to implement an REA data model in a database and how to query the resulting database to retrieve information needed to effectively manage an organization's business activities. Chapter 19 concludes this three-chapter section by examining a number of advanced data modeling and database design issues.

## Database Design Process

Figure 17-1 shows the five basic steps in database design. The first stage (systems analysis) consists of initial planning to determine the need for and feasibility of developing a new system. This stage includes preliminary judgments about the proposal's technological and economic feasibility. It also involves identifying user information needs, defining the scope of the proposed new system, and using information about the expected number of users and transaction volumes to make preliminary decisions about hardware and software requirements. The second stage (conceptual design) includes developing the different schemas for the new system at the conceptual, external, and internal levels. The third stage (physical design) consists of translating the internal-level schema into the actual database structures that will be implemented in the new system. This is also the stage when new applications are developed. The fourth stage (implementation and conversion) includes all the activities associated with transferring data from existing systems to the new database AIS, testing the new system, and training employees how to use it. The final stage is using and maintaining the new system. This includes carefully monitoring system performance and user satisfaction to determine the need for making system enhancements and modifications. Eventually, changes in business strategies and practices or significant new developments in information technology prompt the company to begin investigating the feasibility

**FIGURE 17-1**  
Data Modeling in the  
Database Design Process



of developing a new system, and the entire process starts again (note the arrow returning to the systems analysis stage).

Accountants can and should participate in every stage of the database design process, although the level of their involvement is likely to vary across stages. During the systems analysis phase, accountants help evaluate project feasibility and identify user information needs. In the conceptual design stage, accountants participate in developing the logical schemas, designing the data dictionary, and specifying important controls. Accountants with good database skills may directly participate in implementing the data model during the physical design stage. During the implementation and conversion stage, accountants should be involved in testing the accuracy of the new database and the application programs that will use that data, as well as assessing the adequacy of controls. Finally, many accountants are regular users of the organization's database and sometimes even have responsibility for its management.

Accountants may provide the greatest value to their organizations by taking responsibility for data modeling. *Data modeling* is the process of defining a database so that it faithfully represents all aspects of the organization, including its interactions with the external environment. As shown in Figure 17-1, data modeling occurs during both the systems analysis and conceptual design stages of database design. Next, we discuss two important tools that accountants can use to perform data modeling: entity-relationship diagramming and the REA data model.

## Entity-Relationship Diagrams<sup>1</sup>

An *entity-relationship (E-R) diagram* is a graphical technique for portraying a database schema. It is called an E-R diagram because it shows the various *entities* being modeled and the important *relationships* among them. An *entity* is anything about which the organization wants

<sup>1</sup>The material in this section is based on P. Chen, "The Entity Relationship Model—Toward a Unified View of Data," *Transactions on Database Systems* (March 1976, 1:1): 9–36.

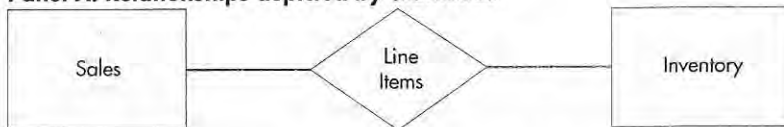
to collect and store information. For example, Fred's Train Shop's database would include entities for employees, customers, suppliers, inventory, and for business events such as sales to customers and deliveries from suppliers. In a relational database, separate tables would be created to store information about each distinct entity; in an object-oriented database, separate classes would be created for each distinct entity.

In an E-R diagram, entities are depicted as rectangles. Unfortunately, however, there are no industry standards for other aspects of E-R diagrams. Some data modelers and authors use diamonds to depict relationships (Figure 17-2, panel A) whereas others do not (Figure 17-2, panel B). Sometimes the attributes associated with each entity are depicted as named ovals connected to each rectangle (Figure 17-2, panel C), whereas other times the attributes associated with each entity are listed in a separate table (Figure 17-2, panel D). In this book, we will be creating E-R diagrams with a large number of entities and relationships. Therefore, to reduce clutter and improve readability, we omit the diamonds for relationships and list the attributes associated with each entity in a separate table. Thus, our diagrams look like panels B and D in Figure 17-2.

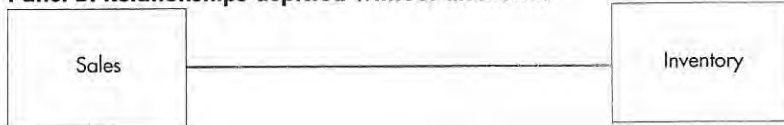
E-R diagrams can be used to represent the contents of any kind of database. For example, the E-R diagram of an intramural sports database might include students, teams, and leagues as entities, whereas an E-R diagram for a school might include students, teachers, and courses as entities. In this book, our focus is on databases designed to support an organization's business activities. Consequently, we will show how E-R diagrams can be used not only to design databases but also to document and understand existing databases and to redesign business processes. Business process management is covered in Part V; in this chapter we focus on using E-R diagrams for database design and for understanding the contents of existing databases.

As noted, E-R diagrams can include many different kinds of entities and relationships among those entities. An important step in database design, therefore, entails deciding which entities need to be modeled. The REA data model is useful for making that decision.

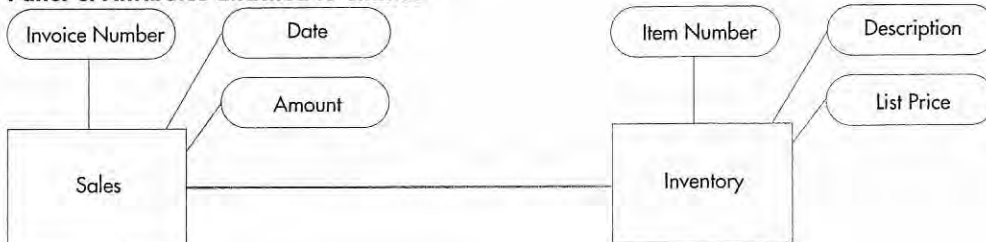
**Panel A: Relationships depicted by diamonds**



**Panel B: Relationships depicted without diamonds**



**Panel C: Attributes attached to entities**



**Panel D: Attributes listed in separate table**

Entity Name	Attributes
Sales	Invoice number, date, amount
Inventory	Item number, description, list price

**FIGURE 17-2**

**E-R Diagram Variations**

## The REA Data Model<sup>2</sup>

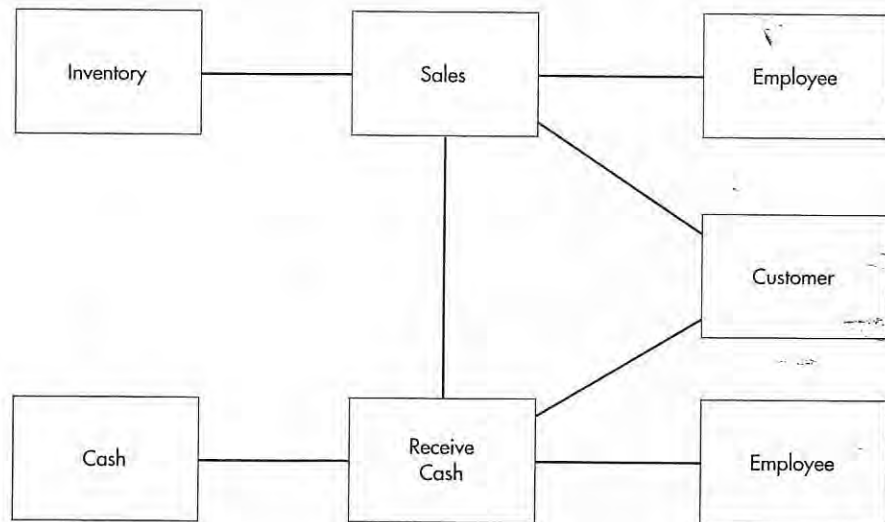
The *REA data model* was developed specifically for use in designing AIS. The REA data model focuses on the business semantics underlying an organization's value-chain activities. It provides guidance for database design by identifying what entities should be included in the AIS database and by prescribing how to structure relationships among the entities in that database. REA data models are usually depicted in the form of E-R diagrams. Consequently, in the remainder of this chapter and throughout the book, we will refer to E-R diagrams developed according to the REA data model as REA diagrams.

### Three Basic Types of Entities

The REA data model is so named because it classifies entities into three distinct categories: the *resources* the organization acquires and uses, the *events* (business activities) in which the organization engages, and the *agents* participating in these events.<sup>3</sup> Figure 17-3 provides examples of these three types of entities.

*Resources* are those things that have economic value to the organization. Figure 17-3 includes two resource entities: cash and inventory. *Events* are the various business activities about which management wants to collect information for planning or control purposes.<sup>4</sup> There are two event entities in Figure 17-3: Sales and Receive Cash. *Agents* are the people and organizations that participate in events and about whom information is desired for planning, control, and evaluation purposes. Figure 17-3 includes two types of agent entities: Employees and Customers.

**FIGURE 17-3**  
Basic Elements of an  
REA Diagram



<sup>2</sup>The material in this section is adapted from William E. McCarthy, "An Entity-Relationship View of Accounting Models," *The Accounting Review* (October 1979): 667-686; William E. McCarthy, "The REA Accounting Model: A Generalized Framework for Accounting Systems in a Shared Data Environment," *The Accounting Review* (July 1982): 554-578; and Guido L. Geerts and W. E. McCarthy, "An Ontological Analysis of the Primitives of the Extended-REA Enterprise Information Architecture," *International Journal of Accounting Information Systems* 3(March 2002): 1-16.

<sup>3</sup>Some REA data modelers have proposed a fourth type of entity, which they call locations. Stores and warehouses would be examples of this fourth type of entity. However, such "location" entities are usually also resources controlled by the organization. Therefore, the authors of this text see no compelling reason to create yet another type of entity and model locations as resources. If an organization does not want or need to store information about locations except to identify where an event occurred, location can be an attribute for each event.

<sup>4</sup>The discussion of events in this section is based on the work of Julie Smith David, "Three 'Events' That Define an REA Methodology for Systems Analysis, Design, and Implementation," Working Paper, Arizona State University, August 1997, and Guido L. Geerts and W. E. McCarthy, "An Ontological Analysis of the Primitives of the Extended-REA Enterprise Information Architecture," *International Journal of Accounting Information Systems* 3 (March 2002): 1-16.

### Structuring Relationships: The Basic REA Template

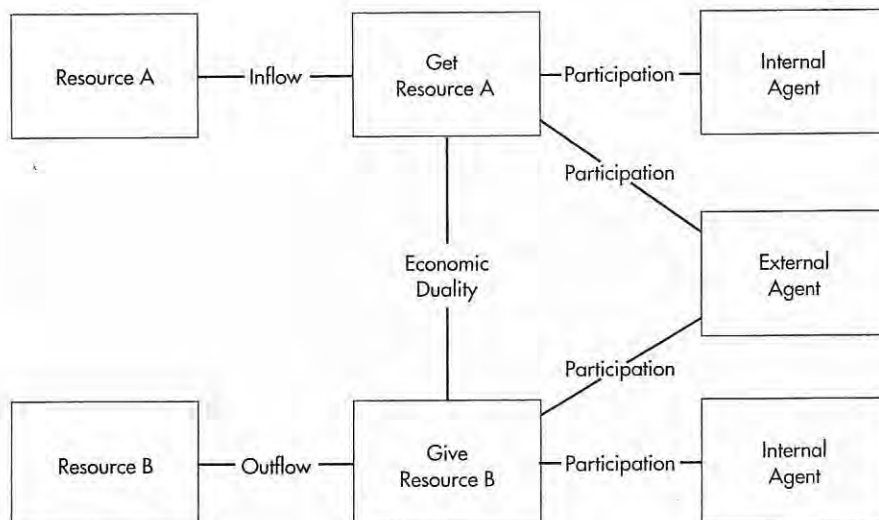
The REA data model prescribes a basic pattern for how the three types of entities (resources, events, and agents) should relate to one another. Figure 17-4 presents this basic pattern. The essential features of the pattern are as follows:

1. Each event is linked to at least one resource that it affects.
2. Each event is linked to at least one other event.
3. Each event is linked to at least two participating agents.

**RULE 1: EVERY EVENT ENTITY MUST BE LINKED TO AT LEAST ONE RESOURCE ENTITY** Events *must* be linked to at least one resource that they affect. Some events, such as the one labeled “Get Resource A” in Figure 17-4, increase the quantity of a resource. Common examples of such “Get” events include the receipt of goods from a supplier (which increases the quantity on hand of inventory) and the receipt of payment from a customer (which increases the amount of cash). Other events, such as the one labeled “Give Resource B” in Figure 17-4, directly decrease the quantity of a resource. Common examples of such “Give” events include paying suppliers and selling merchandise, which decrease the amount of cash and quantity on hand of inventory, respectively.

Relationships that affect the quantity of a resource are sometimes referred to as *stockflow* relationships because they represent either an inflow or outflow of that resource. Not every event directly alters the quantity of a resource, however. For example, orders from customers represent commitments that will eventually result in a future sale of merchandise, just as orders to suppliers represent commitments that will eventually result in the subsequent purchase of inventory. For simplicity, Figure 17-4 does not include any such commitment events. Organizations do, however, need to track the effects of such commitments, both to provide better service and for planning purposes. For example, customer orders reduce the quantity available of the specific inventory items being ordered. Sales staff need to know this information to be able to properly respond to subsequent customer inquiries and orders. Manufacturing companies may use information about customer orders to plan production. Later in the chapter we will see how to add commitment events to the basic pattern shown in Figure 17-4.

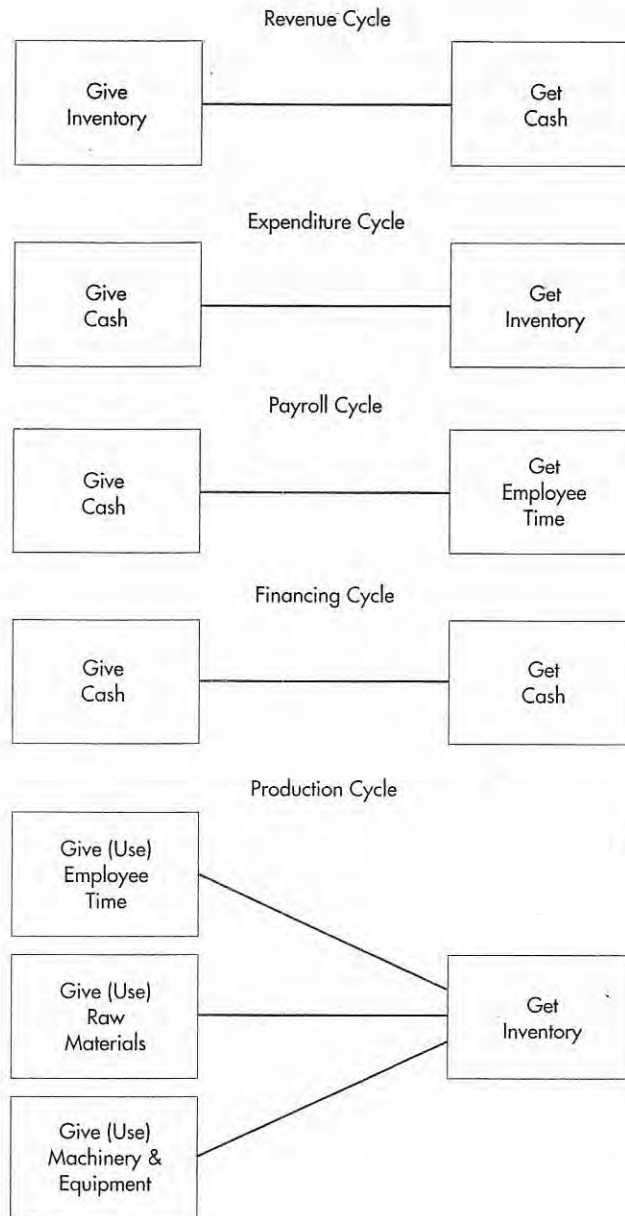
**RULE 2: EVERY EVENT ENTITY MUST BE LINKED TO AT LEAST ONE OTHER EVENT ENTITY** Figure 17-4 also shows that the Get Resource A event is linked to the Give Resource B event in what is labeled as an economic duality relationship. Such give-to-get duality relationships reflect



**FIGURE 17-4**  
Standard REA Template

The names on the lines describe the nature of the relationship. Agents participate in events. The economic duality relationship between the “get” event and the “give” event reflects the fact that organizations must give up one resource (e.g., cash) in order to get some other resource (e.g., inventory). The stockflow relationships between an event and a resource represent either inflows or outflows of a resource.

**FIGURE 17-5**  
**An AIS Viewed as a Set**  
**of Give-to-get Exchanges**



the basic business principle that organizations typically engage in activities that use up resources only in the hopes of acquiring some other resource in exchange. For example, the Sales event, which requires giving up (decreasing) inventory, is related to the Receive Cash event, which involves getting (increasing) the amount of cash. Figure 17-5 shows that each accounting cycle can be described in terms of such give-to-get economic duality relationships. The bottom portion of the figure also shows that sometimes one event can be linked to several other events.

Not every relationship between two events represents a give-to-get economic duality, however. Commitment events are linked to other events to reflect sequential cause-effect relationships. For example, the Take Customer Order event would be linked to the Sales event to reflect the fact that such orders precede and result in sales. Similarly, the Order Inventory (purchase) event would be linked to the Receive Inventory event to reflect another sequential cause-effect relationship.

**RULE 3: EVERY EVENT ENTITY MUST BE LINKED TO AT LEAST TWO PARTICIPATING AGENTS** For accountability, organizations need to be able to track the actions of employees. Organizations also need to monitor the status of commitments and economic duality exchanges engaged in with



outside parties. Thus, Figure 17-4 shows each event linked to two participating agent entities. For events that involve transactions with external parties, the internal agent is the employee who is responsible for the resource affected by that event, and the external agent is the outside party to the transaction. For internal events, such as the transfer of raw materials from the storeroom to production, the internal agent is the employee who is giving up responsibility for or custody of the resource, and the external agent is the employee who is receiving custody of or assuming responsibility for that resource.

## Developing an REA Diagram

This chapter focuses on developing an REA diagram for a single business cycle. In the next chapter we will learn how to integrate REA diagrams for individual business cycles to create one enterprise-wide REA diagram.

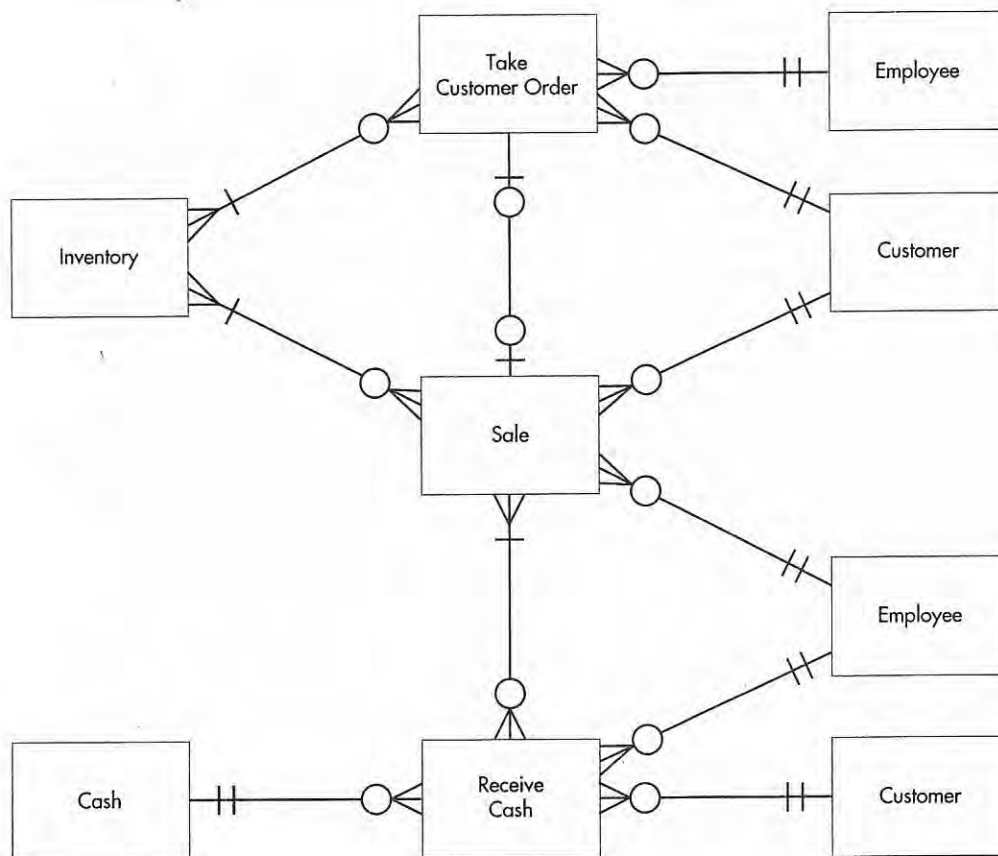
Developing an REA diagram for a specific business cycle consists of the following three steps:

1. Identify the events about which management wants to collect information.
2. Identify the resources affected by each event and the agents who participate in those events.
3. Determine the cardinalities of each relationship.

Let us follow these three steps to see how Paul developed Figure 17-6 to model the revenue cycle of Fred's Train Shop.

### Step 1: Identify Relevant Events

The first step in developing an REA model of a single business cycle is to identify the events of interest to management. At a minimum, every REA model must include the two events that



**FIGURE 17-6**  
Partial REA Diagram for  
Fred's Train Shop  
Revenue Cycle

represent the basic give-to-get economic exchange performed in that particular business cycle (see Figure 17-5). Usually there are other events that management is interested in planning, controlling, and monitoring; they also need to be included in the REA model.

A solid understanding of activities performed in each business cycle (see Chapters 12–16) is needed to identify which events comprise the basic give-to-get economic duality relationships. For example, Chapter 12 explained that the revenue cycle typically consists of four sequential activities:

1. Take customer orders
2. Fill customer orders
3. Bill customers
4. Collect payment from customers

Analysis of the first activity, taking customer orders, indicates that it does not involve either the acquisition of resources from or provision of resources to an external party. It is only a commitment to perform such actions in the future. The second activity, fill customer orders, does reduce the organization's stock of a resource that has economic value (inventory) by delivering it to an external party (the customer). Thus, it represents an example of the prototypical Give Resource event depicted in Figure 17-4. The third activity, billing customers, involves the exchange of information with an external party but does not directly increase or reduce the quantity of any economic resource. Finally, analysis of the fourth activity, collect payments from customers, indicates that it results in an increase in the organization's supply of an economic resource (the entity labeled "Cash" in Figure 17-6) as a result of receiving it from an external party (the customer). Thus, it is an example of the prototypical Get Resource event depicted in Figure 17-4. Consequently, analysis of the basic business activities performed in the revenue cycle indicates that the basic give-to-get economic exchange consists of two events: fill customer orders (usually referred to as the Sales event) and collect payments from customers (often called the Receive Cash event).

In drawing an REA diagram for a single business cycle, it is useful to divide the paper into three columns, one for each type of entity. Use the left column for resources, the center column for events, and the right column for agents. Readability is further enhanced if the event entities are drawn from top to bottom corresponding to the sequence in which they occur. Thus, Paul begins to draw Figure 17-6 by placing the Sales event entity above the Receive Cash event entity in the center column of the paper.<sup>5</sup>

After the economic exchange events are identified, it is necessary to determine which other business activities should be represented as events in the REA model. This, too, requires understanding what each activity entails because only those activities that involve the acquisition of new information need to be included in the model. Returning to our example, Paul notes that the economic duality of Sales and Receive Cash accurately reflects most in-store sales transactions in which the customer selects one or more items and pays for them. Sometimes, however, customers call the store and ask if specific items can be set aside for pickup later that week. To ensure that he reorders popular items on a timely basis, Fred needs not only to set those items aside but also to record such orders in the system. Therefore, Paul decides to add the commitment event Take Customer Order to the REA diagram, placing it above the Sales event because customer orders precede the Sales event.

Paul then considers the other revenue cycle business activity, billing customers. He knows that in-store sales are paid for immediately and, therefore, do not involve a separate "billing" step. But Fred also sells model trains to shopping centers, hotels, and other institutions that want to set up seasonal displays for their customers. Such sales are made on credit, and Fred does subsequently prepare and mail invoices to those customers. However, printing and mailing invoices does not directly increase or decrease any economic resource. Nor does the billing activity represent a commitment to a future economic exchange: The customer's legal obligation to pay arises from the delivery of the merchandise, not from the printing of an invoice. Consequently, as noted in Chapters 12 and 13, many organizations are beginning to realize that billing is a non-value-added activity that can be eliminated entirely. Moreover, the activity of printing an invoice does not add any new information to the database. The prices and quantities

<sup>5</sup>Placement conventions, such as the use of columns and sequential ordering of events, are not *required* to use the REA model to design a database. We suggest these rules only because following them often simplifies the process of drawing an REA diagram and produces REA diagrams that are easy to read.

of items sold were recorded at the time of the sale, at which time the terms of payment were also agreed upon. Thus, the billing activity is simply an information processing event that merely *retrieves* information from the database, similar to writing a query or printing an internal report. Since such information retrieval events do not alter the contents of the database, they need not be modeled as events in an REA diagram. For all the foregoing reasons, Paul realizes that he does not need to include a billing event in his revenue cycle REA diagram for Fred's Train Shop.

But what about accounts receivable? If there is no billing event, how can Fred's Train Shop monitor this balance sheet item? The solution lies in understanding that accounts receivable is merely a timing difference between the two components of the basic economic exchange in the revenue cycle: sales and the receipt of payment. In other words, accounts receivable simply equals all sales for which customers have not yet paid. Consequently, accounts receivable can be calculated and monitored by simply collecting information about Sales and Receive Cash events. The next chapter will illustrate several different ways for extracting information about accounts receivable from a database built using the REA data model.

Finally, notice that there are no events that pertain to the entry of data. The reason for this is that the REA data model is used to design transaction processing databases. The objective is to model the basic value-chain business activities of an organization: what it does to generate revenues and how it spends cash and uses its other resources. Entering data about those events and about the resources and agents associated with them is not usually considered a primary value-chain activity. Thus, just like writing queries and printing reports, data entry activities are not considered important events about which detailed data needs to be collected. Moreover, as discussed in the preceding five chapters, there is a continuous trend to use technology to eliminate routine clerical information processing activities, including data entry. Thus, it is possible to conceive of business events (such as the sale of merchandise) being performed without the need for any separate data entry activities. Indeed, much data entry already occurs as a by-product of performing the business events that are included in the REA diagram. For example, whenever a sale, purchase, receipt of cash, or payment occurs, information about that event is entered in the database. Thus, what gets modeled in the REA diagram is the business event (e.g., the sale transaction) and the facts that management wants to collect about that event, not the entry of that data.

## Step 2: Identify Resources and Agents

Once the relevant events have been specified, the resources that are affected by those events need to be identified. This involves answering three questions:

1. What economic resource is reduced by the "Give" event?
2. What economic resource is acquired by the "Get" event?
3. What economic resource is affected by a commitment event?

Again, a solid understanding of business processes makes it easy to answer these questions. To continue our example, Paul has observed that the Sales event involves giving inventory to customers and that the Receive Cash event involves obtaining payments (whether in the form of money, checks, credit card, or debit card) from customers. Therefore, he adds an Inventory resource entity to the REA diagram and links it to the Sales event entity. The Inventory entity stores information about each product that Fred sells. Then Paul adds a Cash resource entity to the diagram. Although organizations typically use multiple accounts to track cash and cash equivalents (e.g., operating checking account, petty cash, and short-term investments), these are all summarized in one balance sheet account called Cash. Similarly, the Cash resource contains information about every individual cash account. Thus, in a relational database, the "cash" table would contain a separate row for each specific account (e.g., petty cash, checking account, etc.). Paul then links the "Cash" resource entity to the Receive Cash event entity. Finally, the Take Customer Order event involves setting aside merchandise for a specific customer. To maintain accurate inventory records, and to facilitate timely reordering to avoid stockouts, each Take Customer Order event should result in reducing the quantity available of that particular inventory item. Therefore, Paul adds a link between the Inventory resource entity and the Take Customer Order event entity in the REA diagram he is developing for Fred's Train Shop revenue cycle.

In addition to specifying the resources affected by each event, it is also necessary to identify the agents who participate in those events. There will always be at least one internal agent (employee) and, in most cases, an external agent (customer or vendor) who participate in each

event. In the case of Fred's Train Shop's revenue cycle, a customer and a salesperson participate in each sales event. The customer and a cashier are the two agents participating in each Receive Cash event. Both the salesperson and the cashier are employees of Fred's. Thus, both revenue cycle economic exchange events involve the same two general types of agents: employees (the internal party) and customers (the external party). The Take Customer Order event also involves both customers and employees. Therefore, Paul adds both types of agents to the diagram and draws relationships to indicate which agents participated in which events. To reduce clutter, he sometimes links one copy of a particular agent entity to two adjacent event entities.<sup>6</sup>

### Step 3: Determine Cardinalities of Relationships

The final step in drawing an REA diagram for one transaction cycle is to add information about relationship cardinalities. *Cardinalities* describe the nature of the relationship between two entities by indicating how many instances of one entity can be linked to each specific instance of another entity. Consider the relationship between the customer agent entity and the sales event entity. Each entity in an REA diagram represents a set. For example, the Customer entity represents the set of the organization's customers, and the Sales entity represents the set of individual sales transactions that occur during the current fiscal period. Each individual customer or sales transaction represents a specific instance of that entity. Thus, in a relational database, each row in the "Customer" table would store information about a particular customer, and each row in the "Sales" table would store information about a specific sales transaction. Cardinalities define how many sales transactions (instances of the Sales entity) can be associated with each customer (instance of the Customer entity) and, conversely, how many customers can be associated with each sales transaction.

No universal standard exists for representing information about cardinalities in REA diagrams. In this text, we use the graphical "crow's feet" notation style for representing cardinality information because it is becoming increasingly popular and is used by many software design tools. Table 17-1 explains the meaning of the symbols used to represent cardinality information, and Focus 17-1 compares the notation used in this book with other commonly used conventions.

**TABLE 17-1 Graphical Symbols for Representing Cardinality Information**

Symbol	Cardinalities	Example	Meaning
	Minimum = 0; Maximum = 1		Each instance of entity A may or may not be linked to any instances of entity B, but can be linked to at most one instance of entity B.
	Minimum = 1; Maximum = 1		Each instance of entity A must be linked to an instance of entity B, and can only be linked to at most one instance of entity B.
	Minimum = 0; Maximum = many		Each instance of entity A may or may not be linked to any instances of entity B, but could be linked to more than one instance of entity B.
	Minimum = 1; Maximum = many		Each instance of entity A must be linked to at least one instance of entity B, but can be linked to many instances of entity B.

<sup>6</sup>Deciding how many copies of the same entity to include in an REA diagram is a matter of personal taste. Including too many copies clutters the diagram with redundant rectangles, but too few copies can result in a confusing tangled web of lines connecting entities to one another.



## Alternative Methods to Represent Cardinality Information

A number of different notations exist for depicting minimum and maximum cardinalities. Some of the more common alternatives to the crow's feet used in this text are shown here.

Notation	Explanation	Example
(Min, Max)	<p>A pair of alphanumeric characters inside parentheses:                      (0,1) means minimum = 0, maximum = 1                      (1,1) means minimum = 1; maximum = 1                      (0,N) means minimum = 0; maximum = many                      (1,N) means minimum = 1; maximum = many</p>	<p>Each instance of entity A must be linked to at least one instance of entity B but may be linked to many instances of entity B; each instance of entity B may or may not be linked to an instance of entity A but can only be linked to at most one instance of entity A. Note: <i>Some authors and consultants flip which side of the relationship the cardinality pair appears on!</i></p>
UML	<p>One or two alphanumeric characters separated by two periods:                      0..1 means minimum = 0; maximum = 1                      1 means minimum = 1; maximum = 1                      * means minimum = 0; maximum = many                      1 * means minimum = 1; maximum = many</p>	<p>Each instance of entity A must be linked to at least one instance of entity B but may be linked to many instances of entity B; each instance of entity B must be linked to an instance of entity A but can only be linked to at most one instance of entity A.</p>
Maximums only (Microsoft Access)	<p>One alphanumeric character to represent the maximum cardinality in that relationship:                      1 means 1; the infinity symbol (<math>\infty</math>) means many</p>	<p>Each instance of entity A may be linked to many instances of entity B; each instance of entity B can only be linked to at most one instance of entity A.</p>

As shown in Table 17-1, cardinalities are represented by the pair of symbols next to an entity. The four rows in Table 17-1 depict the four possible combinations of minimum and maximum cardinalities. The *minimum cardinality* can be either zero (0) or one (1), depending upon whether the relationship between the two entities is optional (the minimum cardinality is zero; see rows one and three) or mandatory (the minimum cardinality is one, as in rows two and four). The *maximum cardinality* can be either one or many (the crow's feet symbol), depending upon whether each instance of entity A can be linked to at most one instance (as in the top two rows) or potentially many instances of entity B (as in the bottom two rows).

Let us now use the information in Table 17-1 to interpret some of the cardinalities in Figure 17-6. Look first at the Sale-Customer relationship. The minimum and maximum cardinalities next to the Customer entity are both one. This pattern is the same as that in row two in Table 17-1. Thus, the minimum cardinality of one next to the Customer entity in Figure 17-6 indicates that each sale transaction (entity A) *must* be linked to some specific customer (entity B). The maximum cardinality of one means that each sale transaction can be linked to at most *only one*

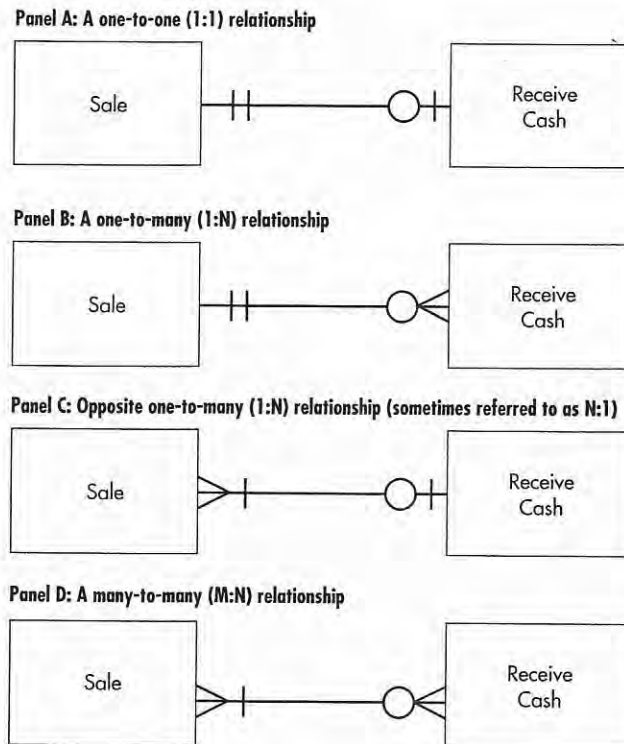
specific customer. This reflects normal business practices: only one legally identifiable customer (which could be an individual or a business) is held responsible for a sale and its subsequent payment. Now look at the cardinality pair next to the Sale entity: as in row three in Table 17-1, the minimum cardinality is zero, and the maximum cardinality is many. The zero minimum cardinality means that the relationship is optional: A customer does not have to be associated with any specific sale transaction. This allows Fred's Train Shop to enter information about prospective customers to whom it can send advertisements before they have ever purchased anything. The maximum cardinality is many, indicating that a specific customer may, and Fred hopes will, be associated with multiple sale transactions (i.e., become a loyal customer who makes repeated purchases from Fred's Train Shop). Now notice that the cardinality pairs next to the Inventory entity in Figure 17-6 have a minimum of one and a maximum of many for every relationship. This is the same pattern as in row four in Table 17-1. This means that every customer order or sale transaction *must* involve at least one inventory item (you cannot sell "nothing") but *may* involve multiple different items (e.g., a customer could purchase both a locomotive and a rail car in the same transaction). Finally, notice that the cardinality pair next to the Sale entity in its relationship with the Take Customer Order entity is like the pattern in row one of Table 17-1. The minimum cardinality of zero reflects the fact that an order may not *yet* have been turned into an actual sale transaction. The maximum cardinality of one indicates that Fred's Train Shop fills all customer orders in full rather than making a number of partial deliveries.

You should be able to interpret the rest of Figure 17-6 by following the same process just presented by comparing the cardinality pairs next to each entity to the four patterns in Table 17-1. Let us now examine what the various types of relationships mean and what they reveal about an organization's business practices.

**THREE TYPES OF RELATIONSHIPS** Three basic types of relationships between entities are possible, depending on the *maximum* cardinality associated with each entity (the minimum cardinality does not matter):

1. A *one-to-one (1:1) relationship* exists when the maximum cardinality for each entity in that relationship is 1 (see Figure 17-7, panel A).

**FIGURE 17-7**  
Examples of Different  
Types of Relationships



2. A *one-to-many (1:N) relationship* exists when the maximum cardinality of one entity in the relationship is 1 and the maximum cardinality for the other entity in that relationship is many (see Figures 17-7, panels B and C).
3. A *many-to-many (M:N) relationship* exists when the maximum cardinality for both entities in the relationship is many (Figure 17-7, panel D).

Figure 17-7 shows that any of these possibilities *might* describe the relationship between the Sales and Receive Cash events. The data modeler or database designer cannot arbitrarily choose which of these three possibilities to use when depicting various relationships. Instead, the cardinalities *must* reflect the organization's business policies. Let us now examine what each of the possibilities depicted in Figure 17-7 means. Figure 17-7, panel A, depicts a one-to-one (1:1) relationship between the Sales and Receive Cash events. The maximum cardinality of 1 associated with the Receive Cash entity means that each Sales event (transaction) can be linked to *at most* one Receive Cash event. This would be appropriate for an organization that had a business policy of not allowing customers to make installment payments. At the same time, the maximum cardinality of 1 associated with each Sale event means that each payment a customer submits is linked to *at most* one sales event. This would be appropriate for an organization that had a business policy of requiring customers to pay for each sales transaction separately. Thus, the 1:1 relationship depicted in Figure 17-7, panel A, represents the typical revenue cycle relationship for business-to-consumer retail sales: Customers must pay, in full, for each sales transaction before they are allowed to leave the store with the merchandise they purchased. Note that it does not matter *how* customers pay for each sales transaction (i.e., with cash, check, credit card, or debit card). Regardless of the method used, there is one, and only one, payment linked to each sales transaction and, conversely, every sales transaction is linked to one, and only one, payment from a customer (payments made by debit and credit cards also involve the card issuer; for simplicity, that transfer agent is not included in Figure 17-6). If management is interested in tracking the frequency of how customers choose to pay, payment method might be recorded as an attribute of the Receive Cash event.

Panels B and C of Figure 17-7 depict two ways that one-to-many (1:N) relationships can occur. Panel B shows that each Sales event may be linked to *many* Receive Cash events. This indicates that the organization has a business policy that allows customers to make installment payments *to the selling organization*. If the customer uses a third-party source of credit, the selling organization receives *one* payment in full from that third party for that particular sales transaction; the customer may be making installment payments to the credit agency, but those payments would not be modeled in an REA diagram for the selling organization. (Think about it: The selling organization has no way of tracking when one of its customers pays a portion of a credit card bill or makes a monthly payment on a bank loan). The situation depicted in Figure 17-7, panel B, does not, however, mean that *every* sales transaction is paid for in installments: The maximum cardinality of N simply means that some sales transactions may be paid in installments. Panel B of Figure 17-7 also shows that each Receive Cash event is linked to *at most* one Sale event. This indicates that the organization has a business policy that requires customers to pay for each sales transaction separately and are not allowed to build up an account balance over a period of time. Thus, Figure 17-7, panel B, represents the revenue cycle of an organization that probably sells big-ticket items. Should a customer return and make another purchase, a separate set of installment payments would be created in order to separately track how much has been paid for each sales transaction.

Figure 17-7, panel C, shows another type of 1:N relationship between the Sale and Receive Cash events. In this case, each Sale event can be linked to *at most* one Receive Cash event. This indicates that the organization has a business policy that does not permit customers to make installment payments. Figure 17-7, panel C, also shows that each Receive Cash event *may* be linked to many different Sale events. This indicates the existence of a business policy allowing customers to make a number of purchases during a period of time (e.g., a month) and then pay off those purchases with one payment. The situation depicted in Figure 17-7, panel C, is quite common, especially for business-to-business sales of nondurable goods.

Figure 17-7, panel D, depicts a many-to-many (M:N) relationship between the Sale and Receive Cash events. It shows that each Sales event may be linked to *one or more* Receive Cash

events and that each Receive Cash event may in turn be linked to *one or more* Sale events. This reflects an organization that has business policies that allow customers to make installment payments and also permits customers to accumulate a balance representing a set of sales transactions over a period of time. Keep in mind, however, that maximum cardinalities of N do not represent mandatory practices: Thus, for the relationship depicted in panel D, some sales transactions may be paid in full in one payment and some customers may pay for each sales transaction separately. The situation depicted in Figure 17-7, panel D, is quite common.

**BUSINESS MEANING OF CARDINALITIES** As noted, the choice of cardinalities is not arbitrary, but reflects facts about the organization being modeled and its business practices. This information is obtained during the systems analysis and conceptual design stages of the database design process. Thus, Paul Stone had to clearly understand how Fred's Train Shop conducts its business activities to ensure that Figure 17-6 was correct.

Let us now examine Figure 17-6 to see what it reveals about Fred's Train Shop's revenue cycle processes. First, note that all of the agent–event relationships are 1:N. This is typical for most organizations: A particular agent often participates in many events. For example, organizations expect that over time a given employee will repeatedly perform a particular task. Organizations also desire their customers to make repeat orders and purchases, just as they typically place orders with the same suppliers. However, for accountability purposes, events are usually linked to a specific internal agent and a specific external agent; hence, the maximum cardinality on the agent side of the agent–event relationships in Figure 17-6 is always 1. If, however, a particular event required the cooperation of a team of employees, the maximum cardinality on the agent side of the relationship would be many.

The minimum cardinalities associated with the agent–event relationships in Figure 17-6 also reflect typical business processes followed by most organizations. The figure shows that each event *must* be linked to an agent (a sale must involve a customer, a payment must come from a customer, etc.); hence the minimum cardinality of 1 on the agent side of the relationship. In contrast, Figure 17-6 shows that the minimum cardinality on the event side of the agent–event relationship is 0. There are several reasons why a particular agent need not have participated in any events. The organization may wish to store information about potential customers and alternate suppliers with whom it has not yet conducted any business. Information about newly hired employees will exist in the database prior to their first day on the job. Finally, there is a fundamental difference in the nature of agent entities and event entities. Organizations usually desire to maintain information about agents indefinitely but typically store information only about events that have occurred during the current fiscal year. Thus, agent entities are analogous to master files, whereas event entities are analogous to transaction files. At the end of a fiscal year, the contents of event entities are typically archived, and the next fiscal year begins with no instances of that event. Thus, at the beginning of a new fiscal year, agents are not linked to any current events.

Figure 17-6 depicts M:N relationships between the inventory resource and the various events that affect it. This is the typical situation for organizations, like Fred's Train Shop, that sell mass-produced items. Most organizations track such inventory by an identifier such as part number, item number, or stock-keeping unit (SKU) number and do not attempt to track each physical instance of that product. When a sale occurs, the system notes which product number(s) were sold. Thus, the same inventory item may be linked to many different sales events. For example, Fred's Train Shop uses product number 15734 to refer to a particular model of a steam locomotive. At a given point in time, it may have five of those locomotives in stock. If, during the course of a weekend, five different customers each purchased one of those locomotives, the system would link product number 15734 to five separate sales events. Hence, the maximum cardinality on the event side of the relationship is many. Of course, Fred's Train Shop, like most organizations, permits (and desires) that customers purchase many different products at the same time. For example, a customer who purchases a steam locomotive (product number 15734) may also purchase a box of curved track (product number 3265). Thus, the system would link one sales event to multiple inventory items; hence the maximum cardinality on the inventory side of the relationship is also many.

But what if an organization sells unique, one-of-a-kind inventory, such as original artwork? Such items can only be sold one time; consequently, the maximum cardinality on the event side




**FOCUS**  
17-2

## Why Should Users Participate in Data Modeling?

Data modeling is not an easy task, as Hewlett-Packard learned when it began designing a new database for its accounting and finance function. A major problem was that the same term meant different things to different people. For example, accounting used the term *orders* to refer to the total dollar amount of orders per time period, whereas the sales department used the term to refer to individual customer orders. Moreover, such confusions existed even within the accounting and finance function. For example, the reporting group used the term *product* to refer to any good currently sold to customers. Thus, the primary key for this entity was product number. In contrast, the forecasting group used the term *product* to refer to any good that was often still in the planning stage and had no product number assigned yet.

To solve these problems, Hewlett-Packard asked the different user groups to actively participate in the data modeling process. The first step was to convince all users of the need for and benefits of creating a data model for their function. Then it was necessary to carefully define the scope of the modeling effort. Hewlett-Packard found that the time

invested in these early steps was worthwhile, because it facilitated the activities of clarifying definitions and developing attribute lists that took place later in the process. The latter activity was an iterative affair that included many revisions. Documentation was critical to this process. Each member of the modeling team and user groups had copies of the proposed lists, which made it easier to spot inconsistencies in definitions.

Hewlett-Packard credits the data modeling approach as contributing significantly to the project's overall success. Data modeling allowed the participants to concentrate first on understanding the essential business characteristics of the new system, instead of getting bogged down in specifying the contents of relational database tables. This helped them to identify and resolve conflicting viewpoints early in the process and paved the way for eventual acceptance of the resulting system. The key step, however, was in getting the different user groups to actively participate in the data modeling process. Otherwise, the resulting data model would not have been as accurate or widely accepted.

entities being modeled. For example, if Fred's Train Shop only made sales to walk-in customers and did not take any orders from businesses, then Figure 17-6 would not need to include the Take Customer Order commitment event.

Although the development of the REA diagram for Fred's Train Shop's revenue cycle may seem to have been relatively straightforward and intuitive, data modeling is usually a complex and repetitive process. Frequently, data modelers develop an initial REA diagram that reflects their understanding of the organization's business processes, only to learn when showing it to intended users that they had omitted key dimensions or misunderstood some operating procedures. Thus, it is not unusual to erase and redraw portions of an REA diagram several times before finally producing an acceptable model. One common source of misunderstanding is the use of different terminology by various subsets of the intended user groups. Focus 17-2 highlights the importance of involving the eventual users of the system in the data modeling process so that terminology is consistent.

## Summary and Case Conclusion

The database design process has five stages: systems analysis, conceptual design, physical design, implementation and conversion, and operation and maintenance. Because of their extensive knowledge of transaction processing requirements and general business functions, accountants should actively participate in every stage.

One way to perform the activities of systems analysis and conceptual design is to build a data model of the AIS. The REA accounting data model is developed specifically for designing a database to support an AIS. The REA model classifies entities into three basic categories: resources, events, and agents. An REA model can be documented in the form of an entity-relationship (E-R) diagram, which depicts the entities about which data are collected as

rectangles and represents the important relationships between entities by connecting lines. The cardinalities of the relationships depicted in REA diagrams specify the minimum and maximum number of times an instance of one entity can be linked to an instance of the other entity participating in that relationship. Cardinalities also provide information about the basic business policies an organization follows.

Developing an REA diagram involves three steps. First, identify the basic events of interest (any activity about which management wants to collect information in order to plan, control, and evaluate performance). Second, identify the resources affected by and the agents who participate in those events. Third, use knowledge about the organization's business practices to add relationship cardinality information to the diagram.

Paul Stone followed these steps to develop an REA diagram for Fred's Train Shop's revenue cycle. He interviewed Fred to understand the store's business policies and used his general knowledge of revenue cycle activities to draw Figure 17-6. Paul showed the diagram to Fred and explained what each portion represents. Fred indicated that the diagram correctly reflects his store's revenue cycle activities. Paul then explained that he will proceed to use the model to design a relational database that Fred can use to automate the analyses he currently does by hand.

## Key Terms

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data modeling 514	agents 516	one-to-many (1:N)
entity-relationship (E-R)	cardinalities 522	relationship 525
diagram 514	minimum cardinality 523	many-to-many (M:N)
entity 515	maximum	relationship 525
REA data model 516	cardinality 523	
resources 516	one-to-one (1:1)	
events 516	relationship 524	

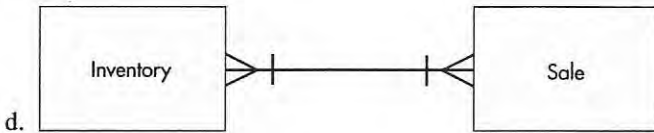
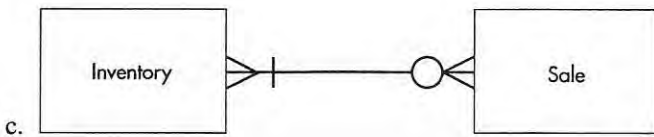
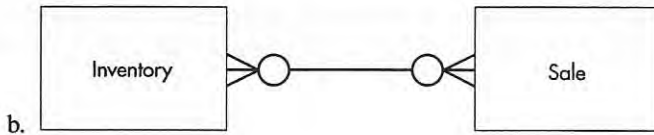
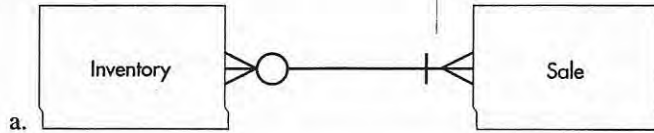
# AIS IN ACTION

## Chapter Quiz

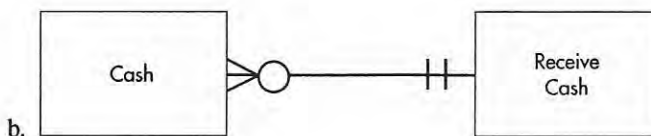
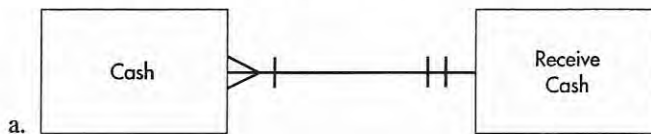
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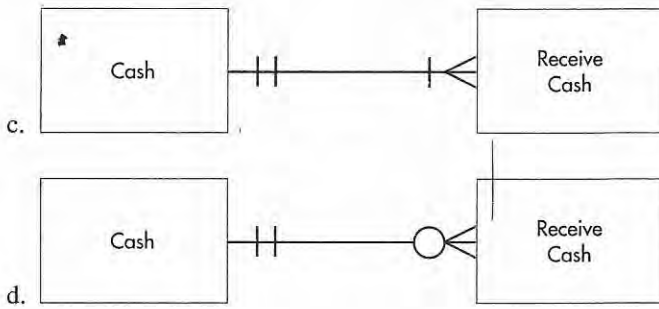
- Accounts Receivable would appear in an REA diagram as an example of which kind of entity?
  - resource
  - event
  - agent
  - none of the above
- Which of the following is NOT likely to be depicted as an entity in the REA data model?
  - customers
  - sales
  - invoices
  - delivery trucks
- In most cases, the relationship between agent entities and event entities is
  - 1:1
  - 1:N
  - M:N
  - 0:N

4. If customers pay for each sales transaction with a separate check and are not permitted to make installment payments on any sales, then the relationship between the Sales and Receive Cash events would be modeled as being which of the following?
- a. 1:1
  - b. 1:N
  - c. M:N
  - d. 0:N
5. Which of the following most accurately models the sales of low-cost, mass-produced items by a retail store?

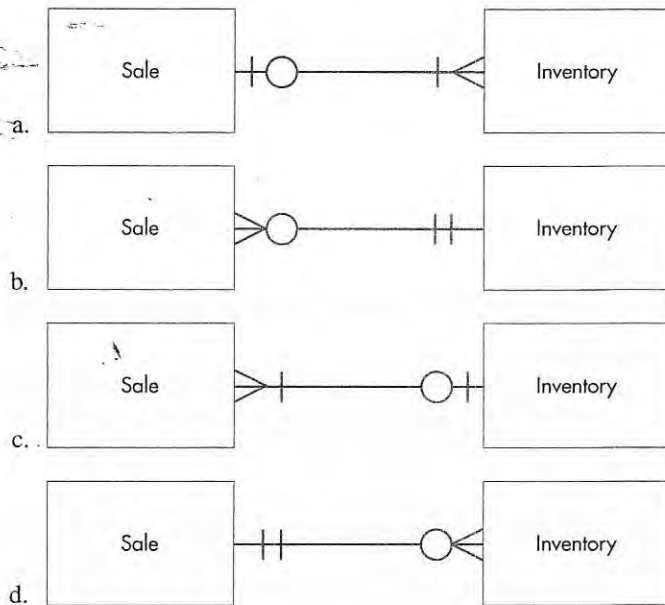


6. Data modeling occurs during which stages of database design?
- a. systems analysis and physical design
  - b. systems analysis and conceptual design
  - c. conceptual design and implementation and conversion
  - d. physical design and implementation and conversion
7. A company has five different cash accounts (checking, money market, petty cash; payroll, and investments). It deposits all payments received from customers into its checking account. Which of the following accurately depicts the relationship between the Cash entity and the Receive Cash event?

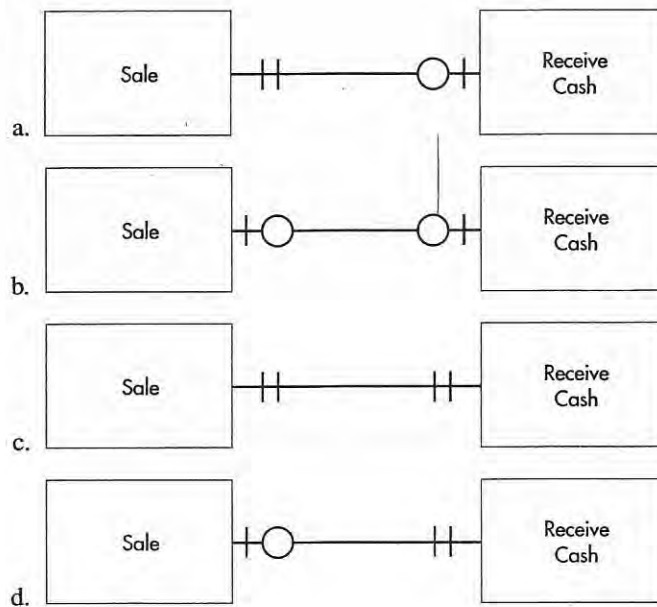




8. EZ Construction Company builds residential houses. It sells only homes that it built. Most of its homes are sold to individuals, but sometimes an investor may purchase several homes and hold them for subsequent resale. Which of the following is the correct way to model the relationship between Sale and Inventory for EZ Construction Company?



9. Which of the following statements about the REA data model is true?
- a. Every event must be linked to at least two agents.
  - b. Every resource must be linked to at least one agent.
  - c. Every event must be linked to at least two resources.
  - d. Every agent must be linked to at least two events.
10. A business operates by always collecting payments for the entire amount of the sale from customers in advance. It then orders the items from its suppliers, and when they all arrive it ships the entire order to the customer. Which of the following describes the relationship between the Sales and Receive Cash events for this company?



## Comprehensive Problem

### Expenditure Cycle for Fred's Train Shop

In order for Fred to sell trains and train accessories, he first needs to have inventory to sell. Thus, as part of his overall engagement, Paul Stone has also prepared an REA model for the expenditure cycle of Fred's Train Shop. The following paragraph describes the expenditure cycle business processes of Fred's Train Shop:

*Fred deals with more than one supplier and often places orders for multiple items at the same time. Fred takes inventory and places orders every Monday. Fred's suppliers strive to provide outstanding service. Therefore, they never consolidate multiple orders into one shipment, but always ship merchandise the day after receiving an order. Usually, Fred's suppliers can fill his entire order in one shipment. Occasionally, however, a supplier may be temporarily out of stock of a particular item. In such cases, the supplier ships as much of the order as possible and then ships the out-of-stock item separately as soon as it becomes available. Fred pays for each order in full at one time; that is, he does not make partial payments on orders received. Some suppliers offer discount terms for early payments; Fred always takes advantage of such offers, paying individual invoices, in full, on the appropriate date. Suppliers who do not offer such discounts send Fred monthly statements listing all orders placed the prior month. Fred pays the entire balance indicated on the statement in one check by the specified due date.*

### Required

Prepare an REA diagram for Fred's Train Shop's expenditure cycle.

## Discussion Questions

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- 17.1. Why is it not necessary to model activities such as entering information about customers or suppliers, mailing invoices to customers and recording invoices received from suppliers as events in an REA diagram?
- 17.2. The basic REA template includes links between two events and links between events and resources and between events and agents. Why do you think the basic REA template does not include direct links between (a) two resources, (b) two agents, or (c) between resources and agents?
- 17.3. How can REA diagrams help an auditor understand a client's business processes?
- 17.4. Which parts of Figure 17-6 would accurately depict almost every organization's revenue cycle? Which parts would change?
- 17.5. What is the relationship between the things that would be represented as resources in an REA diagram and the different categories of assets found on an organization's balance sheet? (*Hint: Are there any assets that would not be modeled as resources? Are there any resources in an REA diagram that are not listed as assets on a balance sheet?*)
- 17.6. How would accounts payable be reflected in an REA diagram? Why?
- 17.7. What are the five stages of the database design process? In which stages should accountants participate? Why?
- 17.8. What is the difference between an Entity-Relationship (E-R) diagram and an REA diagram?

## Problems

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- 17.1. Joe's is a small ice-cream shop located near the local university's baseball field. Joe's serves walk-in customers only. The shop carries 26 flavors of ice cream. Customers can buy cones, sundaes, or shakes. When a customer pays for an individual purchase, a sales transaction usually includes just one item. When a customer pays for a family or group purchase, however, a single sales transaction includes many different items. All sales must be paid for at the time the ice cream is served. Joe's maintains several banking accounts but deposits all sales receipts into its main checking account.

### Required

Draw an REA diagram, complete with cardinalities, for Joe's revenue cycle.

- 17.2. Joe, the owner of the ice-cream shop, purchases ice cream from two vendors. Over the years, he has developed good relationships with both vendors so that they allow Joe to pay them biweekly for all purchases made during the preceding two-week period. Joe calls in ice-cream orders on Mondays and Thursdays. The orders are delivered the next day. Joe buys ice-cream toppings from one of several local stores and pays for each such purchase at the time of sale with a check from the company's main checking account.

### Required

Draw an REA diagram, complete with cardinalities, for Joe's expenditure cycle.

17.3. Sue's Gallery sells original paintings by local artists. All sales occur in the store. Sometimes customers purchase more than one painting. Individual customers must pay for purchases in full at the time of sale. Corporate customers, such as hotels, however, may pay in installments if they purchase more than 10 paintings. Although Sue's Gallery has several bank accounts, all sales monies are deposited intact into the main checking account.

**Required**

Draw an REA diagram for the gallery's revenue cycle. Be sure to include cardinalities.

17.4. Sue's Gallery only purchases finished paintings (it never commissions artists). It pays each artist 50% of the agreed price at the time of purchase, and the remainder after the painting is sold. All purchases are paid by check from Sue's main checking account.

**Required**

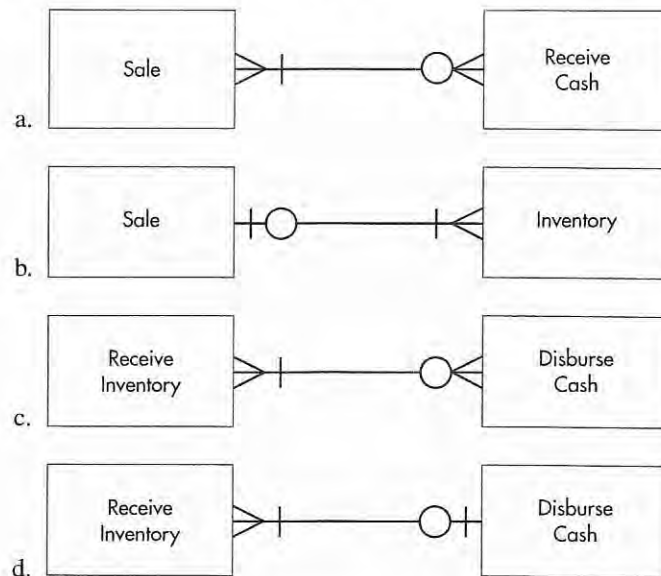
Draw an REA diagram, complete with cardinalities, of the gallery's expenditure cycle.

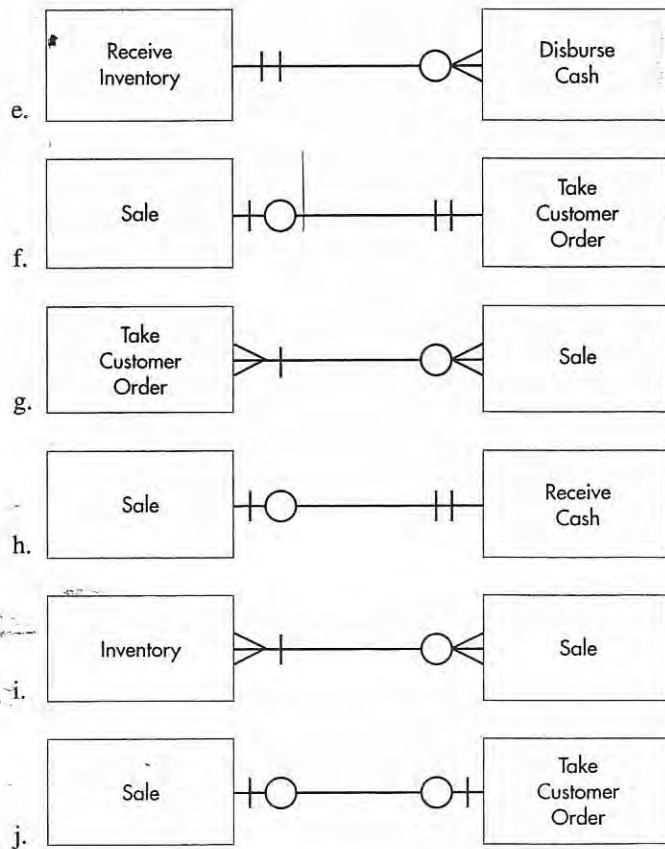
17.5. Develop a data model of Fred's Train Shop's expenditure cycle activities related to the acquisition of office equipment and other fixed assets. Fred sometimes orders multiple pieces of equipment. Vendors usually ship the entire order but sometimes are out of stock of some items. In such cases, they immediately ship to Fred what they have in stock and then send a second shipment when they obtain the other items. Conversely, several orders placed within a short time period with the same vendor might be filled with one delivery. Assume that Fred makes installment payments for most fixed-asset acquisitions but occasionally pays for some equipment in full at the time of purchase.

**Required**

Draw an REA diagram of your data model. Be sure to include cardinalities.

17.6. Provide an example (in terms of companies with which you are familiar) for each of the business situations described by the following relationship cardinalities:





17.7. Model the cardinalities of the following business policies:

- The relationship between the Sale and Receive Cash events for installment sales.
- The relationship between the Sale and Receive Cash events at a convenience store.
- The Take Customer Order–Sale relationship in a situation when occasionally several shipments are required to fill an order because some items were out of stock.
- The Sale–Inventory relationship for a custom homebuilder.
- The relationship between the Sale and Receive Cash events for Dell computers, which requires customers to pay the entire amount of their purchase in advance, prior to Dell shipping the merchandise.
- The relationship between the Sale and Receive Cash events for a retail store that has some in-store sales paid in full by customers at the time of the sale but that also makes some in-store sales to customers on credit, billing them later and permitting them to make installment payments.
- The relationship between the Receive Inventory and Disburse Cash events in the case where suppliers require payment in advance, in full.
- The relationship between the Call on Customers event (i.e., the visit by a salesperson to a potential customer) and the Take Customer Order event for a business that is only conducted door-to-door (e.g., kitchen knives, certain books, etc.) so that the only way



to order the items is when a salesperson visits the customer. (*Hint: do you think every call results in an order?*)

- i. The relationship between the Call on Customers and Take Customer Orders events for a manufacturer which also accepts orders on its Web site.
  - j. The relationship between the Receive Inventory and Disburse Cash events for a company which receives monthly bills from its suppliers for all purchases made the previous month; some suppliers require payment of the entire bill, in full, within 30 days or they will not accept any subsequent orders, but other suppliers accept installment payments.
- 17.8. The Computer Warehouse sells computer hardware, software, and supplies (such as paper). Individual customers just walk into the store, select merchandise, and must pay for their purchases in full before leaving the store. Corporate customers, however, call in orders in advance, so that the items are waiting to be picked up. Corporate customers may charge their purchases to their account. The Computer Warehouse mails corporate customers monthly statements that summarize all purchases made the prior month. Corporate customers pay the entire balance, as listed on the monthly statement, with one check or EFT transaction.

**Required**

Draw an REA diagram of the Computer Warehouse's revenue cycle, complete with cardinalities.

- 17.9. The Computer Warehouse purchases its inventory from more than a dozen different vendors. Orders are placed via telephone, fax, or on the supplier's Web site. Most orders are delivered the next day. Most orders are filled completely in one shipment, but sometimes a supplier is out of stock of a particular item. In such situations, the bulk of the order is shipped immediately and the out-of-stock item is shipped separately as soon as it arrives (such shipments of back orders are never combined with any new orders placed by the Computer Warehouse). The Computer Warehouse 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 allow it to make installment payments.

**Required**

Draw an REA diagram of the Computer Warehouse's expenditure cycle, complete with cardinalities.

- 17.10. Stan's Southern Barbeque Supply Store orders mass-produced barbecue products from various suppliers. Stan's maintains information about a contact person at each supplier along with all required address information. Each purchase order has the order number, date, tax, and total. Purchase orders also contain the following information for each product ordered: stock number, description, and price. The manager of Stan's places orders by fax several times a day, whenever he notices that an item is running low. Some suppliers fill each individual order separately. Others, however, consolidate orders and fill all of them in one weekly delivery. Stan's suppliers never make partial shipments; if they are out of stock of a certain item, they wait until they obtain that item and then ship the entire order. Some suppliers require payment at the time of delivery, but others send Stan's a monthly statement detailing all purchases during the current period. Two suppliers allow Stan's to make installment payments for any individual purchase orders that exceed \$20,000.

**Required**

Draw an REA diagram with cardinalities for the expenditure cycle of Stan's Southern Barbeque Supply Store.

## Case17-1 REA Data Modeling Extension

An important analytical and problem-solving skill is the ability to adapt and transfer patterns learned in one setting to other situations. This chapter explained how to develop an REA diagram for a business that sells tangible inventory. Yet some businesses provide only a service. For example, the following narrative describes Sparky's Amusement Park's revenue cycle.

Sparky's Amusement Park is an entertainment park run by recent college graduates. It caters to young people and others who are young at heart. The owners are very interested in applying what they have learned in their information systems and marketing classes to operate a park better than any other in the area.

To accomplish these goals, guests of the park are given a personal "membership card" as they enter. This card will be used to identify each guest. Assume that a new card is issued each time a guest comes to the park. As a result, the system does not have to track one person over a period of time.

As at other parks, guests pay a flat fee for the day and then are able to ride all of the attractions (such as a double-looping roller coaster and the merry-go-round) for no extra charge. The owners, however, want to track the rides each guest takes and the attractions the guests use. They plan to have guests swipe

their membership card through a computerized card reader, which automatically enters information into the computer system. This should allow the owners to gather data about the following:

- Number of people who use each piece of equipment. (How many people rode the Ferris wheel today?)
- Number of times each piece of equipment is operated daily.
- Times of day the attraction is busy or slow. (When was the carousel the busiest?)
- Number of attractions each guest uses. (How many different pieces of equipment did customer 1122 ride?)
- Number of rides each guest enjoys. (How many different rides did customer 1122 enjoy? Did each guest go on any rides more than once?)

### Required

Draw an REA diagram for Sparky's revenue cycle only. Be sure to include cardinalities. State any assumptions you had to make.

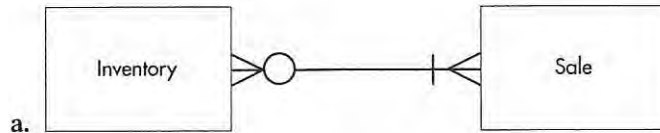
(This problem is adapted from one developed for classroom use by Dr. Julie Smith David at Arizona State University.)

# AIS IN ACTION SOLUTIONS

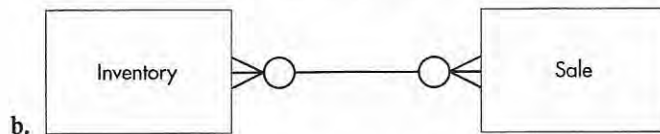
## Quiz Key

1. Accounts Receivable would appear in an REA diagram as an example of which kind of entity?
  - a. resource (Incorrect. Accounts Receivable is not a resource as defined in the REA model, but simply equals the difference between the Sales and Receive Cash events.)
  - b. event (Incorrect. Accounts Receivable is not an event, but represents the difference between two events.)
  - c. agent (Incorrect. Agents are people or organizations.)
  - ▶ d. none of the above (Correct. Accounts Receivable would not appear as an entity in an REA diagram because it represents the difference between two events.)
2. Which of the following is NOT likely to be depicted as an entity in the REA data model?
  - a. customers (Incorrect. Customers are an agent entity.)
  - b. sales (Incorrect. Sales are an event entity.)

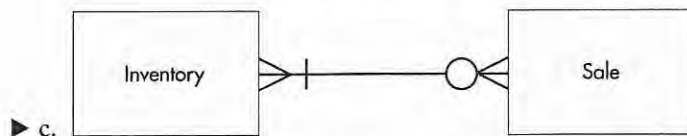
- ▶ c. invoices (Correct. Invoices are paper outputs of a database—they do not meet the definition of being either a resource, an event, or an agent and, therefore, are not modeled as an entity in a REA diagram.)
  - d. delivery trucks (Incorrect. Delivery trucks are an economic resource entity.)
3. In most cases, the relationship between agent entities and event entities is
- a. 1:1 (Incorrect. Over time, agents can participate in many events.)
  - ▶ b. 1:N (Correct. Over time, agents usually participate in many events. Usually, for accountability purposes, an event is linked to only one specific internal agent and one specific external agent. Occasionally, a complex task may be linked to a team of internal agents, but this is not the norm.)
  - c. M:N (Incorrect. This pattern may occasionally occur, but it is not the norm.)
  - d. 0:N (Incorrect. There is no such thing as a 0:N relationship.)
4. If customers pay for each sales transaction with a separate check and are not permitted to make installment payments on any sales, then the relationship between the Sale and Receive Cash events would be modeled as being which of the following?
- ▶ a. 1:1 (Correct. Each sales transaction is linked to only one payment (no installments) and each payment is linked to only one sales transaction (separate checks).)
  - b. 1:N (Incorrect. This indicates that each sale event could be linked to multiple cash receipts, implying installment payments.)
  - c. M:N (Incorrect. This not only indicates the possibility of installment payments but also the use of one check to pay for multiple sales.)
  - d. 0:N (Incorrect. There is no such thing as a 0:N relationship.)
5. Which of the following most accurately models the sales of low-cost, mass-produced items by a retail store?



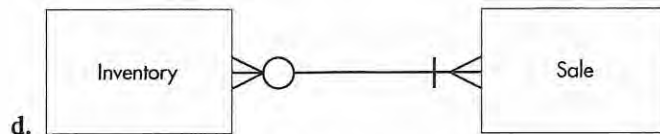
(Incorrect. This indicates that every inventory item must be linked to at least one sale, but that a sales transaction may consist of no inventory.)



(Incorrect. This shows that a sales transaction can consist of no inventory items.)

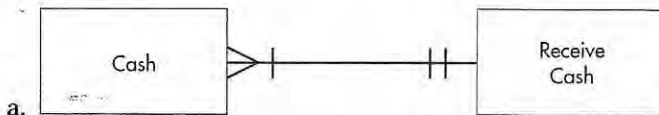


(Correct. Each sale must involve at least one item of inventory, but possibly many; conversely, each inventory item may not be linked to any sales transaction, but a given item could be linked to many sale events.)

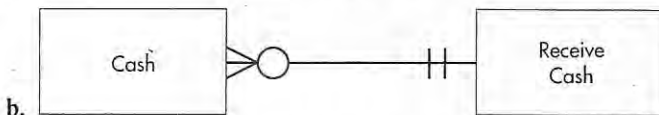


(Incorrect. This says that every inventory item must be linked to at least one sales transaction—this is not true at the beginning of a fiscal year and also precludes storing information about new products prior to their being sold.)

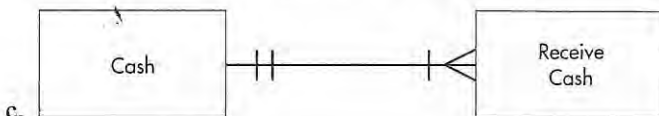
6. Data modeling occurs during which stages of database design?
- a. system analysis and physical design (Incorrect. Data modeling occurs during the system analysis and conceptual design stages of the database design process.)
  - ▶ b. system analysis and conceptual design (Correct.)
  - c. conceptual design and implementation and conversion (Incorrect. Data modeling occurs during the system analysis and conceptual design stages of the database design process.)
  - d. physical design and implementation and conversion (Incorrect. Data modeling occurs during the system analysis and conceptual design stages of the database design process.)
7. A company has five different cash accounts (checking, money market, petty cash, payroll, and investments). It deposits all payments received from customers into its checking account. Which of the following accurately depicts the relationship between the cash entity and the receive cash event?



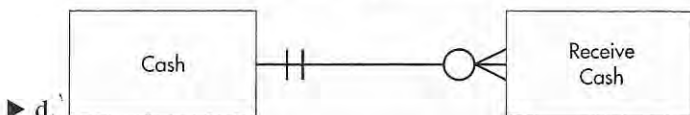
(Incorrect. This says that every Cash account must be linked to at least one Receive Cash event and that a Receive Cash event could be linked to multiple cash accounts.)



(Incorrect. Same problems as in a.)

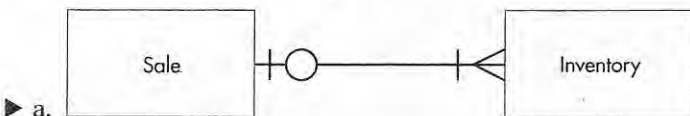


(Incorrect. This says that every Cash account must be linked to at least one Receive Cash event, which is not true: At the beginning of a new fiscal year, there are no Receive Cash events and four of the company's five Cash accounts never directly receive funds collected from customers.)

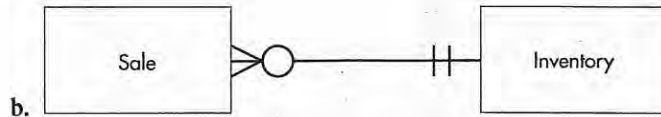


(Correct. This shows that some Cash accounts may not be linked to any Receive Cash events, whereas others may be linked to many events. Conversely, this shows that each Receive Cash event must be linked to a Cash account, and to only one Cash account.)

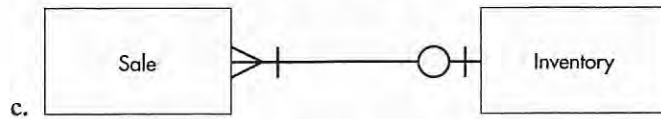
8. EZ Construction Company builds residential houses. It sells only homes that it has built. Most of its homes are sold to individuals, but sometimes an investor may purchase several homes and hold them for subsequent resale. Which of the following is the correct way to model the relationship between Sales and Inventory for EZ Construction Company?



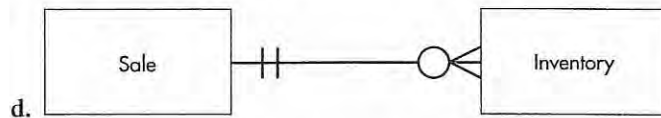
(Correct. Each sale must involve at least one home from inventory but could involve many; conversely, each home may or may not be sold (yet) but can be sold at most one time.)



(Incorrect. This shows that a sale can only involve at most one home from inventory and it shows that a given home can be sold multiple times.)



(Incorrect. This shows that a sale could involve no homes or at most one home, and it shows that every home must be sold but could be sold more than once.)

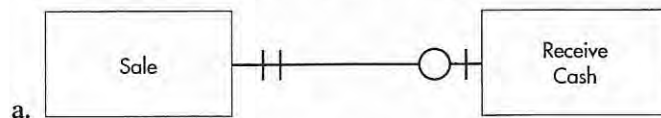


(Incorrect. This shows that every home must be sold and it also shows that a sale could involve no homes.)

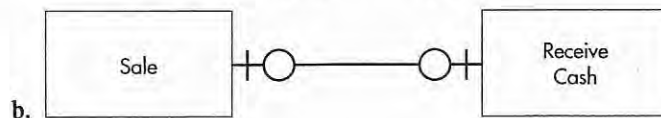
9. Which of the following statements about the REA data model is true?

- ▶ a. Every event must be linked to at least two agents. (Correct.)
- b. Every resource must be linked to at least two agents. (Incorrect. Resources and agents are not usually directly linked to one another.)
- c. Every event must be linked to at least two resources. (Incorrect. Every event must be linked to at least one resource.)
- d. Every agent must be linked to at least two events. (Incorrect. Some agents may only need to be linked to one event.)

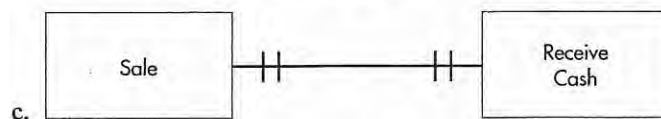
10. A business operates by always collecting payments for the entire amount of the sale from customers in advance. It then orders the items from its suppliers, and when they all arrive it ships the entire order to the customer. Which of the following describes the relationship between the sales and Receive Cash events for this company?



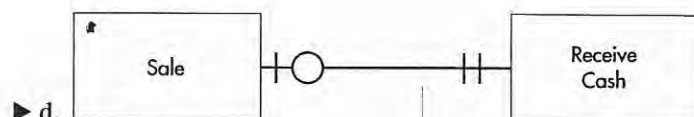
(Incorrect. This shows that a Sale event might not be linked to any Receive Cash events, which means that the merchandise is delivered prior to the customer's payment. Another problem is that this shows that every Receive Cash event must be linked to a Sale event, but the company receives payment prior to delivering the merchandise.)



(Incorrect. Same problems as in a.)



(Incorrect. This shows that every Receive Cash event must be linked to a Sale event, but this is not true because the company receives cash prior to shipping the merchandise.)



(Correct. This shows that each Sale event must be linked to a prior Receive Cash event but that a Receive Cash event may not (yet) be linked to any Sale event.)

## Comprehensive Problem Solution

### REA Diagram of Expenditure Cycle for Fred's Train Shop

To create an entity-relationship diagram using the REA model, follow the three basic steps outlined in the chapter.

#### 1 Identify Events

As explained in the chapter, the first step is to identify all relevant events or transactions using the basic “give-to-get” exchange. After talking to Fred about how he buys the inventory he needs, Paul identifies three basic events that occur:

1. Order Inventory.
2. Receive Inventory.
3. Pay for Inventory, which Paul decides to call “Disburse Cash.”

#### 2 Identify Resources and Agents

Next, identify the resources involved with these events. Paul determines that there are two resources involved with these events:

1. Inventory
2. Cash

Then identify the agents or people needed to make these events happen, remembering that there are usually two agents for each event, one internal to Fred's store (i.e., an employee) and one external to Fred's store (i.e., the supplier). Paul lists the following agents as being involved in the Order Inventory event:

1. Purchasing Clerk
2. Supplier

The following are the agents involved in the Receive Inventory event:

3. Receiving Clerk
4. Supplier

The following are the agents involved in the Disburse Cash event:

5. Supplier
6. Cashier

#### 3 Determine Cardinalities of Relationships

After all events, resources, and agents are identified, the next step is to determine how all of these entities interact by determining the cardinalities of all of the relationships between and among the entities. This involves three steps:

1. Specify cardinalities of event-agent relationships.
2. Specify cardinalities of event-resource relationships.
3. Specify cardinalities of event-event relationships.

### 1 Event-Agent Relationship Cardinalities

After talking with Fred, Paul understands that any employee can order merchandise from suppliers. However, one and only one employee is involved in each order event. Similarly, any employee can check in deliveries from suppliers. Because model train merchandise is not heavy or bulky, each delivery is checked in by only one employee. Fred, or his wife, signs all checks to suppliers, and only one signature is ever required. Thus, the *maximum* cardinality on the agent side of relationships between events and internal agents (employees) is always 1. Obviously, an employee must participate in each event: There must be some employee who places an order, there must be some employee who checks in a delivery, and either Fred or his wife must sign each check. Thus, the *minimum* cardinality on the agent side of relationships between events and internal agents is also 1.

Orders, receipts of inventory, and payments all involve suppliers. Each event must be linked to a particular supplier: A purchase order must identify and be sent to a supplier, a delivery comes from some supplier, and a payment is made to some identifiable supplier. Moreover, each event can be linked to *only one* supplier: Each order is placed with a *specific* supplier, each delivery comes from a *specific* supplier, and each payment is made to a *specific* supplier (e.g., each check is made payable to one, and only one, supplier). Thus, the minimum and maximum cardinalities on the agent side of relationships between events and external agents is 1.

Paul also knows that information about both internal and external agents is maintained indefinitely but that information about events is maintained only for the current fiscal year. Therefore, at the beginning of each fiscal period, no internal agent and no external agent is linked to any order, inventory receipt, or payment events. Thus, the *minimum* cardinality on the event side of relationships between events and agents is 0. During the course of the year, however, the same employee may place many different orders or may check in many different deliveries of merchandise. In addition, both Fred and his wife will sign many different checks that are sent to suppliers. Conversely, during the year many orders may be placed with the same supplier; many deliveries may be received from the same supplier; and many payments may be made to the same supplier. Thus, the *maximum* cardinality on the event side of relationships between events and agents is N.

### 2 Event-Resource Relationship Cardinalities

Each order must involve at least one inventory item but could be for many different items. Similarly, each delivery of merchandise from a supplier must involve at least one inventory item but may include many different items. Consequently, Paul depicts the minimum cardinality as 1 and the maximum cardinality as N on the inventory side of all relationships between the inventory resource and various events.

Information about inventory is maintained indefinitely, but only orders and inventory receipts that occurred during the current fiscal year are maintained in the database. Thus, at the beginning of each fiscal year the inventory entity is not linked to any order or receive inventory events. During the course of the year, however, a particular inventory item may be ordered and received many times. Thus, Paul depicts the minimum cardinality as 0 and the maximum cardinality as N on the event side of all relationships between the Inventory resource and various events affecting it.

Each payment must be made from some general ledger cash account. In addition, each payment can be made from only one specific account. For example, a check can be linked to either the operating checking account or the payroll checking account, but it cannot be linked to both accounts. Therefore, Paul sets the minimum and maximum cardinalities to 1 on the resource side of the relationship between the Cash resource and the Disburse Cash event.

Information about the various cash accounts in the general ledger (operating checking, payroll, investment, etc.) is maintained indefinitely, but the Disburse Cash event entity contains information only about payments made during the current fiscal year. Therefore, at the beginning of each fiscal year, the cash resource is not linked to any Disburse Cash events. During the course of the year, however, a given cash account may be linked to many different Disburse Cash events. Thus, the minimum cardinality is 0 and the maximum cardinality is N on the event side of the relationship between the Cash resource and the Disburse Cash event.

**3 Event-Event Relationship Cardinalities**

Orders occur before deliveries. Some orders, however, may include items that are out of stock; when that happens, the merchandise in stock is sent immediately, and one or more additional shipments are made for any items that the supplier had to back order. Thus, one order can be linked to multiple Receive Inventory events. Consequently, Paul assigns a minimum cardinality of 0 and a maximum cardinality of N on the Receive Inventory side of the relationship between the Order Inventory and Receive Inventory events.

Fred's employees have been trained to accept only deliveries for which a valid purchase order exists. Thus, each Receive Inventory event must be linked to an order. Fred's suppliers never consolidate multiple orders into one delivery; thus, each Receive Inventory event can be linked to at most one order event. Therefore, Paul depicts the minimum and maximum cardinalities on the Order Inventory side of the relationship between the Receive Inventory and Order Inventory events as both being 1.

Often, Fred pays for deliveries in the following month. Thus, there may be Receive Inventory events that are not yet linked to any Disburse Cash events. Fred always pays for deliveries in full; he never makes installment payments. Therefore, each Receive Inventory event is linked to at most one Disburse Cash event. Consequently, Paul assigns a minimum cardinality of 0 and a maximum cardinality of 1 to the Disburse Cash side of the relationship between the Receive Inventory and Disburse Cash events.

Fred's only pays for deliveries after the merchandise has been received and inspected. Thus, every Disburse Cash event must be linked to a preceding Receive Inventory event. Oftentimes, Fred or his wife will write one check to pay for several deliveries received during the preceding month. Therefore, Paul draws the minimum cardinality as 1 and the maximum cardinality as N on the Receive Inventory side of the relationship between the Receive Inventory and Disburse Cash events.

After completing the three steps, Paul produced the following REA diagram of the expenditure cycle of Fred's Train Shop.

