Chapter 10

The REA Approach to Database Modeling

LEARNING OBJECTIVES

After studying this chapter, you should:

- Recognize the economic foundations of the REA model.
- Understand the key differences between traditional ER modeling and REA modeling.
- Understand the structure of an REA diagram.
- Be able to create an REA diagram by applying the view modeling steps to a business case.
- Be able to create an entity-wide REA diagram by applying the view integration steps to a business case.

This chapter examines the resources, events, and agents (REA) model as a means of specifying and designing accounting information systems that serve the needs of all of the users in an organization. The chapter is comprised of three major sections. The first introduces the REA approach and comments on the general problems associated with traditional accounting practice that can be resolved through an REA approach. This section presents the REA model and describes the structure of an REA diagram.

The basic REA model consists of three entity types (resources, events, and agents) and a set of associations linking them. Resources are things of economic value to the organization and are the objects of economic exchanges with trading partners. REA events fall into two general groups: economic events and support events. Economic events are phenomena that effect changes (increases or decreases) in resources. Support events include control, planning, and management activities that are related to economic events but do not directly effect a change in resources. **Agents** are individuals within and outside the organization who participate in an economic event. A key feature of REA is the concept of economic duality. Each economic event is mirrored by another event in the opposite direction. These dual events constitute the give event and receive event of an economic exchange.

The second section presents the multistep process of view modeling to create an REA model. The focus here is on modeling a single view of the entire database. The steps involved are: (1) identify the event entities to be modeled, (2) identify the resource entities changed by events, (3) identify the agent entities participating in events, and (4) determine associations and cardinalities between entities.

The third and final section presents the task of view integration, in which several individual REA diagrams are integrated into a single enterprise-wide model. The steps involved in view integration are: (1) consolidate the individual models; (2) define primary keys, foreign keys, and attributes; and (3) construct physical database and produce user views. The section concludes with a discussion of the advantages of REA in achieving competitive advantage.

The REA Approach

Central to the database philosophy is the recognition that corporate data should support the information needs of all users in the organization. An important aspect of data modeling, therefore, is creating a model that faithfully reflects the organization's physical reality. This is not easily accomplished when different people within the organization see and use the same data differently.

You will recall from Chapter 9 that a **user view** is the set of data that a particular user needs to achieve his or her assigned tasks. For example, a general ledger clerk's user view will include the organization's chart of accounts, but not detailed transaction data. A sales manager's view may include detailed customer sales data organized by product, region, and salesperson. A production manager's view may include finished goods inventory on hand, available manufacturing capacity, and vendor lead times.

A problem arises in meeting these diverse needs when a single view that is inappropriate for entity-wide purposes dominates the collection, summarization, storage, and reporting of transaction and resource data. The accounting profession has long been criticized for focusing too narrowly on the role of accounting information. Many researchers today encourage the profession to shift its emphasis away from debits, credits, double-entry accounting, and GAAP and move toward providing useful information for decision making and helping organizations identify and control business risk.

Modern managers need both financial and nonfinancial information in formats and at levels of aggregation that the traditional GAAP-based accounting systems generally fail to provide. The response within many organizations to the dominant single view of accounting information has been to create separate information systems to support each user's view. This has resulted in organizations with multiple information systems that are functionally disconnected. Often data entered in one system needs to be re-entered in the others. With such widespread duplication of data, accuracy and data currency issues pose serious problems.

Such concerns have led a number of database researchers to develop **semantic models** or frameworks for designing accounting information systems that support multiple user views. A semantic model captures the operational meaning of the user's data and provides a concise description of it. One such example, of great importance to accounting, is the REA model. In 1982, REA was originally proposed as a theoretical framework for accounting.[1] Since that time, however, it has gained considerable attention as a practical alternative to traditional accounting systems.

The REA Model

The **REA model** is an accounting framework for modeling an organization's critical resources, events, and agents and the relationships between them. Unlike some traditional

1 W. E. McCarthy, "The REA Accounting Model: A Generalized Framework for Accounting Systems in a Shared Data Environment," *The Accounting Review* (July 1982): 554–77.

accounting systems, REA systems permit both accounting and nonaccounting data to be identified, captured, and stored in a centralized database. From this repository, user views can be constructed that meet the needs of all users in the organization. REA models may be implemented within either relational or object-oriented database architectures. For purposes of discussion in this chapter, we will assume a relational database since this is the more common architecture for business applications.

Figure 10-1 illustrates the basic REA model, which is a unique version of an ER diagram consisting of three entity types (resources, events, and agents) and a set of associations linking them. From this point, we will refer to this documentation technique as an **REA diagram**. The conventions for describing associations, assigning cardinality, and normalizing tables as discussed in Chapter 9 for traditional ER diagrams also apply to REA diagrams.

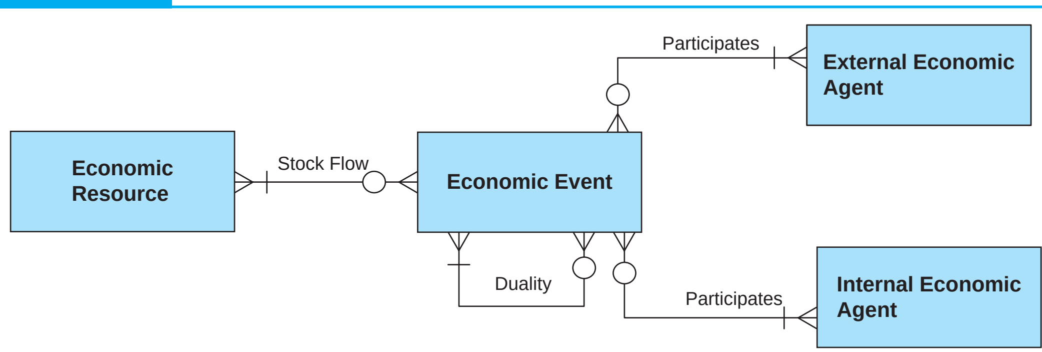
Elements of an REA Model

Resources. Economic **resources** are things of economic value to the organization. They are defined as objects that are both scarce and under the control of the enterprise. Resources are used in economic exchanges with trading partners and are either increased or decreased by the exchange.

Events. REA modeling embraces two classes of events: economic events and support events. **Economic events** are phenomena that effect changes (increases or decreases) in resources as represented by the **stock flow** relation in Figure 10-1. They result from activities such as sales of products to customers, receipt of cash from customers, and purchases of raw material from vendors. Economic events are the critical information elements of the accounting system and must be captured in as disaggregated (highly detailed) form as possible to provide a rich database.

Support events (not shown in Figure 10-1) include control, planning, and management activities that are related to economic events, but do not directly effect a change in resources. Examples of support events include (1) determining inventory availability for a customer prior to making a sale, (2) verifying supporting information (performing a three-way-match) prior to disbursing cash to a vendor, and (3) checking customer credit before processing a sale.

FIGURE 10-1 **Basic REA Model**



Agents. Economic agents are individuals and departments that participate in economic and support events. They are parties both inside and outside the organization with discretionary power to use or dispose of economic resources. Each economic event is associated with at least one **internal agent** and one **external agent** who participate in the exchange. The respective roles of internal and external agents in transactions with outsiders are usually apparent. For example, in a sales transaction, the internal agents are various employees of the company and the external agent is the customer. For purely internal transactions, however, the roles of internal and external agent may not be so obvious. The convention in REA modeling is to treat such transaction as if they were sales. For example, in the transfer of products from work-in-process to finished goods inventory, the work-in-process (WIP) clerk is viewed as selling the product to the finished goods clerk. Therefore, the clerk giving up control and reducing the resource (work-in-process clerk) is the internal agent and the clerk assuming control and increasing the resource (finished goods clerk) is the external agent.

Internal and external agents are also involved in support events, but the exchange involves information rather than economic resources. For example, a customer (external agent) checking on product prices receives information from the Sales Clerk (internal agent), who gives up the information. Linking internal agents to events in this way promotes control and permits organizations to assess the actions taken by their employees.

Duality. REA's semantic features derive from the elements of an economic transaction. The rationale behind an economic transaction is that two agents each give the other a resource in exchange for another resource. In actuality, the exchange is a pair of economic events, which is expressed via the **duality** association shown in Figure 10-1. In other words, each economic event is mirrored by an associated economic event in the opposite direction. Figure 10-2 expands the basic REA model to illustrate the connection between these dual events: the **give event** and **receive event**. From the perspective of the organization function being modeled, the give half of the exchange decreases the economic resource, as represented by the outflow association. The receive half of the exchange increases the economic resources represented by an inflow association. Figure 10-3 presents several examples of the give and receive events as they relate to the revenue, expenditure, and conversion cycles.

Note that an economic exchange does not require duality events to occur simultaneously. For example, inventory is reduced immediately by the sale to a customer, but cash may not be increased by the customer's remittance for several weeks. The REA model accommodates credit-based transactions and the associated time lags, but does not employ traditional mechanisms such as accounts receivable or accounts payable ledgers in accounting for these events. In fact, REA rejects the need for any accounting artifacts, including journals, ledgers, and double-entry bookkeeping. As mentioned previously, economic phenomena should be captured in a disaggregated form consistent with the needs of multiple users. To reflect all relevant aspects of economic events, therefore, business data must not be preformatted or artificially constrained. Journals, ledgers, and double-entry bookkeeping are the traditional mechanisms for formatting and transmitting accounting data, but they are not essential elements of an accounting database. REA systems capture the essence of what accountants account for by modeling the underlying economic phenomena directly. Organizations employing REA can thus produce financial statements, journals, ledgers, and double-entry accounting reports directly from event database tables via user views. We demonstrate how this is done later in the chapter.

FIGURE 10-2 REA Model Showing Duality of a Give and Receive Exchange

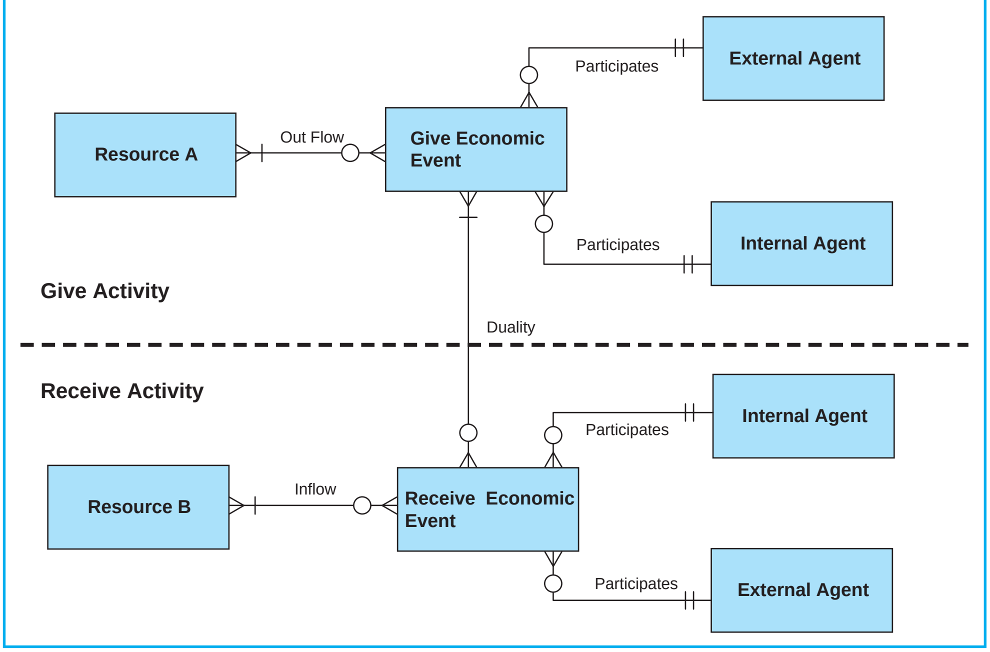
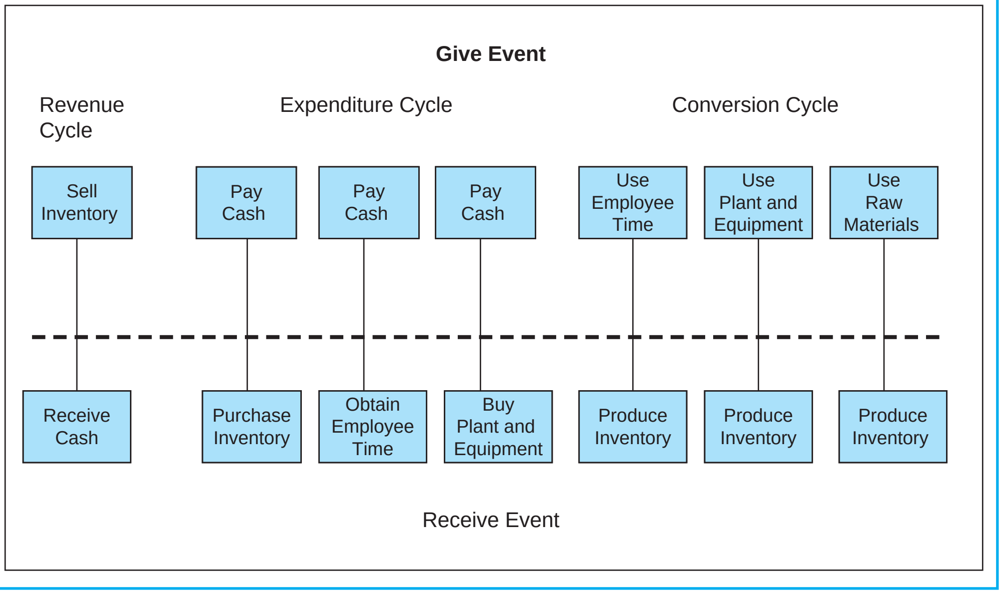


FIGURE 10-3 Examples of Give and Receive Events



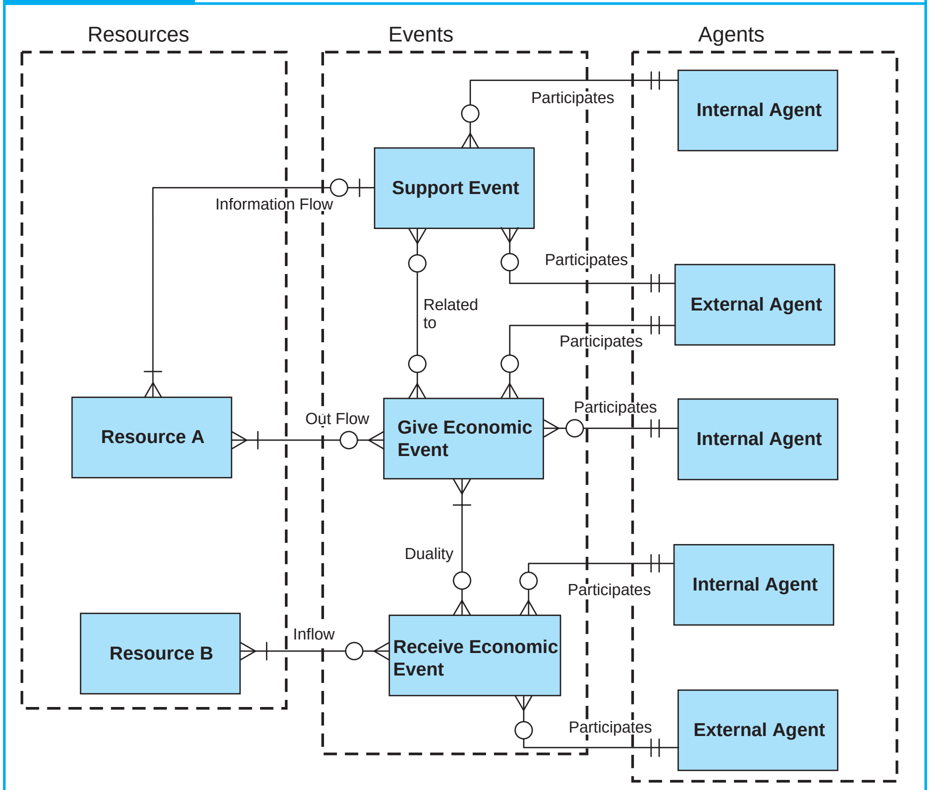
Developing an REA Model

In the previous chapter, we described the process of **view modeling**, in which the database designer identifies and models the set of data that individual users need to make a decision or perform a task. The result of this process is an ER diagram depicting the user's data model. The REA approach uses semantic modeling to construct an REA diagram, which in some ways is similar to an ER diagram, but in other respects quite different. Before we describe REA view modeling, we need to examine these differences.

Differences between ER and REA Diagrams

ER and REA diagrams differ visually in a significant way. Entities in ER diagrams are of one class, and their proximity to other entities is determined by their cardinality and by what is visually pleasing to keep the diagrams readable. Entities in an REA diagram, however, are divided into three classes (resources, events, and agents) and organized into constellations by class on the diagram. This arrangement is illustrated in Figure 10-4. Note that during view integration (discussed later), when several individual REA diagrams are merged to form a single global model, the constellations of entities may necessarily be altered. As a design tool during the view modeling phase, however, the constellation convention is typically followed.

FIGURE 10-4 Arrangement of Entities in an REA Diagram



A second difference between ER and REA diagrams involves the sequencing of events. ER diagrams present a static picture of the underlying business phenomena. Relationships between data are shown through cardinality and associations, but the sequence of activities that determine the cardinality and associations are not clearly represented. REA diagrams, however, are typically organized from top to bottom within the constellations to focus on the sequence of events. An advantage of this is that during systems development, management and nontechnical users better understand REA diagrams.

The third difference between ER and REA diagrams pertains to naming conventions for entities. In ER diagrams, entity names are always represented in the singular noun form. REA modeling applies this rule when assigning names to resource and agent entities. Event entities, however, are given verb (action) names such as Sell Inventory, Take Order, or Receive Cash. The reader should, therefore, be careful to not confuse an event entity with a process. Event entities on an REA diagram represent and describe database tables that will store data about processes, but they are not representing or describing the processes themselves.

View Modeling: Creating an Individual REA Diagram

This section describes the view modeling process as applied to creating an REA diagram. The process involves the following steps:

1. Identify the event entities.
2. Identify the resource entities.
3. Identify the agent entities.
4. Determine associations and cardinalities between entities.

These procedures are performed for each organizational function being modeled. The result is several individual REA diagrams. The modeling process is completed during the view integrating phase (described later) where the individual models are consolidated into a single global model. To illustrate REA view modeling, we will use a simplified description of a revenue cycle process. Following are its key features:

> Apex Supply Company is a downtown Philadelphia wholesaler of electrical products that sells to electrical retailers. It carries an inventory of approximately 10,000 items. Customers place orders by phone and buy on credit through a line-of-credit arrangement with Apex. A typical transaction involves the customer first contacting the customer services department to verify availability and check the price of the item or items being sought. If the customer decides to buy, he or she is transferred to a sales agent, who takes the order. The shipping clerk sends the products to the customer by a common carrier. The billing clerk records the sale in the sales journal, prepares an invoice, and sends it to the customer, who is given 30 days to make payment. The accounts receivable clerk also receives a copy of the invoice and records it in the accounts receivable ledger. Subsequently (within 30 days) the customer sends a check and the remittance advice to Apex. The cash receipts clerk receives the check, records it in the cash receipts journal, and updates the cash account. The remittance advice goes to the accounts receivable clerk, who updates (reduces) the customer's account receivable.

Step 1. Identify the Event Entities

The first step in developing an REA model is to identify the event entities in the function being modeled. The events in this revenue cycle example can be identified as the value-added actions that Apex employees take. These entities include Verify Availability, Take

Order, Ship Product, and Receive Cash. An REA model must, at a minimum, include the two economic events that constitute the *give* and *receive* activities that reduce and increase economic resources in the exchange. In addition, it may include support events, which do not change resources directly. We will next examine each identified event above to determine whether it should be classified an economic event or a support event.

Verify Availability. The Verify Availability event is a support event because it does not directly increase or decrease a resource. The decision to add this entity to the model will depend on management's need for information regarding customer inquiries. Such information could help them determine which inventory items customers most frequently demand. This may be different from what Apex is actually selling to customers. For example, an analysis of inquiries that do not lead to placed orders may indicate that customers are shopping around for, and getting, better deals from Apex competitors. We will assume, therefore, that Verify Availability is a value-added activity that should be modeled in the REA diagram.

Take Order. Depending on the circumstances, Take Order could be either an economic or support event. Taking an order typically involves only a commitment on the part of the seller to sell goods to the customer. It may even involve adjusting (decreasing) the inventory available for sale to prevent it from being sold or promised to other customers. This commitment, however, does not cause a real decrease in inventory and is not an economic exchange. Furthermore, if the client subsequently cancels the order before it is shipped, no economic exchange will occur. On the other hand, if taking an order causes the buyer to expend resources to obtain or manufacture the product on behalf of the customer, then an economic event will have occurred. For the purposes of this example, we will assume that no economic consequences derive directly from the Take Order event and it is, therefore, a support event.

Ship Product. Ship Product is an economic event. This is the give half of an economic exchange and reduces the inventory resource directly.

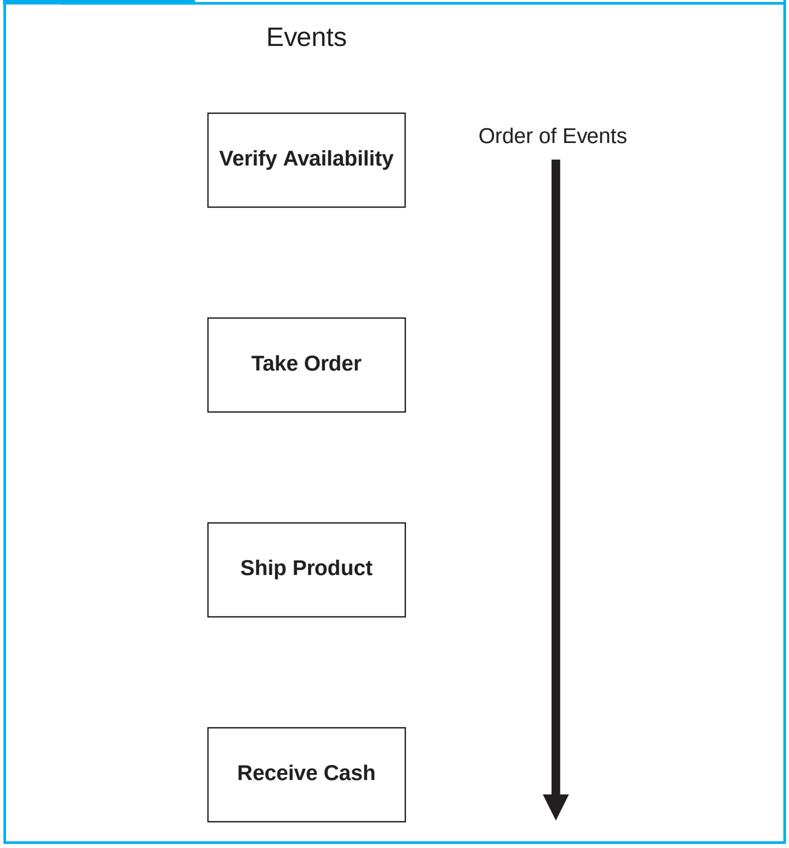
Receive Cash. Similarly, the Receive Cash event is an economic event. This is the receive half of the exchange that increases the cash resource.

Invalid Entity Types. REA modeling focuses on **value chain** events. These are the activities that use cash to obtain resources including equipment, materials, and labor and then employ those resources to earn new revenues. Bookkeeping tasks such as recording a sale in the journal and setting up an account receivable are not value chain activities. These are invalid entity types and should not be included in an REA diagram.

A fundamental precept of REA is the rejection of accounting artifacts, including journals, ledgers, and double-entry bookkeeping. Capturing transaction data in sufficient detail adequately serves traditional accounting requirements. For example, an account receivable is the difference between a sale to a customer and cash received in payment of the sale. Therefore, analyzing data pertaining to the Ship Product (sales) and Receive Cash events can satisfy the information needs related to the accounts receivable and billing functions described in the Apex case above.

Once the valid event entities are identified and classified as either economic or support events, they are placed on the REA diagram. REA convention is to arrange these entities in their sequence of occurrence from top to bottom on the diagram. Figure 10-5 presents the four events above in sequence of occurrence.

FIGURE 10-5 Arrangement of Events Entities in Order of Occurrence



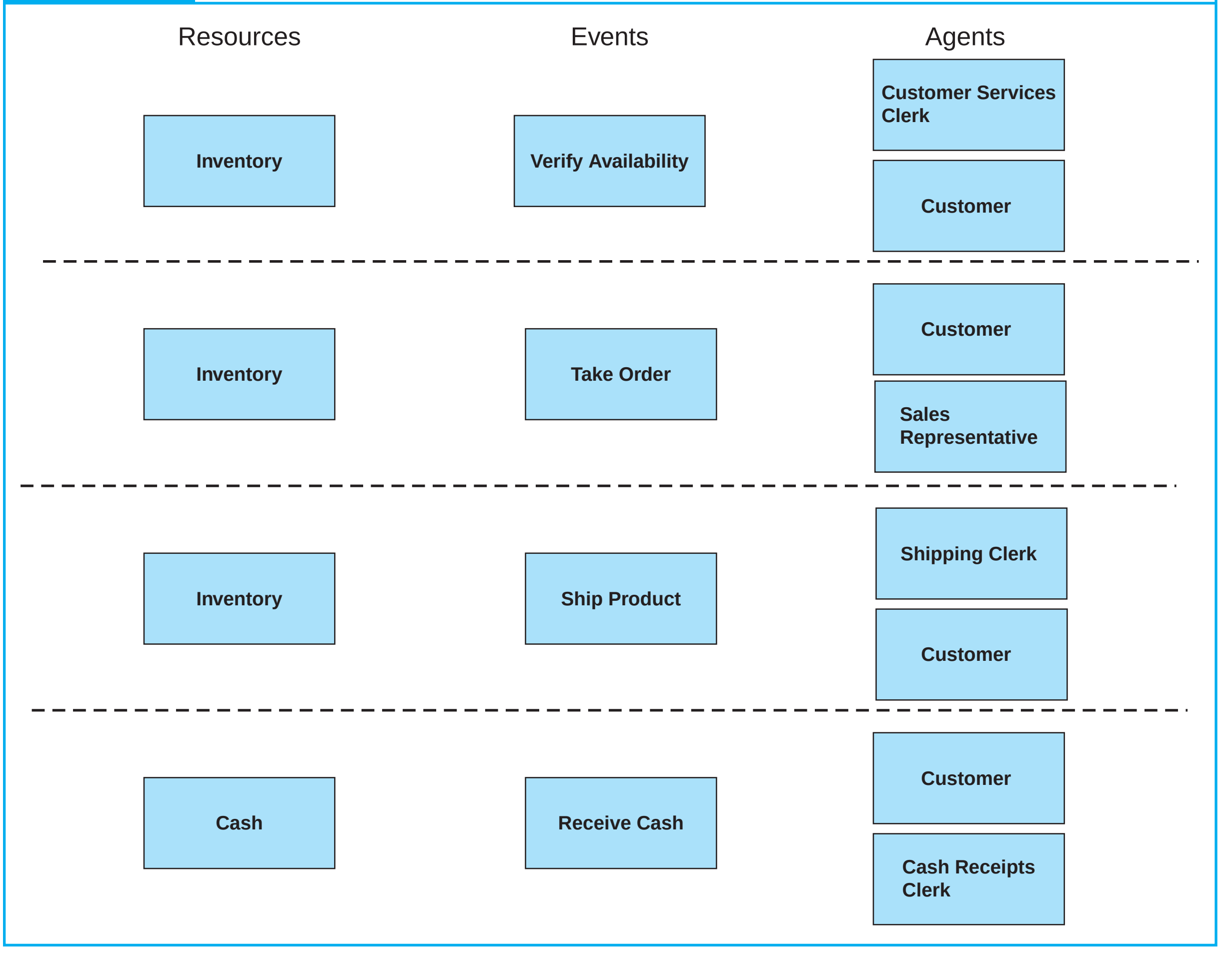
Step 2. Identify the Resource Entities

The next step in creating the REA diagram is to identify the resources that are impacted by the events selected to be modeled. Each economic event in an REA model must be linked to at least one resource entity whose economic value will be either reduced or increased by the event. Support events are also related to resources but do not effect a change in the resource value.

One could make the theoretical argument that all employee actions, including support events such as Verify Availability or Take Order, consume a resource called Employee Service. In fact, this resource is increased as employees render their services to the organization and is simultaneously decreased as those services are employed in the performance of a task. In situations where employee services are tracked to specific projects or products, this entity would provide meaningful data and should be included in the REA model. Since we can presume that this is not the case for Apex Supply, Employee Services will not be modeled.

In the Apex revenue cycle, economic events change only two resources. The Ship Product event reduces the inventory resource and the Receive Cash event increases the cash resource. The Verify Availability and the Take Order support events are also associated with inventory, but they do not change it. The resource and associated event entities are presented in Figure 10-6.

FIGURE 10-6 **REA Model Showing Events and Related Resources and Agents**



Step 3. Identify the Agent Entities

Each economic event entity in an REA diagram is associated with at least two agent entities. One of these is an internal agent and the other is an external agent. The external agent associated with all four events in the Apex case is Customer. In addition, four internal agents are associated with the four events:

1. The customer services clerk, who participates in the Verify Availability event.
2. The sales representative, who participates in the Take Order event.
3. The shipping clerk, who participates in the Ship Product event.
4. The cash receipts clerk, who participates in the Receive Cash event.

Note that each of these internal agents is in fact an instance of the Employee entity type. For illustration purposes on the REA diagram, we identify each instance of Employee (for example, Sales Representative or Shipping Clerk) as a separate entity. The database that ultimately emerges from this model, however, will employ a single Employee table, and each instance shown in the model will be a row in that table. Figure 10-6 illustrates the relationship between the events and associated external and internal agents in the Apex case.

Step 4. Determine Associations and Cardinalities between Entities

We discussed in detail in Chapter 9 the topics of entity association and cardinality. This section assumes familiarity with these topics, which are only briefly reviewed.

Association is the nature of the relationship between two entities, as the labeled line connecting them represents. **Cardinality** (the degree of association between the entities) describes the number of possible occurrences in one entity that are associated with a single occurrence in a related entity. Four basic forms of cardinality are possible: zero or one (0,1), one and only one (1,1), zero or many (0,M), and one or many (1,M).

Figure 10-7 presents three alternative methods for presenting cardinalities in an REA diagram. Alternative 1 presents the crow's foot notation method discussed in Chapter 9. The example illustrates that a single occurrence (record) in Entity A is associated with zero or many occurrences in Entity B. Thus the lowest possible cardinality is zero and the highest is many. Looking in the other direction, the notation states that a single occurrence in Entity B is associated with one and only one occurrence in Entity A. Sometimes lower and upper cardinality are explicitly written on the association line between the entities as shown in Alternative 2 in the figure. A shorthand version of this is presented as Alternative 3, which shows only the upper cardinality and presumes the lower cardinality to be zero. The upper cardinalities for each entity define the overall association. For example, the entities in Figure 10-7 are said to have a 1:M association. Other possible associations are 1:1 and M:M.

Figure 10-8 presents a revised data model for Apex. Notice that it has been simplified for better readability by eliminating redundant instances of the Customer and Inventory entities that were depicted in Figure 10-6. In addition, Figure 10-8 shows the association

FIGURE 10-7 **Alternative Techniques for Representing Cardinality**

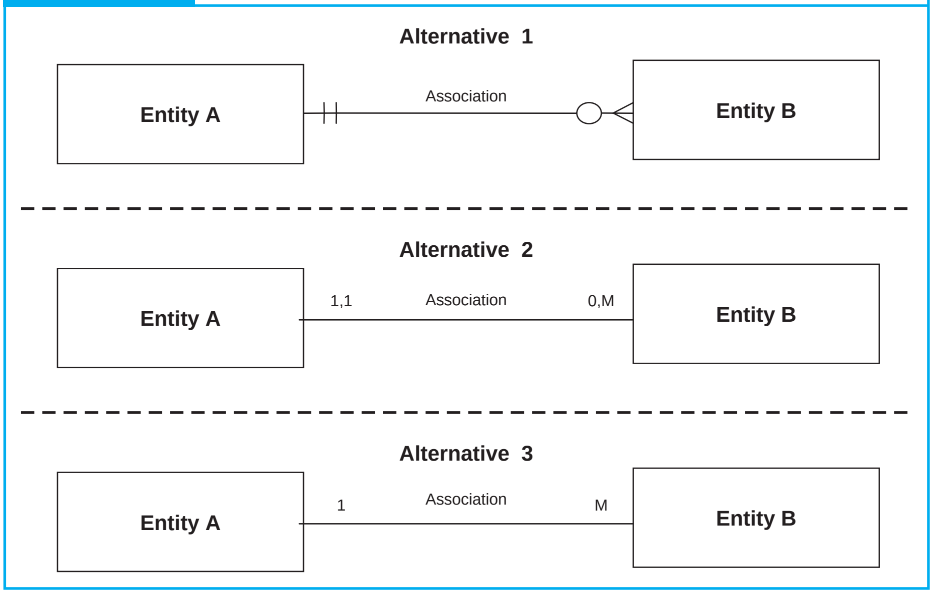
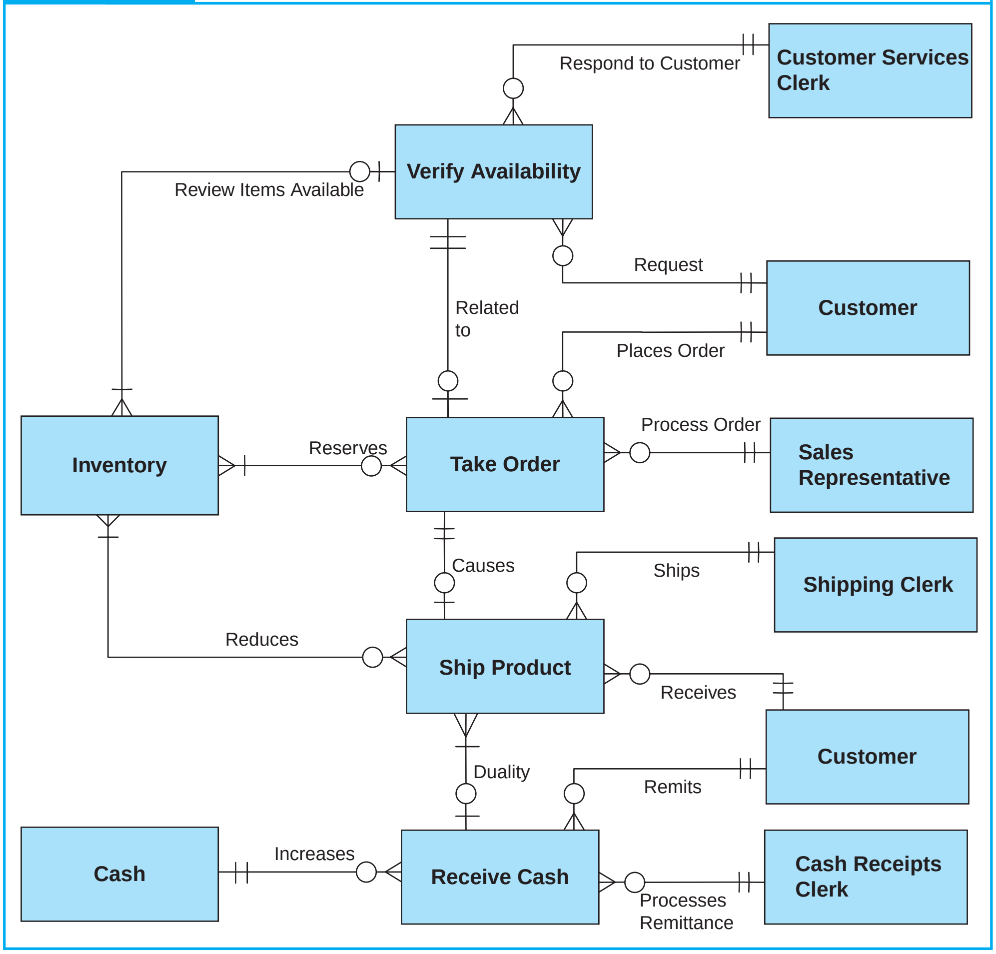


FIGURE 10-8 **Associations and Cardinality in an REA Diagram**



and cardinality between entities using the crow's foot notation method. Cardinality reflects the business rules that are in play for a particular organization. Sometimes the rules are obvious and are the same for all organizations. For example, the normal cardinality between the Customer and Take Order entities are 1,1 and 0,M. This signifies that a particular customer may have placed zero or many orders during the sales period and that each order is for only one customer. The association between these entities is 1:M and would never be 1:1 since this would mean that the organization restricts each customer to an upper limit of only one order, which is illogical. The association between internal agents and event entities follows this same pattern. An organization would expect its employees to participate in many events over time, not just one. Most of the cardinalities in Figure 10-8 reflect rules that are self-explanatory. A few points that need further explanation are presented next.

Cardinality between the Verify Availability and Take Order Entities. Each occurrence of the Verify Availability entity is the result of a customer inquiry. We know from the case description, however, that not all inquiries result in a customer order. On the other hand, we will make the simplifying assumption that each Take Order occurrence is the result of an inquiry. The cardinality on the Take Order side of the relation, therefore, is 0,1. On the Verify Availability side, it is 1,1.

Cardinality between the Take Order and Ship Product Entities. The 0,1 cardinality on the Ship Product side of the relation reflects the timing difference between orders taken and shipped. Since sales are not processed instantly, we can assume that an order will exist (occurrence of Take Order) that has not yet been shipped (no occurrence of Ship Product). Furthermore, an order that is canceled before being shipped would also result in no Ship Product record being created.

Cardinality between the Ship Product and Receive Cash Entities. Business terms of trade and payment policies vary greatly. Companies that make credit sales to consumers often accept partial payments over time. This would result in many cash receipts occurrences for a single shipment occurrence. On the other hand, companies whose customers are other businesses typically expect payment in full when due. Business customers, however, may consolidate several invoices on a single cash payment to reduce check writing. Since the Apex company is a wholesaler that serves business customers, we will assume that debts are paid in full (no multiple partial payments) and that Apex customers may pay for multiple shipments with a single cash receipt. The cardinality in Figure 10-8 reflects this business rule.

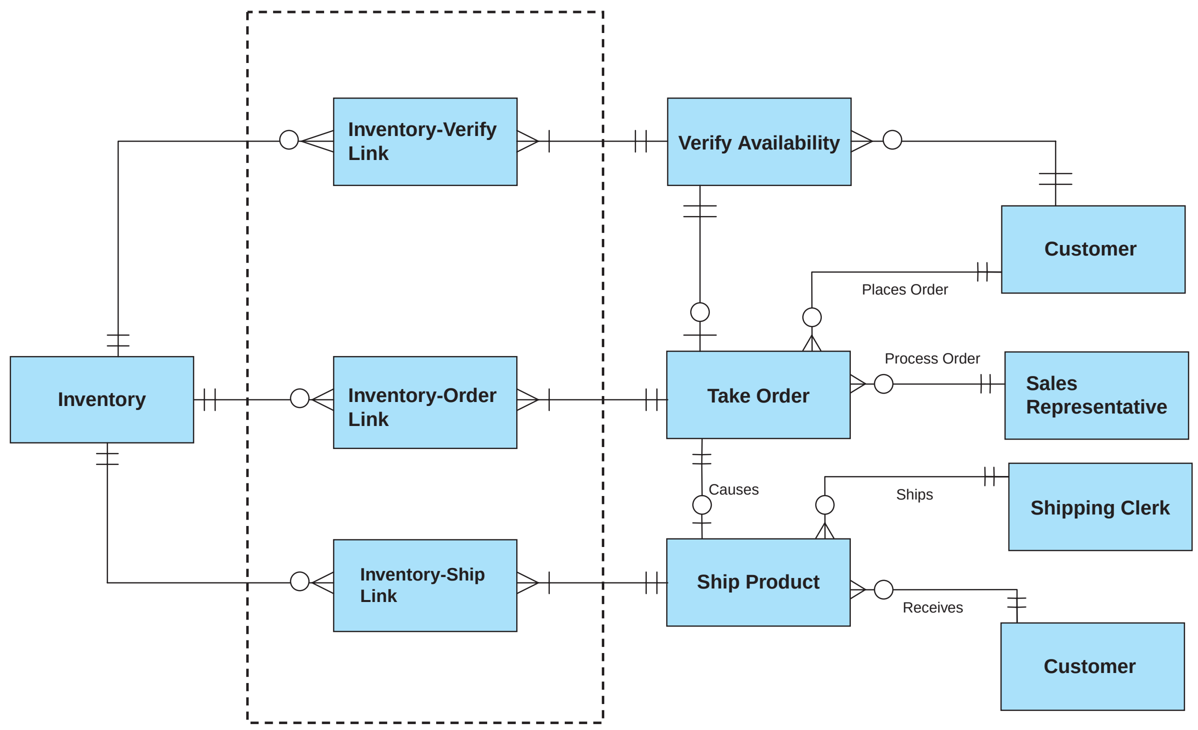
Cardinality between the Cash and Receive Cash Entities. The cash resource of an organization is comprised of several different accounts, such as the general operating account, payroll imprest account, petty cash, and so on. These are consolidated for financial reporting into a single account, but are used and tracked separately. The cardinality depicted in this relationship implies that cash is received from many customers and is deposited into one account.

Many-to-Many Associations. The model in Figure 10-8 depicts three examples of M:M associations. The first of these is between the Verify Availability and Inventory entities. A 1,M cardinality exists at the Inventory end of the association and a 0,M cardinality lies at the Verify Availability end. This suggests that a particular customer query could involve one or many items of inventory, and each item may have been queried zero or many times in the period. The second M:M association exists between the Take Order and Inventory entities. A 1,M cardinality exists at the Inventory end of the association and a 0,M cardinality is at the Take Order end. This means that a particular order may contain one or many different items of inventory and that a particular item may have never been ordered (perhaps a new product) or may have been ordered many times during the period. A similar situation exists between the Ship Goods and Inventory entities. In each of these cases the upper cardinalities of M creates an M:M association, which we know from Chapter 9 must be reconciled. These situations are the result of repeating group data that need to be normalized before implementing the model in a relational database.[2] The solution is to create three link tables that contain the primary keys of the associated tables. The link tables will also contain details pertaining to items queried, the orders taken, and the products shipped.

When modeling traditional ER diagrams, it is often convenient to include the link tables in the model (as in Chapter 9) so that it reflects closely the actual database. The inclusion of link tables in an REA diagram, however, creates a conflict with the rule that an event entity should be connected to at least one resource and at least two agent entities. Figure 10-9 shows how

2 See Chapter 9 and its appendix for a complete discussion about normalizing repeating group data.

FIGURE 10-9 Link Tables in an REA Diagram



a portion of the Apex REA diagram would appear when link tables are inserted. Although link tables are a technical requirement for implementing an M:M association in a relational database, they are not a technical requirement for modeling the database. Including the link table in an REA diagram disrupts its visual integrity and adds little to one's understanding of the conceptual model. Ultimately, during implementation, the database designer will create the link tables. Indeed, the database cannot function without them. For REA diagramming purposes, however, the link tables need only be implied via the M:M associations.

View Integration: Creating an Enterprise-Wide REA Model

The view modeling process described in the previous section produced an individual REA model of the revenue cycle for Apex Supply. This section explains how multiple REA diagrams, each created in its own view modeling process, are integrated into a single global or enterprise model. The section then explains how the enterprise model is implemented into a relational database and user views constructed. The **view integration** process involves three basic steps:

1. Consolidate the individual models.
2. Define the primary keys, foreign keys, and attributes.
3. Construct the physical database and produce user views.

Step 1. Consolidate the Individual Models

Since Apex is a wholesale supply company with no production facilities, model consolidation for them will include the previously developed revenue cycle model (Figure 10-8) and the expenditure cycle models for purchases/cash disbursements and payroll illustrated in Figure 10-10 and Figure 10-11, respectively. A brief explanation of the resources, events, agents, and cardinalities for two expenditure cycle models is provided next.

Purchases and Cash Disbursement Procedures

Figure 10-10 shows three event entities in Apex's purchases and cash disbursement system. The first of these, the Order Product entity, is a support event that does not directly increase the Inventory (resource) entity. Upon recognizing the need for inventory, which sales to customers (revenue cycle) depleted, the purchasing clerk (internal agent) selects a supplier (external agent) and places the order. This act does not constitute an economic event, but is a commitment to buy. The link from the event entity to the Inventory entity indicates that the records will be adjusted to show that the items in question are on order.

FIGURE 10-10 REA Diagram of Purchases and Cash Disbursement Procedures

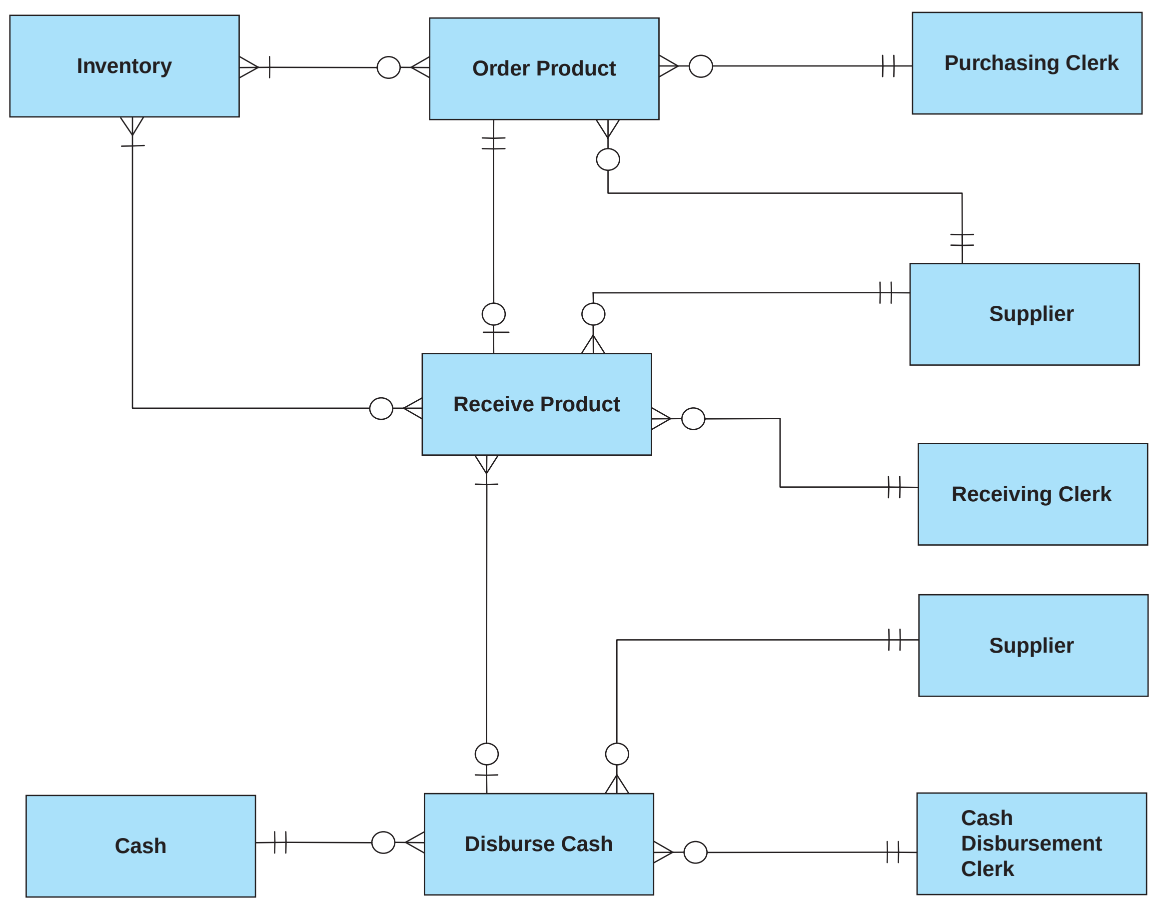
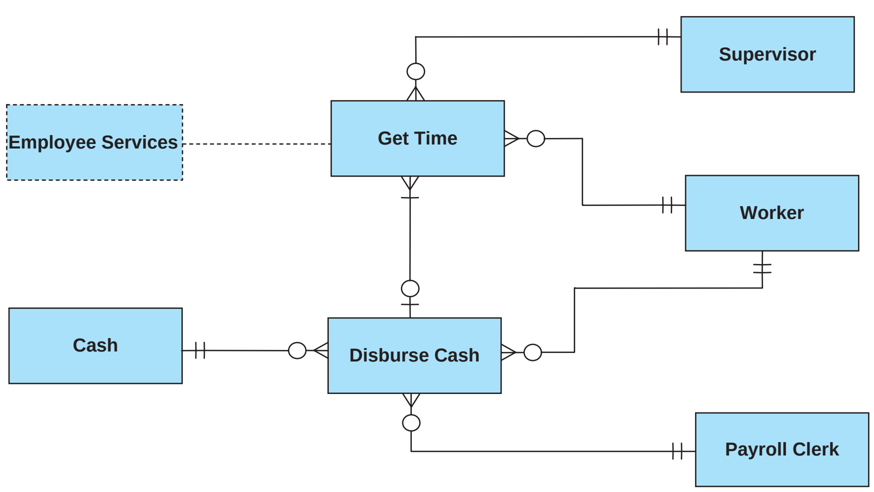


FIGURE 10-11 REA Diagram of Payroll Procedures



The quantity on hand, however, will not be increased at this time. The on-order information will prevent items from being accidentally reordered and will assist customer service clerks in advising customers as to the status of inventory and expected due dates for out-of-stock items. The 1:M association between Supplier and Order Product indicates that each order goes to only one supplier and that a particular supplier may have received zero or many orders during the period.

The second event entity is Receive Product, which is an economic event that causes a change in an economic resource. This is the receive half of the exchange and increases inventory. Goods are received from the supplier and the receiving clerk processes them. This involves counting, inspecting, transporting the products into the warehouse, transferring title to Apex, and updating the inventory records. The 0,1 cardinality in the association between the Order Product and Receive Product entities implies that at any point in time, an order may exist (occurrence of Order Product) that has not yet been received (no occurrence of Receive Product).

The third event represented in the diagram is Disburse Cash. This is the economic event that constitutes the give half of an economic exchange. In this case, it causes the Cash resource to be decreased. The 1:M association with the Supplier entity implies that each disbursement is made to only one supplier, but each supplier may receive zero or many disbursements during the period. The 1:M association between Disburse Cash and Receive Product implies that each product receipt is paid in full (no multiple partial payments), but many receipts may be combined and paid with a single disbursement to reduce check writing.

Notice that M:M associations exist between the Order Product and Inventory entities and between the Receive Product and Inventory entities. These illustrate that orders placed with suppliers and received from them may contain one or many items. From the opposite side, these associations signify that each item of inventory may have been ordered and received zero or many times in the period. As previously discussed, each M:M association needs to be resolved by adding a linking entity. Tables for the linking entities will ultimately be created in the database, but the entities will not be included in the REA diagram. Keep in mind also that the internal agents are represented in the REA diagram as separate entities. This is done to illustrate more clearly their respective roles. In reality, these agents are instances of the Employee entity and will be collapsed into a single Employee table in the final database.

Payroll Procedures

The REA diagram in Figure 10-11 describes the data model for Apex Supply's payroll procedures. The model consists of only two economic events: Get Time and Disburse Cash. The Get Time event is the receive half of the economic exchange. This involves a worker (internal agent) giving up his or her time, which is represented by the Employee Services resource. The supervisor (external agent) assumes control of the resource. Unlike the tangible economic resources of cash and inventory, time does not have a stock flow element and cannot be stored. The Get Time event increases time, and various task performance events simultaneously decrease time. Earlier in the chapter, the Employee Services resource was discussed as a possible resource to be modeled in the Apex Supply database. In situations where employee services are directly tracked to products produced or services rendered to clients (that is, consulting, legal services, or public accounting), it makes sense to model this resource. Since Apex does not track employee time to such activities as individual customers served or orders taken, transforming this entity into a physical database table serves no purpose. To maintain consistency with the REA modeling convention that each event must be linked to a resource, however, Employee Services is included in Figure 10-11 as a shadow resource (dotted lines) only. It will not be not be modeled in the final enterprise-wide REA diagram.

The Get Time event captures the daily time-giving instances of employees through a timekeeping mechanism such as an electronic time clock. For salaried employees, the time-capturing process may simply involve the passage of time. The zero cardinality in the associations between the Get Time and the Worker and Supervisor entities reflects the possibility that some employees may not have contributed time during the period. This would include, for example, new employees or employees on sick leave.

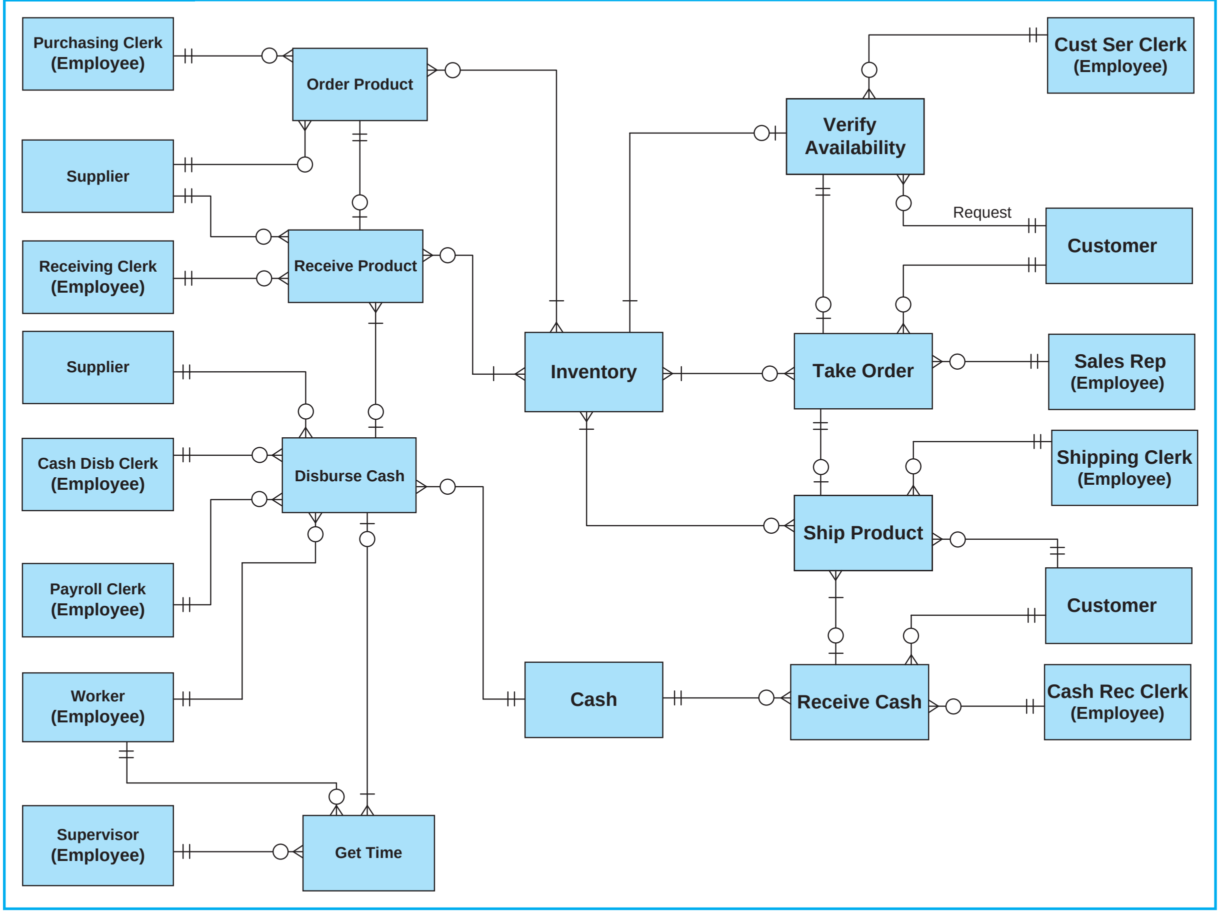
The Disburse Cash event is the give half of the economic exchange. This involves distributing cash to an employee (now the external agent) for services rendered. The payroll clerk (internal agent) participates in this event, which reduces the cash resource. The association between the Disburse Cash and Get Time events reflects the timing differences between employees giving up their time and receiving payment for it, since they are usually not paid daily. Typically, employees work for a week, two weeks, or even a month before getting paid. Therefore, the 1,M cardinality on the Get Time side of the association implies that at least one and possibly many instances of Get Time will exist for each instance of Disburse Cash. The 0,1 cardinality on the Disburse Cash side of the association implies that at a point in time (midweek), a Get Time instance will exist that has not yet been paid. Each Get Time instance, however, is paid only once.

Merge Individual REA Diagrams

With the individual REA diagrams created and explained, we are now ready to consolidate them into a single enterprise-wide diagram (see Figure 10-12). By flipping the expenditure cycle diagrams to create a mirror image effect, the common resources of Inventory and Cash are centered in the diagram. These are flanked by two constellations of events, which increase and decrease them. The agents form periphery constellations in the diagram.

To simplify the diagram, redundant event, agent, and resource entities have been collapsed into a single entity where possible. For example, the Disburse Cash event, which is an element of both the Payroll and Purchase/Cash Disbursement procedures for Apex

FIGURE 10-12 Integrated REA Diagram



Supply is represented only once in the consolidated model. Also, the Cash and Inventory entities are present only once on the consolidated diagram. To maintain perspective as to the roles played by internal agents, they are depicted as individual entities rather than collectively as Employee. Finally, to avoid crossing association lines between entities, the Supplier and Customer agents appear more than once in the diagram.

Step 2. Define Primary Keys, Foreign Keys, and Attributes

With the data model constructed, we are now ready to design the relational database tables. This involves determining primary keys, assigning foreign keys, and defining the attributes of the tables. A separate table will be constructed for each valid entity in the REA integrated diagram in Figure 10-12. This will require 18 tables, which are explained below:

- The 10 internal agents represented in Figure 10-12 will be collapsed into a single Employee table.
- The two external agents (Customer and Supplier) will each require a separate table.
- The two resources Inventory and Cash will each be a table.

- The eight events will require a table each.
- The five M:M relations represented in the diagram will each require a linking table.

Rules for Primary Keys and Attributes. Table 10-1 presents the 18 tables in Apex's database along with their primary keys, foreign keys, and attributes. The determination of primary keys and attributes comes from an understanding of each table's purpose, which results from a detailed analysis of user needs. The database designer should select a primary key that logically and uniquely defines the nonkey attributes in the table. In some cases, this is accomplished with a simple sequential code such as an Invoice Number, Check Number, or Purchase Order number. In other situations, block codes, group codes, alphabetic codes, and mnemonic codes are better choices. We discussed the advantages and disadvantages of various coding techniques in detail in Chapter 8.

Some table attributes are common to all organizations and can be derived from common sense and adherence to best practices. Other attributes are unique to specific applications and can be derived only from thorough and detailed analyses of individual user views. Each attribute assigned to a table should, however, appear directly or indirectly (a calculated value) in one or more user views. If data stored in a table are not used in a document, report, or a calculation that is reported in some way, then it serves no purpose and should not be part of the database.

Rules for Foreign Keys. The degree of association between tables (that is, 1:1, 1:M, or M:M) determines how foreign keys are assigned. We discussed the key-assignment rules for linking tables in Chapter 9, which are briefly reviewed in this section.

Keys in 1:1 Associations. In 1:1 associations, one side of the association will typically have a minimum cardinality of zero. When this is the case, the primary key of the table with the 1,1 cardinality should be embedded as a foreign key in the table with the 0,1 cardinality. Reversing this rule will create a table structure in which the 1,1 cardinality table contains instances of foreign keys with a null (blank) value. Although such a link will work, it is a poor table design that can lead to inefficiencies and possible processing errors. By following the rule, however, all foreign key values in the table on the 0,1 cardinality side of the association will be non-null. For example, we can see from Table 10-1 that the primary key for the Verify Availability table (Inquiry Number) is assigned as a foreign key to the Take Order table.

Keys in 1:M Associations. Where a 1:M association exists between tables, the primary key of the 1 side is embedded in the table of the M side. For example, the primary key of the Employee table (Employee Number) has been assigned as a foreign key to the Verify Availability, Take Order, and Ship Product tables.

Keys in M:M Associations. Tables in an M:M association cannot accept an embedded foreign key from the related table. Instead, the database designer must create a separate link table to contain the foreign keys. By inserting a link table between the original tables, the M:M association is transformed into two 1:M associations (see Figure 10-9). The link table can now accept the primary keys of the tables on the 1 side of the two new associations. This process results in a combined (composite) key that serves as a primary key for defining the attributes (if any) in the link table. Each component of the composite key also serves also as a foreign key for locating related records in the associated tables. Five

TABLE 10-1 Tables, Keys, and Attributes in Apex Database

Table Name	Primary Key	Foreign Key(s)	Attributes
Inventory	Item Number		Description, Warehouse Location, Quantity on Hand, Reorder Point, On-Order Quantity, Available for Sale, Supplier Number, Unit Cost, Retail Price, Turnover Rate, Lead Time, Usage Rate, Economic Order Quantity, Stock-Out History, Scrap History
Cash	Account Number		Balance
Verify Availability	Inquiry Number	Customer Number Employee Number	Date, Start Time, End Time
Take Order	Order Number	Inquiry Number Customer Number Employee Number	Order Date, Promised Date, Terms of Trade
Ship Product	Invoice Number	Order Number Customer Number Employee Number	Invoice Amount, Shipped Date, Due Date, Close Date
Receive Cash	Remittance Number	Customer Number Employee Number Account Number	Customer Check Number, Date, Amount
Order Product	Purchase Order Number	Supplier Number Employee Number	Order Date, Expected Delivery Date, Expected Total Price
Receive Product	Receiving Report Number	Supplier Number Employee Number Purchase Order Number Check Number	Date Received, Carrier, Total Amount Due, Due Date
Disburse Cash	Check Number	Supplier Number Cash Disb Clerk (EMPL) Worker (EMPL) Payroll Clerk (EMPL) Account Number	Amount, Date
Get Time	Time Card Number	Check Number Supervisor (EMPL) Worker (EMPL)	Pay Period, Day1-in, Day1-out, Day2-in, Day2-out, ... Day7-in, Day7-out
Customer	Customer Number		Name, Address, Line of Credit, Available Credit, Current Balance, Last Payment Date
Supplier	Supplier Number		Name, Address, Terms of Trade, Vendor Lead Time, Carrier Used, On-Time Delivery Record, Incomplete Shipments Record, Damaged Shipments Record, Price Disputes Record
Employee	Employee Number		SSN, Name, Address, Date of Birth, Job Title, Data Hired, Pay Rate, Vacation Time Accrued
Inventory-Verify Link	Item Number Inquiry Number		Quantity Requested, Quantity on Hand, Sale, Comments
Inventory-Order Link	Item Number Order Number		Quantity Ordered
Inventory-Ship Link	Item Number Invoice Number		Quantity Shipped, Actual Price
Ord-Prod-Inven Link	Item Number Purchase Order Number		Order Quantity
Rec-Prod-Inven Link	Item Number Receiving Report Number		Quantity Received, Actual Unit Cost, Condition

link tables are presented in Table 10-1: Inventory-Verify Link, Inventory-Order Link, Inventory-Ship Link, Ord-Prod-Inven Link, and Rec-Prod-Inven Link.

Normalized Tables. The assignment of primary keys and attributes to relational tables must always comply with the rules of normalization discussed in Chapter 9. Recall that improperly normalized tables exhibit negative operational symptoms called anomalies, including the update anomaly, the insertion anomaly, and the deletion anomaly. One or more of these anomalies will exist in tables that are not normalized to the **third normal form (3NF)** level. These anomalies are caused by structural problems within tables known as repeating groups, partial dependencies, and transitive dependencies. Normalization involves systematically identifying and removing these dependencies from the table(s) under review. Tables in 3NF will be free of anomalies and will meet two conditions:

1. All nonkey attributes will be wholly and uniquely dependent on (defined by) the primary key.
2. None of the nonkey attributes will be dependent on (defined by) other nonkey attributes.

The database tables in Table 10-1 are in 3NF, but contain only minimal attributes. Keep in mind that databases are not static. As user needs change and additional user views are developed, additional attributes and perhaps additional tables may need to be included in the database. These additions must comply with normalization rules to preserve the structural integrity of tables and avoid anomalies. For a complete discussion of anomalies, dependencies, and normalization techniques, please review the appropriate sections of Chapter 9 and its appendix.

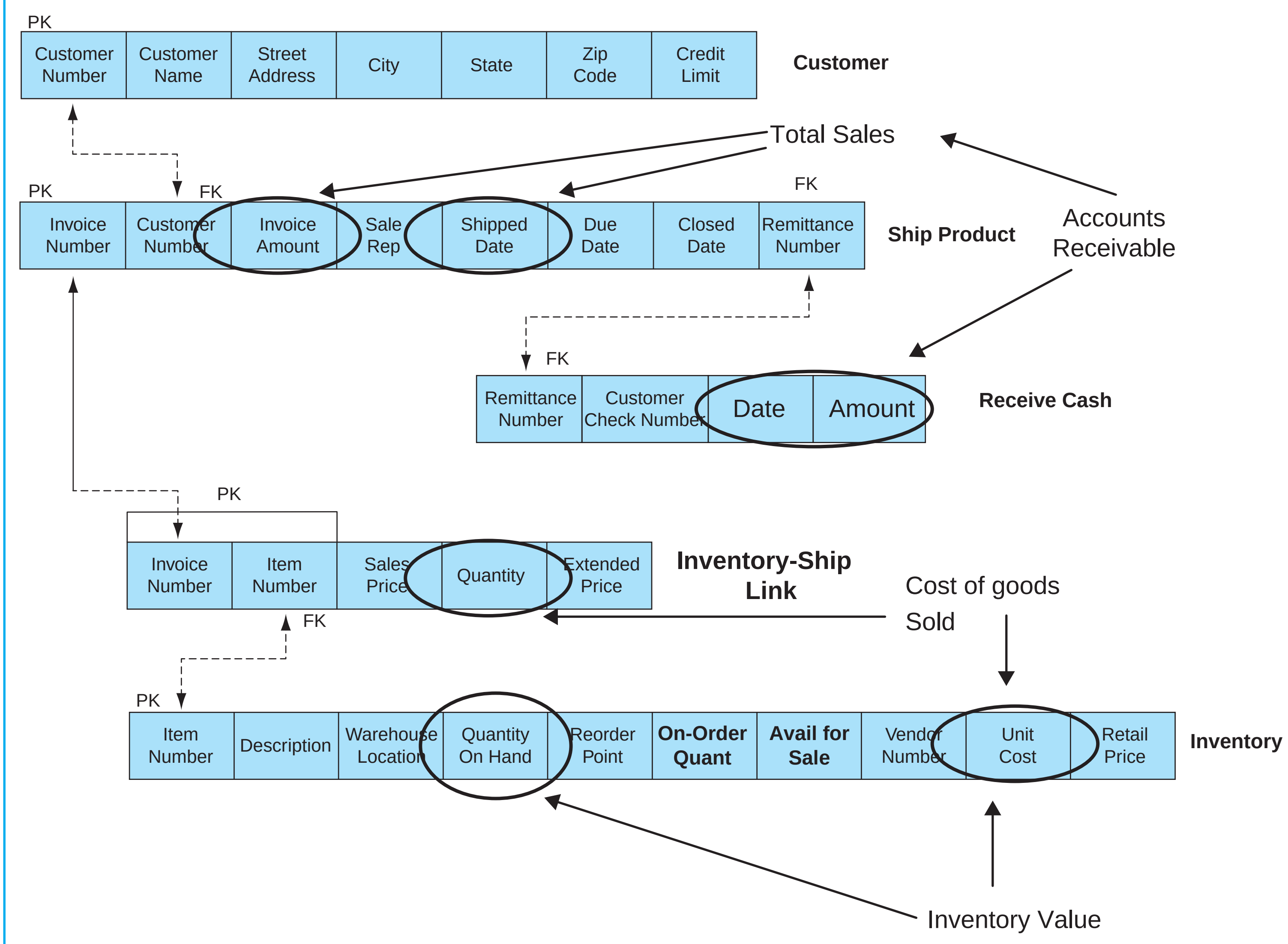
Step 3. Construct Physical Database and Produce User Views

At this point, the database designer is ready to create physical relational tables based on the descriptions in Table 10-1. Once the tables have been constructed, some of them must be populated with data. Resource and agent tables must be initialized with data values such as inventory quantities on hand, customer names and addresses, and employee data. The new system will start operations with beginning values for the attributes of these tables. In contrast, event tables start out empty and will be populated through actual transaction processing activities.

The resulting database should be rich enough to support the information needs of all users of the system being modeled. This includes the needs of accountants, operations personnel, and management. The reports, computer screens, and documents that constitute these views are derived from structured query language (SQL) commands and computer programs that access the normalized tables in the database and navigate between them using the foreign keys as links. In this section, we present some examples of the reports that can be produced from rich event tables.

Producing Financial Statements and Other Accounting Reports. In a traditional system, financial statements are typically prepared from general ledger accounts, whose values are derived from journal voucher postings. Accounting artifacts, including journals, ledgers, and double-entry accounting, however, are not entities in an REA model. Instead, these traditional accounting mechanisms are reproduced from the event tables. To illustrate, Figure 10-13 presents the structures for several relational tables in the Apex database. These table structures correspond to the tables listed in Table 10-1, but

FIGURE 10-13 Calculating Accounting Numbers from REA Tables



some of the attributes have been omitted to simplify the figure. The figure demonstrates how financial statement accounting figures can be constructed from underlying event data. The calculations are:

Total Sales = The sum of the Invoice Amount attribute in the Ship Product table for all items shipped on or before the year-end closing date.

Accounts Receivable = Total Sales minus the sum of the Receive Cash table's Amount attribute for all remittances received on or before the year-end closing date.

Cost of Goods Sold = Sum of Quantity sold in the Inventory-Ship Link table multiplied by the Unit Cost attribute in the Inventory table.

Inventory = Quantity On Hand attribute multiplied by Unit Cost attribute in the Inventory table.

Accounting figures extracted in this way from REA tables can be used to prepare income statements, balance sheets, and even journal entries as illustrated with the journal voucher report in Figure 10-14.

Producing Management Reports from REA Tables. A key objective of REA is to create a database capable of supporting multiple user views. This section illustrates examples of nonaccounting user reports that Apex Supply could produce from their database. Figure 10-15 depicts an inventory status report that their purchasing agent would use. This report identifies items to be ordered and the respective suppliers. The data for this report come from the Inventory and Supplier tables in Table 10-1. Figure 10-16 is a sales activity report organized by customer and product, which the sales manager would use. The report is constructed from data in the Customer, Ship Product, Inventory-Ship link, and Inventory tables. Figure 10-17 is a customer inquiry report. The purpose of this report is to track customer inquires against actual sales. The report indicates how much time is spent on each customer inquiry and whether it led to a sale. The Customer, Verify Availability, Inventory-Verify Link, Inventory, and Take Order tables provide the data for the report.

FIGURE 10-14 **Reproducing Journal Entries from REA Tables**

Journal Voucher Report

JV Num	Date	Title	Acct Num	Debit	Credit
1	2/14/07	Cash Acct Rec Sales	101 103 401	1000 2000	 3000
2	2/14/07	Cost of Goods Sold Inventory	501 108	2500	 2500
⋮	⋮	⋮	⋮	⋮	⋮

FIGURE 10-15 Inventory Status Report

Item Number	Description	Quantity On Hand	Reorder Point	Supplier Number	Name	Address	Tele Num
At78	Bracket	100	150	22	Ozment Sup	123 Main St.	555–7895
Y24	3 Way Sw	95	150	24	Buell Co.	2 Broadhead	555–3436
TW23	120 V outlet	100	150	27	B&R Sup	Westgate Mall	555–7845
RT12	Toggle switch	440	450	22	Ozment Sup	123 Main St.	555–7895
Pp56	Gasket	400	450	24	Buell Co.	2 Broadhead	555–3436
qr2	Meter	442	450	28	Harris Manuf	24 Linden St.	555–3316
yu88	Brace	10	10	22	Ozment Sup	123 Main St.	555–7895

FIGURE 10-16 Constructing a Management Sales Report from REA Tables

Apex Sales Report

Customer Number : 19321
Customer Name : ABE Electric
Address : 520 Main St.,City

Invoice #	Date	Invoice Total	Part Num	Quantity	Unit Price	Ext'd Price
12390	11/11/07	$850	Y24	5	$20	$100
			T W23	10	50	500
			Ey43	25	10	250
12912	11/21/07	$300	rw34	10	$30	$300

Customer Total: $1,150

* * * * * * * * * * * * * * * * * * * * * * * * * *

Customer Number : 19322
Customer Name : ARK Electronics
Address : 2289 Elm St., City

Invoice #	Date	Invoice Total	Part Num	Quantity	Unit Price	Ext'd Price
12421	11/13/07	$1,000	TW23	10	$20	$200
			Fr23	2	50	100
			LI45	7	100	700
12901	11/20/07	$500	TE67	10	$30	$300
			Ht12	10	20	200

Customer Total: $1,500

* * * * * * * * * * * * * * * * * * * * * * * * * *

Next Customer

•
•
•

Next Customer

FIGURE 10-17 Customer Inquiry Report

Customer Inquiry Report 2/14/07 – 7/14/07										
Inq Num	Date	Cust Num	Start Time	End Time	Product	Quantity Requested	Quantity On Hand	Sale	Emp Num	Comments
483	2/14	19334	9:22	9:30	TW23	5	61	yes	5	None
					TW67	18	4	no	7	Look elsewhere
					RB14	20	80	no	3	Too expensive
484	2/14	18325	9:38	9:42	HT12	8	22	yes	7	None
485	2/14	12325	10:03	10:20	NW34	1	6	no	7	Look elsewhere

REA and Value Chain Analysis

The competitive advantages to organizations that adopt the REA approach are most clearly seen from the perspective of the **value chain**. These are the activities that add value or usefulness to an organization's products and services. To remain competitive, organizations must differentiate between their various business activities, prioritizing them on the basis of their value in achieving organizational objectives. This means being adaptable and responsive to changes in the environment, including their relationships with suppliers, customers, and other external entities that influence performance. Modern decision makers need information systems that help them look beyond their internal operations to those of their trading partners.

One approach adopted for this purpose is known as **value chain analysis**. This analysis distinguishes between primary activities and support activities: primary activities create value; support activities assist in the achievement of the primary activities. By applying value chain analysis, an organization can look beyond itself and maximize its ability to create value, for example, by incorporating the needs of its customers in its products or accommodating the flexibility of its suppliers in scheduling its production.

Traditional information systems are not well suited to supporting value chain activities. Organizations that have applied value chain analysis have generally done so outside the traditional accounting information system by providing such information separately to the decision makers. Frequently, this involved the creation of separate information systems, which results in data redundancy, data concurrency, and system integration problems. As a single information system framework capable of capturing generic and fine-grained data, REA can overcome these problems and is capable of providing the following advantages.

1. The REA approach to modeling business processes helps managers focus on the key elements of economic events and identify the non-value-added activities that can

be eliminated from operations. Improving the operational efficiency of individual departments thus generates excess capacity that can be redirected to increase the overall productivity of the firm.

2. The storage of both financial and nonfinancial data in a common database reduces the need for multiple data collection, storage, and maintenance procedures.
3. Storing financial and nonfinancial data about business events in detailed form permits a wider range of management decisions by supporting multiple user views.
4. The REA model provides managers with more relevant, timely, and accurate information. This will translate into better customer service, higher-quality products, and flexible production processes.

REA Compromises in Practice

The advantages to operational efficiency, systems integration, and value chain analysis have drawn great attention to REA as a theoretical model for system and database design. As a practical matter, however, larger organizations often compromise the REA model for financial statement reporting purposes. While it is possible to extract traditional financial information from event data (as illustrated in Figure 10-13), doing so from millions of individual event records can be problematic. Instead, most companies implementing an REA model create an event database for operations, planning, and control purposes and maintain a traditional general ledger system separately in the background for financial reporting. Enterprise resource planning (ERP) systems, which are discussed in the next chapter, exemplify the successful integration of event-based and traditional database designs within a single system.

Summary

This chapter examined the REA model as a means of specifying and designing accounting information systems that serve the needs of all users in an organization. It began by defining the key elements of REA. The basic model employs a unique form of an ER diagram called an REA diagram, which consists of three entity types (resources, events, and agents) and a set of associations linking them. The rules for developing an REA diagram were then explained and illustrated in detail.

Each event in an REA diagram is linked to at least one resource and to at least two agents. An important aspect of the model is the concept of economic duality, which specifies that each economic event must be mirrored by an associated economic event in the opposite direction. These dual events constitute the give and receive activities in an economic exchange.

The chapter went on to illustrate the development of an REA database for a hypothetical firm following a multistep process called view modeling. The steps involved are: (1) identify the event to be modeled; (2) identify the resource changed by events; (3) identify the agents participating in events; and (4) determine associations and cardinalities between entities. The result of this process is an REA diagram for a single organizational function. This next section in the chapter explained how multiple REA diagrams (revenue cycle, purchases, cash disbursements, and payroll) are integrated into a global or enterprise-wide model. The enterprise model was then implemented into a relational database structure and user views were constructed. The view integration process involved three steps: (1) consolidate the individual models; (2) define primary keys, foreign keys, and attributes; and (3) construct the physical database and produce the user views.

The chapter concluded with a discussion of how REA modeling can improve competitive advantage by allowing management to focus on the value-added activities of their operations. For financial statement reporting purposes, however, many companies compromise the pure REA model by maintaining a traditional general ledger system.

Key Terms

agents (496)
association (506)
cardinality (506)
duality (499)
economic events (498)
external agent (499)
give event (499)
internal agent (499)
REA diagram (498)
REA model (497)
receive event (499)
resources (498)
semantic models (497)
stock flow (498)
support events (498)
third normal form (3NF) (516)
user view (497)
value chain (503)
value chain analysis (520)
view integration (509)
view modeling (501)

Review Questions

1. What is a user view?
2. What is a semantic data model?
3. What is an REA diagram?
4. What are economic resources?
5. What are economic events?
6. What are support events?
7. What are economic agents?
8. Define duality.
9. What is view modeling?
10. What is represented by the labeled lines connecting entities in an REA diagram?
11. Why are journals and ledgers not modeled in an REA diagram?
12. Define association.
13. Define cardinality.
14. Name the four basic forms of cardinality.
15. What is view integration?
16. List the steps involved in view integration.
17. What is the rule for assigning foreign keys in a 1:1 association?
18. What is the rule for assigning foreign keys in a 1:M association?
19. What is the rule for assigning foreign keys in an M:M association?
20. Define the value chain.

Discussion Questions

1. From the perspective of an organization, explain duality as it relates to the give and receive events of an economic exchange.
2. Explain the relationship between cardinality and association.
3. Discuss the rules for assigning primary keys to database tables.
4. Discuss the rules for linking events to resources and agents in an REA diagram.
5. How are external and internal agents modeled in REA diagrams for transactions that involve purely internal exchanges, such as raw material moving into production?
6. Explain how REA databases are able to support financial statement reporting when they do not employ journals and ledgers.
7. Distinguish between economic events and support events and provide examples of each.
8. Describe the minimum number and type of events that an REA diagram must include.
9. Why are traditional accounting events such as recording a transaction in a journal or posting to ledgers not modeled in REA diagrams?
10. ER diagrams usually include the link tables in the model to resolve M:M associations. REA diagrams typically do not show link tables. Explain.
11. Employee time is a resource that is always used but is not always modeled in an REA diagram. Explain and give examples.
12. When are data in 3NF?

Multiple-Choice Questions

1. The concept of duality means that an REA diagram must consist of
   a. two events—one of them economic and the other support.
   b. two agents—one of them internal and the other external.
   c. two resources—one increased and the other decreased by the same event.
   d. all of the above.
   e. none of the above.
2. Each economic event in an REA diagram is always*:
   a. linked to at least two resource entities.
   b. linked to two external agents.
   c. linked to two internal agents.
   d. linked to another economic event.
   e. linked to a support event.
3. Which of the following are characteristics of economic agents?
   a. They participate in economic events, but do not assume control of the resources.
   b. They participate in economic events, but not in support events.
   c. Internal agents are employees of the company whose system is being modeled.
   d. External agents are not employees of the company whose system is being modeled.
   e. All of the above describe agents.
4. Which of the following is true?
   a. REA diagram entities are arranged in constellations by entity class.
   b. ER diagrams present a static picture of the underlying business phenomena.
   c. Entity names in ER diagrams are always in the noun form.
   d. Events entity names in REA diagrams are in the verb form.
   e. All of the above are true statements.
5. Which of the following events would be LEAST likely to be modeled in an REA diagram?
   a. customer inquiries
   b. sales to a customer
   c. accounts payable
   d. cash
   e. all of these events would be modeled

6. Which of the following associations would most likely describe the relationship between an internal agent and an economic event?
   a. 1:M
   b. 1:1
   c. M:M
   d. 0:M
   e. none of the above
7. Which of the following tables would most likely have a composite key?
   a. Take Order
   b. Ship Goods
   c. Inventory-Ship Link
   d. Cash
   e. none of the above
8. Which of the following associations requires a separate table in the database?
   a. 1:1
   b. 1:M
   c. M:M
   d. all of the above
9. When assigning foreign keys in a 1:1 association
   a. the primary key of each table should be embedded as a foreign key in the related table.
   b. the primary key on the 0,1 side of the relation should be embedded as the foreign key on the 1,1 side.
   c. the primary key on the 1,1 side of the relation should be embedded as the foreign key on the 0,1 side.
   d. a link table must be created to accept the foreign keys of both tables.
   e. none of the above is true.
10. When assigning foreign keys in a 1:M association
   a. the primary key of each table should be embedded as a foreign key in the related table.
   b. the primary key on the 0,M side of the relation should be embedded as the foreign key on the 1,1 side.
   c. the primary key on the 1,1 side of the relation should be embedded as the foreign key on the 0,M side.
   d. a link table must be created to accept the foreign keys of both tables.
   e. none of the above is true.

Problems

1. REA Diagrams

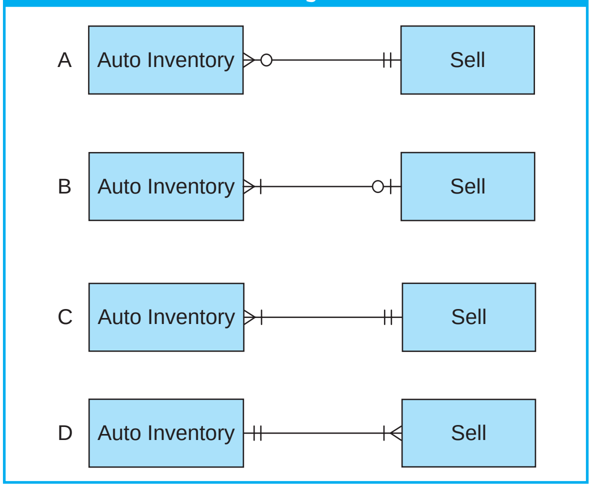
Describe three differences between REA diagrams and ER diagrams.

2. REA Associations

Bentley Restorations Company restores and sells top-end classic and antique automobiles. Most of its customers are private collectors, but some are investors who buy multiple cars and hold them for resale. Bentley extends no credit terms. All sales are for cash.

Required:
Which of the relationships in the opposite column properly models the entity associations for Bentley Restorations? Explain your answer.

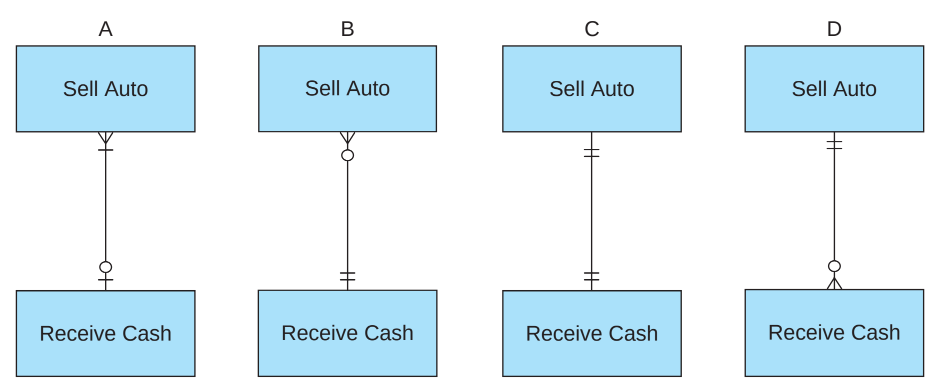
Problem: 2
REA Diagrams



3. REA Associations

Based on the data in Problem 2, which of the following relationships in the next page prop-

Problem: 3
REA Associations



erly models the entity associations for Bentley Restorations? Explain your answer.

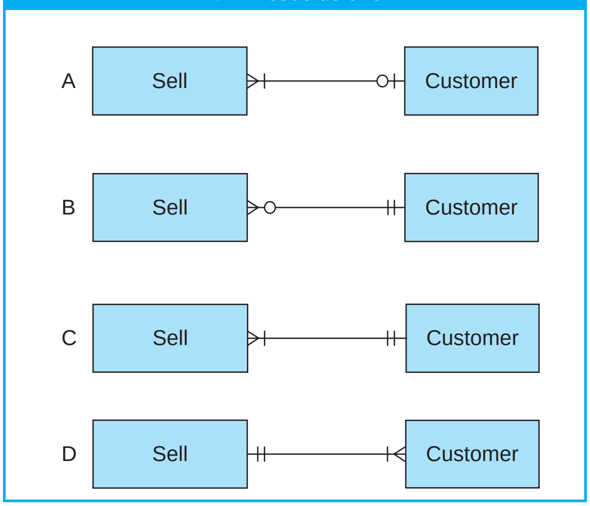
4. REA Associations

Based on the data in Problem 2, which of the relationships below properly models the entity associations for this situation? Explain your answer.

5. REA Model Extract

Prepare an REA model depicting the issuance of raw materials into the manufacturing process. Identify the resource, event, and agent entities. Show the cardinalities in the associations between entities.

Problem: 4
REA Associations



6. REA Model—Horizon Books

Horizon Books is a bookstore in downtown Philadelphia. It carries an inventory of approximately 5,000 books. Customers come in and browse the shelves, select their books, and take them to the cashier. At the cashier's desk, they can also discover whether a particular book is in stock, place orders for books not currently available in the bookstore, and collect and pay for books previously ordered. There are no credit sales. All customers pay for their purchases at the time of purchase.

Required:
Prepare an REA model for Horizon's database. Show all cardinalities in the associations.

7. REA Model—Feinman Computers

Feinman Computers sells desktop computer systems that it manufactures from parts and software that third-party vendors provide. Customers are both private consumers and small businesses. Consumers pay cash or by credit card, but business customers buy on credit. A credit check is made of all new business customers before approving a line of credit. Sales are made online or by a hard-copy order document that customers mail or fax to the company.

When a credit order is received, the sales clerk verifies inventory availability, prepares a sales order and sends the stock release copy to Willy, a warehouse employee who picks the goods and arranges shipment. Willy then prepares the bills of lading and shipping notices. Barb in the billing department receives the shipping notice from Willy and updates the inventory subsidiary ledger to account for the reduction in inventory. Barb files the stock release, prepares the invoice, and mails a copy of it to the customer. Barb then updates the sales journal and then sends the invoice, sales order, stock release, and shipping notice to the accounts receivable department.

Adam in the accounts receivable department files the documents that Barb sent him and updates the accounts receivable subsidiary ledger. Mickey in the mail room receives remittance advices and customer checks sent in payment of accounts. He sends the remittance advice to Adam for posting to the accounts receivable ledger and sends the checks to Carol, the cash receipts clerk. At the end of the day, she prepares a deposit slip and deposits the checks into the company's bank account, files the bank receipt, and updates the cash receipts journal.

Cash sales to consumer customers are handled in a manner similar to the process describe above except that checks or credit card account numbers are submitted with the original order.

At the end of each week, John, an accounting clerk, reconciles all transactions and posts them to the general ledger.

Required:

a. Prepare the REA model of the sales/collection process.
b. Show the cardinalities for all associations.
c. List the tables, keys, and attributes needed to implement this model in a relational database.

8. REA Model—K Cannon, Inc.

K Cannon, Inc., is a manufacturer of portable CD players. The company purchases raw materials such as plastics and computer chips for its conversion cycle. The following describes K Cannon's purchases and payments procedures.

John, the purchasing department clerk, monitors raw materials inventory levels and prepares a purchase requisition when purchases are necessary. These are sent to the purchasing agent, who prepares six copies of a purchase order. Two purchase orders are sent directly to the vendor. One is placed in an open purchase order file in the purchasing department, and one is used to post to the purchases journal. Each week, the purchasing department clerk prepares a journal voucher from the purchases journal and sends it to the general ledger department for posting. The accounts payable and the receiving departments also each receive a copy of the purchase order, which they file temporarily.

Upon receiving the raw materials, the receiving department clerk creates five copies of the receiving report. One copy is sent each to the raw materials warehouse and the accounts payable department. Two copies are sent to the purchasing department, where one is filed and one is used to update the inventory records. The final copy is filed in the receiving department with the purchase order and packing slip. Vendors send their invoices to the accounts payable department, where they are used to update the accounts payable subsidiary ledger.

In the cash disbursements department, Larry receives the information from the accounts payable department, such as the purchase requisition, purchase order, receiving report, and invoice. He then prepares and signs the checks for the suppliers. After preparation of the checks, these supporting documents are sent back to the accounts payable department. Each week, Larry prepares a journal voucher and sends it to the general ledger department for posting.

Required:

a. Prepare the REA model of the purchase cash payments process.
b. Show the cardinalities for all associations.
c. List the tables, keys, and attributes needed to implement this model in a relational database.

9. REA Model—Payroll System

Every two weeks, employees for a manufacturing firm submit their time cards to the supervisor, who reviews and approves them.

They are the submitted to the payroll department. At that time, the human resources clerk also submits a personnel action to the payroll clerk. The payroll clerk enters the information from these source documents into the employee records and then adds the employee hours to a payroll register reflecting employee pay rates, deductions, and job classification. One copy of the payroll register, along with the time cards, is filed in the payroll department, and one copy is sent to the accounts payable department.

Next the payroll clerk sends the employee paychecks to the cash disbursements department. The checks are signed and distributed to the employees by the paymaster. The accounts payable department prepares a cash disbursements voucher. A copy of the voucher and a copy of the payroll register are sent to the cash disbursements department and are then posted to the general ledger. The cash disbursements clerk writes a check for the entire payroll and deposits it in the payroll imprest cash account. A copy of the check, the disbursement voucher, and the payroll register are sent back to the accounts payable department, where they are filed.

Required:

a. Prepare the REA model of the payroll process.
b. Show the cardinalities for all associations.
c. List the tables, keys, and attributes needed to implement this model in a relational database.

10. REA Model—Fixed Asset System

Asset acquisition begins when the department manager recognizes the need to obtain or replace an existing fixed asset. The manager prepares two copies of a purchase requisition; one is filed in the department, and one is sent to the purchasing department. The purchasing department uses the purchase requisition to prepare three copies of a purchase order. One copy of the purchase order is sent to the supplier, another copy is sent to the accounts payable department, and the third copy is filed in the purchasing department. The receiving department receives the assets and packing slip from the vendor and prepares a receiving report. One copy of the receiving report is sent to accounts payable, one is sent to the department manager, and one is sent to the inventory department clerk and used to update the inventory records.

The accounts payable clerk receives the invoice, which she compares to the purchase order and receiving report. The AP clerk inputs the information into the computer terminal, posts the liability, updates the purchase journal, and prints out hard copies of a journal voucher and cash disbursement voucher. The journal voucher is sent to the general ledger department, and the cash disbursements voucher and the supplier's invoice are sent to the cash disbursements department. The purchase order and the receiving report are filed in accounts payable. The cash disbursements clerk prepares and posts a check to the check register using the information from the supplier's invoice and the cash disbursements voucher, and prints a hard copy of the check, which is sent to the vendor. The cash disbursements voucher is sent on to the general ledger department.

The department manager also handles asset maintenance and asset disposal. The manager adjusts the fixed asset inventory subsidiary account balances as the assets depreciate over time. When an asset has reached the end of its useful life, a disposal report is prepared. The department manager sends an asset status summary to the general ledger. The general ledger department clerk reconciles the cash disbursements voucher, the journal voucher, and the asset status summary and posts to the general ledger accounts.

Required:

a. Prepare the REA model of the fixed asset procedures.
b. Show the cardinalities for all associations.
c. List the tables, keys, and attributes needed to implement this model in a relational database.