CHAPTER 4

DOCUMENTING INFORMATION SYSTEMS

LEARNING OBJECTIVES

AFTER READING THIS CHAPTER, YOU SHOULD BE ABLE TO:

- READ AND EVALUATE DATA FLOW DIAGRAMS.
- READ AND EVALUATE SYSTEMS FLOWCHARTS.
- PREPARE DATA FLOW DIAGRAMS FROM A NARRATIVE.
- PREPARE SYSTEMS FLOWCHARTS FROM A NARRATIVE.

To find out what impact the Sarbanes-Oxley Act of 2002 (SOX) has had on the process of documenting business processes and internal controls, we spoke with a Director at PricewaterhouseCoopers LLP and asked her how she was using flowcharting in SOX and other related work. Her response follows:

> Auditors and business advisors at PricewaterhouseCoopers LLP use flowcharts and systems narratives in a variety of engagements, including financial audits, business process reengineering, and security reviews.
>
> The passage of Sarbanes-Oxley has reemphasized the importance of documenting business processes and internal controls. For example, Sarbanes-Oxley Section 404 requires that organizations document internal controls over their financial reporting processes. This mandate requires more extensive documentation than has been prepared in the past. Various people may be involved in preparing this documentation, including financial managers, business process owners, internal auditors, external auditors, and others. Once documented, the client uses the documentation to understand the flow of transactions through the process, identify where controls have been implemented, identify where gaps may exist in the control structure, and define or improve controls to close any gaps.
>
> To comply with Sarbanes-Oxley, the auditors conduct walkthroughs of their clients' systems to understand the process flows and to evaluate the controls over financial reporting. One of my clients has over 3,000 relevant controls. We cannot gain an adequate understanding of how these controls operate without having good documentation; detailed workflows are a key element of these discussions. Obviously, the level of effort put into the first year review would be difficult to sustain. Clients will benefit from using a central, electronic repository for their documentation that allows them to manage changes. Understanding and managing risks associated with change in the internal control structure is a key element to moving forward with an efficient and sustainable internal control framework.[1]

1 Sally Bernstein, Director, PricewaterhouseCoopers LLP, assisted us in the preparation of this.

Synopsis

In this chapter, you will learn to read and prepare documentation that depicts business processes and the controls within those processes. You will learn that data flow diagrams portray business process activities, stores of data, and flows of data among those elements. Systems flowcharts, on the other hand, present a comprehensive picture of the management, operations, information systems, and process controls embodied in business processes. In Chapters 5 and 6, we show you how to read and prepare entity-relationship diagrams. Proficiency with these tools will help you understand and evaluate business processes, information systems, and internal controls.

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Auditors, systems analysts, students, and others use documentation to understand, explain, evaluate, and improve complex business processes, information systems, and internal controls. Let's consider, for example, the order-to-cash process described in Chapter 2. Recall, that this process includes all of the activities associated with receiving a customer order, picking the goods off of a warehouse shelf, packing and shipping the goods, billing the customer, and receiving and depositing the customer's payment. Further, the information system supporting this business process is likely an enterprise system, has a number of PCs connected to it via telecommunications links, is used by dozens of people within and outside the organization, has one or more ERP systems with many modules and perhaps hundreds of programs, and performs functions for virtually every department in the organization. This system processes thousands of business events and hundreds of requests for management information and has people throughout the organization preparing inputs and receiving system outputs. In an e-business environment, this system might be accessed directly, perhaps automatically, by systems and individuals in the organization's supply chain.

For such a system, we require "pictures," rather than a narrative description, to "see" and analyze all the activities, inputs, and outputs. Being able to draw these diagrams demonstrates that we understand the system and can explain the system to someone else. For example, with a systems flowchart, we can understand and analyze document flows (electronic and paper) through the operations, management, and information processes. Perhaps our analysis will lead to system improvements. We are convinced that, after preparing and using systems documentation, you will agree that data flow diagrams, systems flowcharts, and entity-relationship diagrams are much more efficient (and effective) than narratives for working with complex systems. The application of these tools, even to the relatively simple systems depicted in this textbook, should convince you of this.

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In addition to using documentation to understand and improve a system, an organization can use it for other important purposes. For example, documentation is used to explain systems and to train personnel. Also, auditors use documentation to understand systems and to evaluate systems' controls. Management, internal auditors, consultants, and independent auditors have recently all become more engaged in this last activity to comply with Section 404 of the Sarbanes-Oxley Act of 2002.

Introduction

We will begin by showing you how to read data flow diagrams and flowcharts. Next, we will show you how to prepare those diagrams and flowcharts. These documentation tools will be used throughout the remainder of the textbook. If you invest time now to study and practice using these tools, your improved understanding of the following chapters will reward your effort. You cannot achieve this chapter's learning objectives

with traditional study methods; you cannot be a passive observer in these proceedings. You must work along with us as we demonstrate these tools. Further, you must practice these tools to develop your skills.

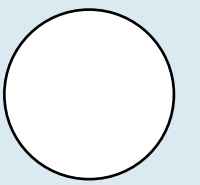
Reading Systems Documentation

The two types of systems documentation considered in this chapter are data flow diagrams and systems flowcharts. In the following section, you will learn how to read and interpret this documentation.

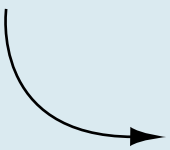
Reading Data Flow Diagrams

A **data flow diagram (DFD)** is a graphical representation of a system. A DFD depicts a system's components; the data flows among the components; and the sources, destinations, and storage of data. Figure 4.1 shows the four symbols used in a DFD. Study these symbols and their definitions before reading on.

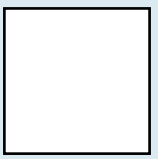
FIGURE 4.1 Data Flow Diagram (DFD) Symbols



Bubble symbol depicts an entity or a process within which incoming data flows are transformed into outgoing data flows.(a)



Data flow symbol represents a pathway for data.



External entity symbol portrays a **source** or a **destination** of data outside the system.

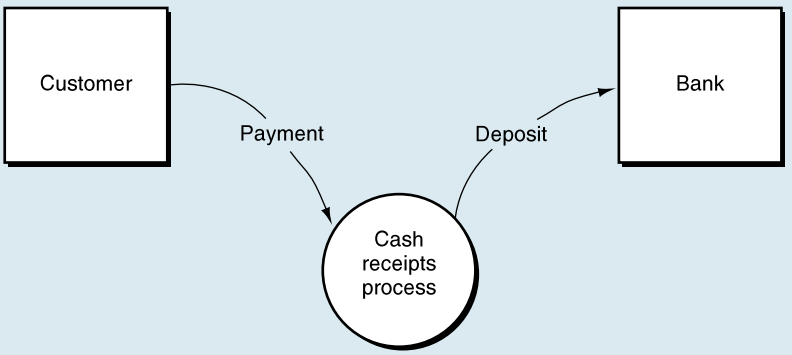
Data store symbol represents a place where data are stored.(b)

NOTES:

a. A bubble can be either an entity on a physical data flow diagram or a process on a logical data flow diagram.

b. The data store symbol may represent a view—a portion—of a larger enterprise database.

FIGURE 4.2 A Context Diagram



Context Diagram

Figure 4.2 is an example of our first type of DFD, the **context diagram**. A context diagram is a top-level, or least detailed, diagram of an information system that depicts the system and all of its activities as a single bubble, and shows the data flows into and out of the system and into and out of the external entities. **External entities** are those entities (i.e., persons, places, or things) outside the system that send data to, or receive data from, the system.[2]

Physical Data Flow Diagram

A **physical data flow diagram** is a graphical representation of a system showing the system's internal and external entities and the flows of data into and out of these entities. An **internal entity** is an entity (i.e., person, place, or thing) within the system that transforms data.[3] Internal entities include, for example, accounting clerks (persons), departments (places), and computers (things). Therefore, physical DFDs specify *where*, *how*, and *by whom* a system's processes are accomplished. A physical DFD does not tell us *what* activities are being accomplished. For example, in Figure 4.3 (pg. 102) you see that the sales clerk receives cash from the customer and sends cash, along with a register tape, to the cashier. So, you see *where* the cash goes and how the cash receipts data are captured (that is, on the register tape), but you don't know exactly *what* was done by the sales clerk.

Note that the physical DFD's bubbles are labeled with nouns and that the data flows are labeled so as to indicate *how* data are transmitted between bubbles. For example, the sales clerk sends Form 66W to bookkeeping. Note that a data store's location indicates exactly *where* (in bookkeeping), and a data store's label indicates *how* (in a blue sales book) a system maintains sales records.

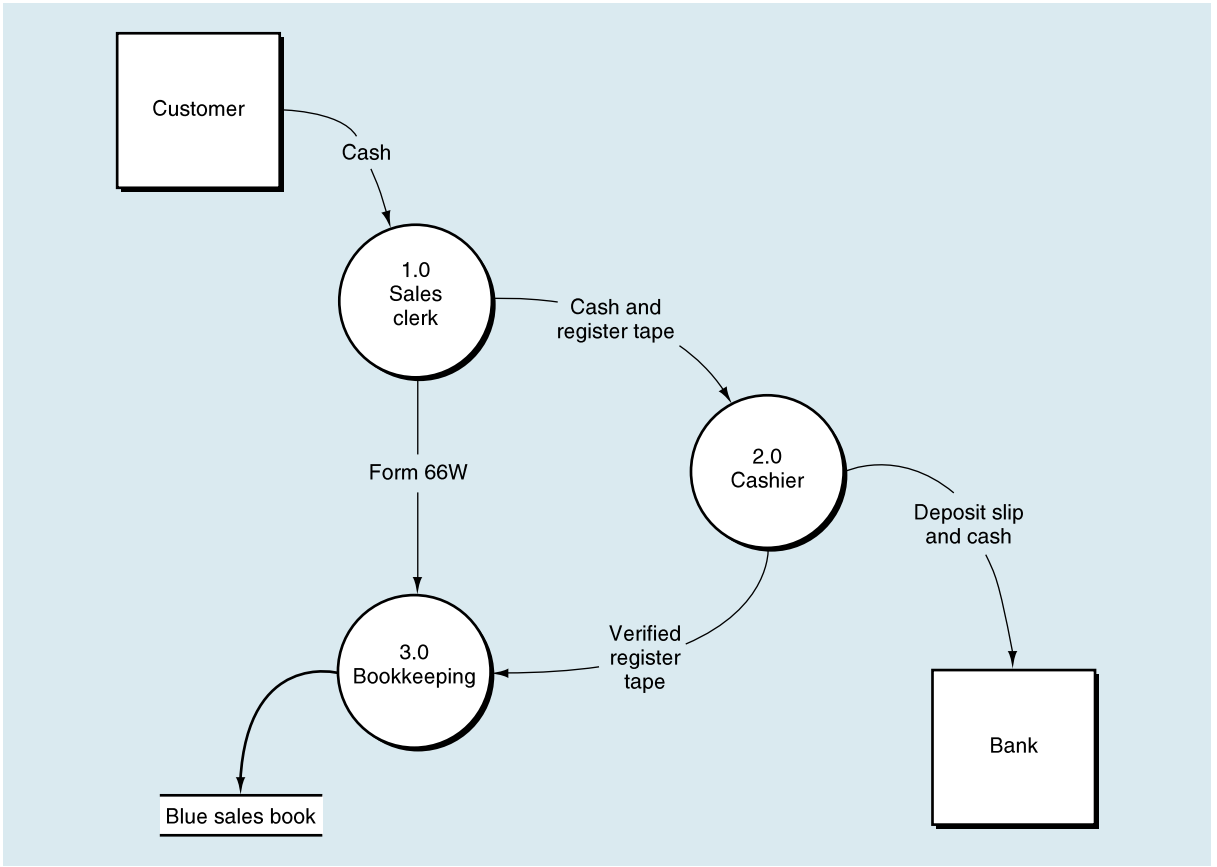
Logical Data Flow Diagram

A **logical data flow diagram** is a graphical representation of a system showing the system's processes (as bubbles), data stores, and the flows of data into and out of the processes and data stores. Logical DFDs are used to document information systems

2 Used in this manner, *entities* is a narrower concept than that used in Chapter 1 where they were all persons, places, and things.

3 As with external entities, internal entities is a narrower concept than entities described in Chapter 1.

FIGURE 4.3 A Physical Data Flow Diagram



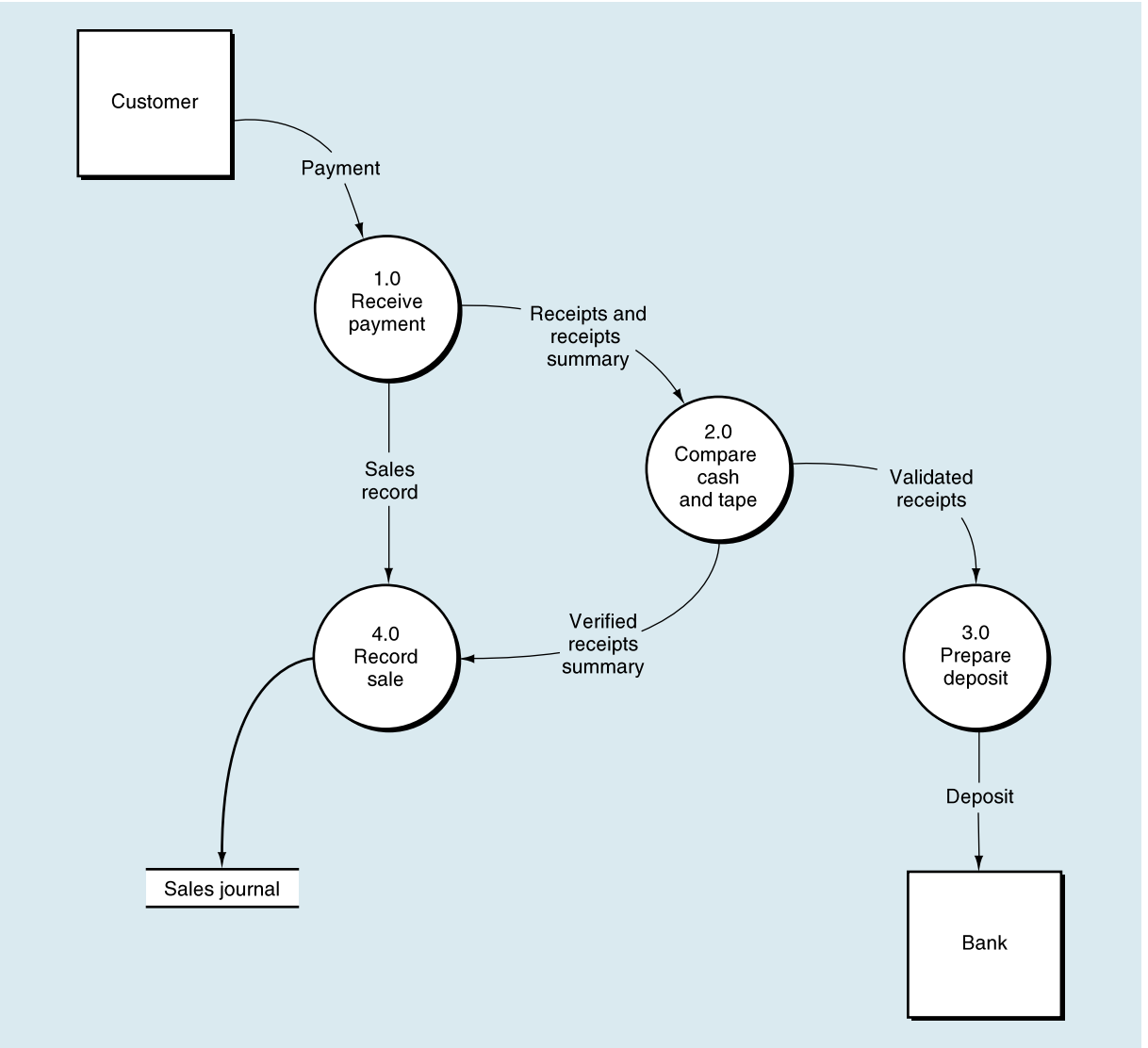
because we can represent the logical nature of a system—what activities the system is performing—without having to specify *how*, *where*, or *by whom* the activities are accomplished. *What* a system is doing will change less over time than *how* the system is doing it. For example, a cash receipts system typically receives customer payments and posts them to the customer's account. Over time, however, the form of the payment—cash, check, or electronic funds—and the method of recording—manual or computer—may change.

The advantage of a *logical* DFD (versus a *physical* DFD) is that we can concentrate on the functions that a system performs. See, for example, Figure 4.4, where the labels on the data flows describe the nature of the data, rather than *how* the data are transmitted. Is the payment in the form of a check, cash, credit card, or debit card? We don't know. Is the sales journal a book, card, or electronic file? Again, we don't know. We do know that customer payments are received, verified for accuracy, recorded in a sales journal, and deposited in the bank. So, a logical DFD portrays a system's activities, whereas a physical DFD depicts a system's infrastructure. We need both pictures to understand a system completely.

Finally, note that the processes in Figure 4.4 are labeled with verbs that describe the activities being performed, rather than with the nouns as we saw in the physical DFD.

Figure 4.4 is a top-level view of the single bubble in Figure 4.2 (pg. 101), the context diagram. Because all of the bubbles in Figure 4.4 contain numbers followed by a decimal

FIGURE 4.4 A Logical Data Flow Diagram (Level 0 Diagram)

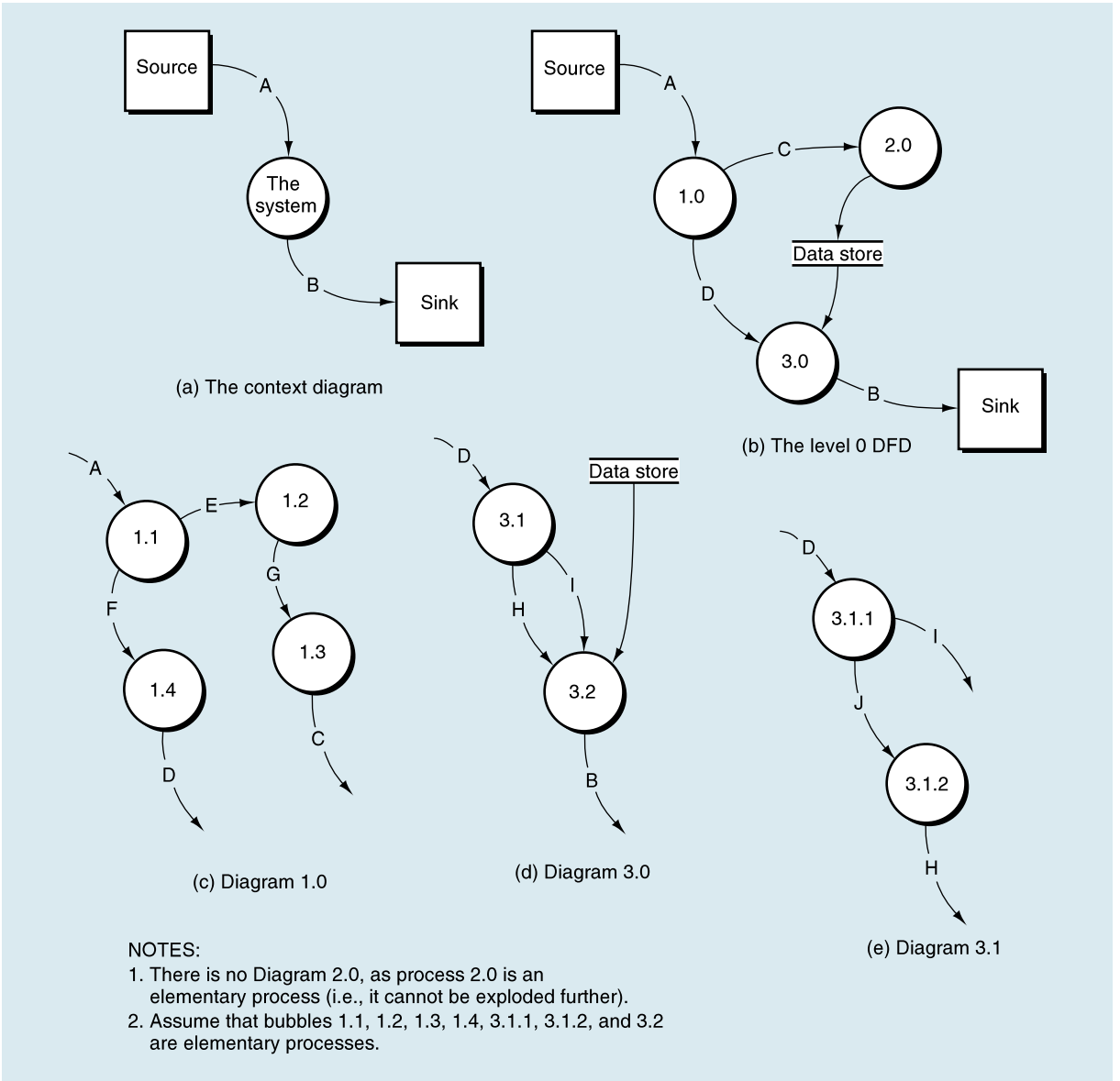


point and a zero, this diagram is often called a "level 0" diagram.[4] Notice that each of the data flows into and out of the context bubble in Figure 4.2 also flow into and out of the bubbles in Figure 4.4 (except for the flows between bubbles, such as "Sales record," which were contained *within* the bubble in Figure 4.2). When two DFDs—in this case, the context and the level 0—have equivalent external data flows, we say that the DFDs are **balanced**. Only balanced sets of DFDs (that is, a context diagram, a logical DFD, and a physical DFD) are correct.

To derive Figure 4.4, we have "exploded" the context diagram in Figure 4.2 into its top-level components. We have looked inside the context diagram bubble to see the

4 Even though physical DFDs are similarly numbered, we do not use the term "level 0" when referring to a physical DFD because there are no lower-level DFDs.

FIGURE 4.5 A Set of Balanced DFDs



major subdivisions of the cash receipts process. The successive subdividing, or "exploding," of logical DFDs is called **top-down partitioning**, and when properly performed, leads to a set of balanced DFDs.

We will use Figure 4.5, which depicts a generic set of balanced DFDs, to study partitioning and balancing. Notice that the level 0 DFD (part b) has the same input "A" and the same output "B" as the context diagram (part a). Now look at part c, an explosion of bubble 1.0. Part c has the same input "A" and the same outputs "C" and "D" as does bubble 1.0 in part b. This relationship must exist because diagram 1.0 (part c) is an explosion of bubble 1.0 in part b. The same can be said for part d, the

partitioning of bubble 3.0. Finally, part e shows diagram 3.1, a partitioning of bubble 3.1 in part d. Study Figure 4.5 and make sure you understand the relationships among levels in this set of DFDs. While you are studying the figure, you might also note the convention used to number the bubbles at each level. Also, note that the entity boxes that appear in the context and level 0 diagrams do not usually appear in diagrams below level 0.

Reading Systems Flowcharts

A **systems flowchart** is a graphical representation of a business process, including *information processes* (inputs, data processing, data storage, and outputs), as well as the related *operations processes* (people, equipment, organization, and work activities). These flowcharts depict the sequence of activities performed as the business events flow through the process.[5] Containing manual and computer activities, the systems flowchart presents a logical and physical rendering of the *who*, *what*, *how*, and *where* of information and operations processes.

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The systems flowchart gives you a complete picture of a system by combining the physical and logical aspects. Physical and logical DFDs each depict different aspects of a system. In addition, the systems flowchart includes the operations process and management context for a system. These aspects are ignored in the DFDs. As noted at the beginning of the chapter, auditors and managers use systems flowcharts to understand a system and to analyze a system's controls. In this text, we use systems flowcharts for a similar purpose. Taken together, DFDs and flowcharts provide multiple, complementary methods for describing a system.

Systems Flowcharting Symbols

Figure 4.6 (pg. 106) shows the systems flowcharting symbols that we will use in this textbook. We have intentionally limited this set to reduce your work in learning the symbols. You should take some time now to study the symbols in Figure 4.6.

Common Systems Flowcharting Routines

Figure 4.7 (pg. 108–109) contains routines often found on systems flowcharts. Follow along as we describe each of these routines.

Figure 4.7, part a, depicts a typical two-step data entry process that might be described as follows:

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> The data entry clerk keys an input document into a computer. The computer accesses data in data store 1 (perhaps a table of valid codes, such as customer codes) and in data store 2 (perhaps a table of open sales orders) to edit/validate the input. The computer displays the input, including any errors. The clerk compares the input document to the display, keys corrections as necessary, and accepts the input. The computer updates the table in data store 2 and notifies the clerk that the input has been recorded.

Notice the following about Figure 4.7, part a:

- The edit or validate step may be performed with one or more data stores.
- The display is implied with most, if not all, data entry processes.
- By combining the "Edit/validate input" rectangle with the "Record input" rectangle, we could depict this input process in one step without losing much detail about the activities being performed.

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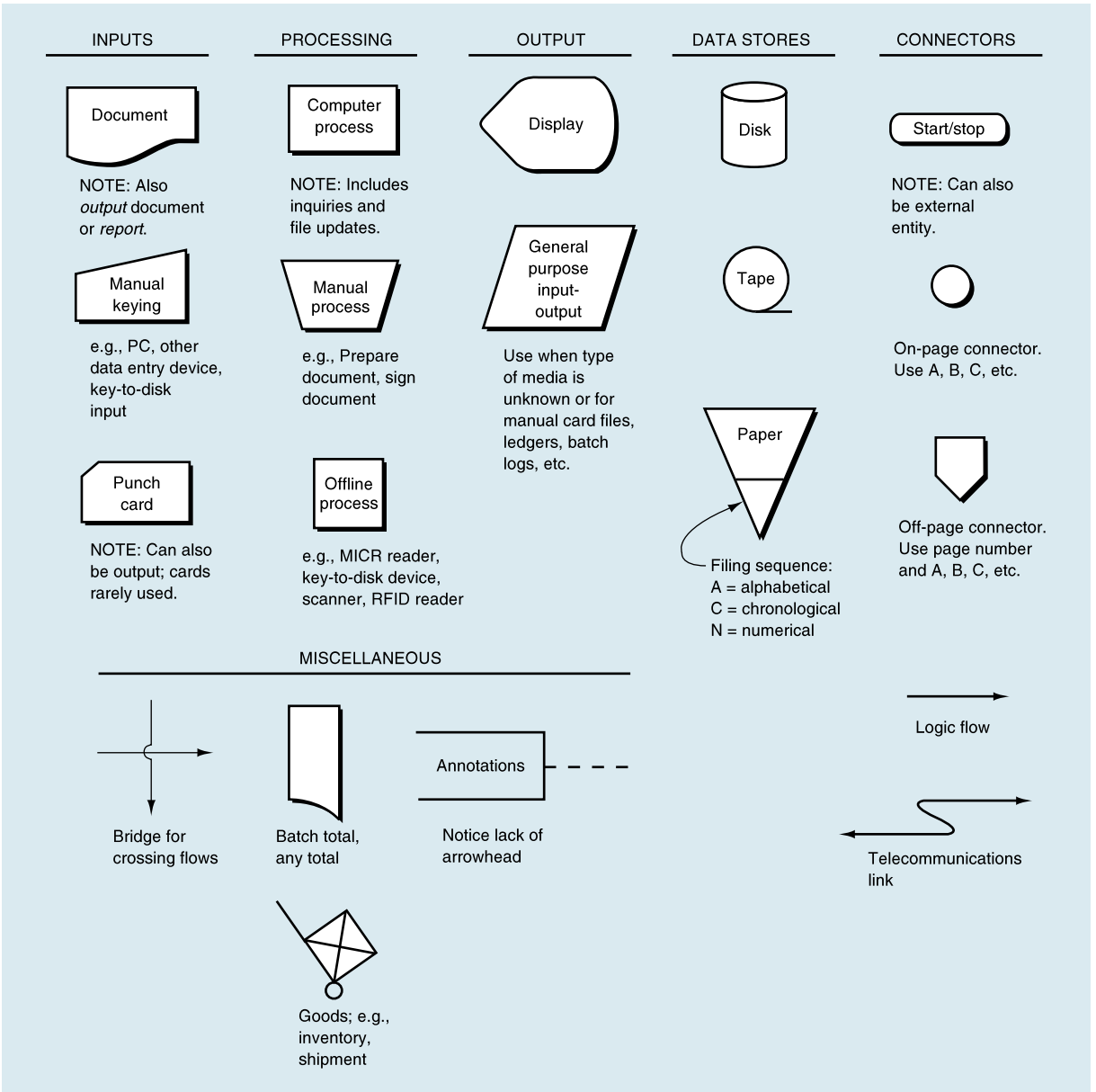
5 Because the systems flowcharts in this text depict information *and* operations processes, they are often referred to as "process flowcharts."

FIGURE 4.6 Systems Flowcharting Symbols



- The manual processes undertaken by the clerk are isolated in a separate column to distinguish them from the automated processes undertaken by the computer.
- We show the input document at the bottom of the column to indicate that the document "flows" through the input process.

Figure 4.7, part b, depicts a typical computer query, which might be described as follows:

> A user keys a query request into a computer. The computer accesses the table(s) in one or more data stores and presents a response to the user.

Notice the following about Figure 4.7, part b:

- The user and computer activities are again isolated in separate columns.
- The display is an implied element of the query request.

Figure 4.7, part c, depicts the update of master data stored in a sequential data store and might be described as follows:

> Inputs (cash receipts, for example) that had previously been recorded on a magnetic disk are input to the computer, along with the existing (old) master data (accounts receivable master data, for example). The computer updates the existing master data and creates a new version of the master data.

Notice the following about Figure 4.7, part c:

- When sequential master data are updated, we show two data store symbols on a flowchart. One symbol represents the existing (old) version, and the other represents the new version.
- A dashed line connects the new with the old master data version to show that the new becomes the old version during the next update process.

Figure 4.7, part d, depicts the input and reconciliation of computer inputs and might be described as follows:

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> The user batches the input documents, prepares batch totals, and keys the documents into the computer. The computer records the inputs on a disk and notifies the user as each input is accepted. The user files the input documents in numerical sequence. At the end of the batch, the computer prepares an exception and summary report that includes batch totals. The user compares the computer batch totals to those prepared prior to entry of the documents.[6]

Notice the following about Figure 4.7, part d:

- The annotation makes it clear that the computer prepares the exception and summary report after the user has completed entry of the batch.
- The user's comparison of the batch totals is depicted with a dashed line instead of the manual process symbol.
- If the batch totals had been input with the batch, the computer—rather than the user—could compare the batch totals.

Figure 4.7, part e, depicts the entry and key verification of inputs into a networked personal computers system and might be described as follows:

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> A data entry clerk (perhaps clerk 1) enters documents into a networked PC system. The system records the inputs on a disk and notifies the user of the acceptance of each input. The documents are then forwarded to a different clerk (say clerk 2) who keys the documents again.[7] Differences are resolved, and the event data are updated to reflect the verifications and corrections.

Notice the following about Figure 4.7, part e:

- The networked PCs are an offline device and should be depicted with a square—rather than a rectangle—and in a column separate from the computer.

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6 Batch totals are discussed in Chapter 9.

7 The majority of data processing errors occur at the data entry stage, and the majority of those errors can be attributed to misreading or miskeying the input. Because it is unlikely that two different clerks will make the same reading or keying mistake, the rekeying by a different clerk will discover the majority of these errors.

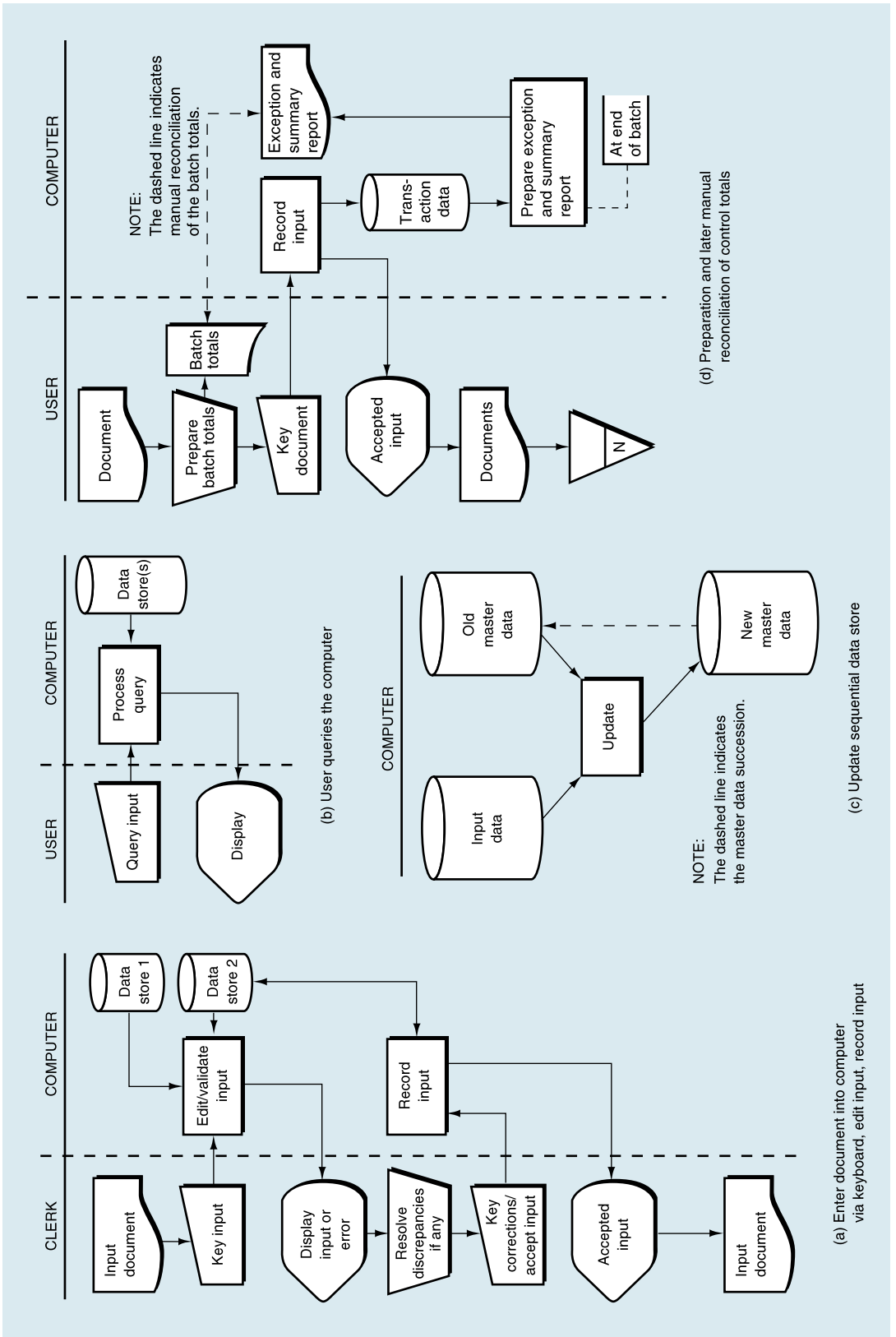


FIGURE 4.7 Common Systems Flowcharting Routines

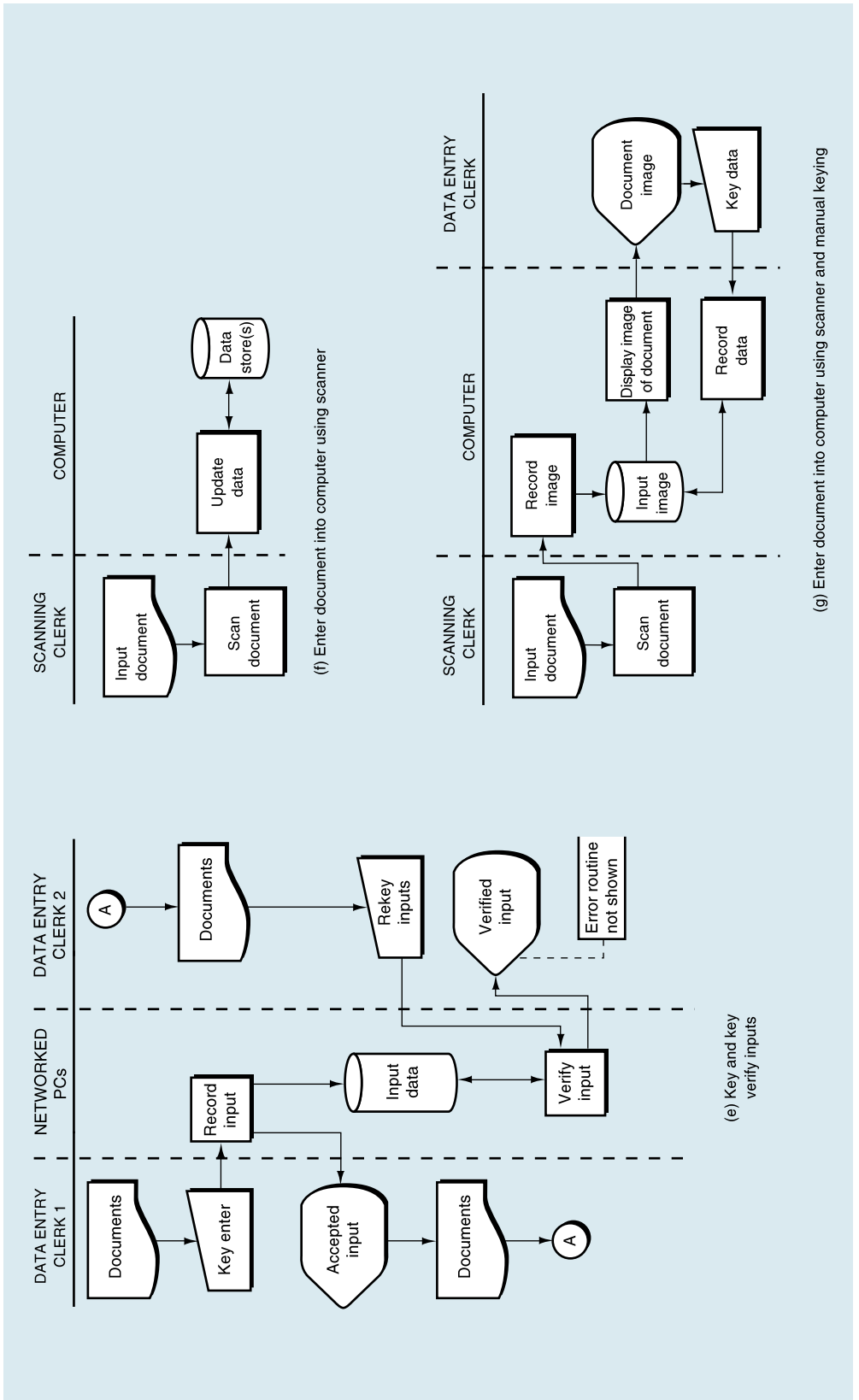


FIGURE 4.7 Common Systems Flowcharting Routines (Continued)

- We show the data entry clerks in two columns to emphasize that the keying and verification are performed by two different clerks.
- Clerk 2 probably follows an established procedure to reconcile differences found during the verification step. We use the annotation ("Error routine not shown") to suggest the existence of these procedures.

Figure 4.7, part f, depicts the entry and recording of an input using a scanner and might be described as follows:

> A clerk scans a document into the computer. Using the data from the scanned document, the computer updates the data located on one or more data stores.

Notice the following about Figure 4.7, part f:

- We represent the scanner with the offline process symbol.
- We could include a display coming from the scanner, showing the clerk the document that had just been scanned.
- To be able to read data from the document, the scanner must have optical character recognition (OCR) capabilities.[8]

Figure 4.7, part g, depicts the entry and recording of an input using a scanner and a keyboard and might be described as follows:

> A clerk scans a document into the computer. The computer routes an image of the scanned input to a data entry clerk, who keys data from the document's image into the computer. The computer records the keyed data with the scanned document.

You should quickly become reasonably proficient in reading flowcharts if you learn these routines. You may encounter many different flowcharting methods during your career, but the principles you learn here will carry over to those techniques.

Preparing Systems Documentation

In this section, we show you how to prepare data flow diagrams and systems flowcharts. We also will give you our own tried and true guidelines for creating DFDs and systems flowcharts. As mentioned earlier in this chapter, you will learn these concepts best by studying and practicing these steps as you go along.

Preparing Data Flow Diagrams

We use DFDs in two main ways. They are drawn to document an existing system or created from scratch when developing a new system. In this section, we explain a process for deriving a set of DFDs from a narrative that describes an existing system.

The Narrative

Figure 4.8 contains a narrative describing the cash receipts system for Causeway Company. The first column indicates the paragraph number; the second column contains the line number for the text of the narrative.[9] We describe here an orderly method for drawing the DFDs for the Causeway system. You will get the most benefit from this

8 Document scanning and OCR are discussed in Chapter 10.

9 We add line numbers to our narrative here only to help with our discussion. Normally you would not include line numbers.

FIGURE 4.8 Narrative of the Causeway Cash Receipts System

Para	Line	Text
1	1	Causeway Company uses the following
	2	procedures to process the cash received from
	3	credit sales. Customers send checks and
	4	remittance advices to Causeway. The
	5	mailroom clerk at Causeway endorses the
	6	checks and writes the amount paid and the
	7	check number on the remittance advice.
	8	Periodically, the mailroom clerk prepares a
	9	batch total of the remittance advices and
	10	sends the batch of remittance advices to
	11	accounts receivable, along with a copy of
	12	the batch total. At the same time, the
	13	clerk sends the corresponding batch of
	14	checks to the cashier.
2	15	In accounts receivable, a clerk enters
	16	the batch into the computer by keying
	17	the batch total, the customer number, the
	18	invoice number, the amount paid, and the
	19	check number. After verifying that the
	20	invoice is open and that the correct amount
	21	is being paid, the computer updates the
	22	accounts receivable master data. If there
	23	are any discrepancies, the clerk is notified.
3	24	At the end of each batch (or at the
	25	end of the day), the computer prints a
	26	deposit slip in duplicate on the printer
	27	in the cashier's office. The cashier
	28	compares the deposit slip to the
	29	corresponding batch of checks and then
	30	takes the deposit to the bank.
4	31	As they are entered, the check number
	32	and the amount paid for each receipt are
	33	logged on disk. This event data is used to
	34	create a cash receipts listing at the end of
	35	each day. A summary of customer accounts
	36	paid that day is also printed at this time. The
	37	accounts receivable clerk compares these
	38	reports to the remittance advices and batch
	39	totals and sends the total of the cash
	40	receipts to the general ledger office.

section if you follow the instructions carefully, perform each step as directed, and don't read ahead. As you follow along, you may want to draw your diagrams by hand or use the software package of your choice.

Table of Entities and Activities

Our first step is to create a table of entities and activities. In the long run, this list will lead to quicker and more accurate preparation of DFDs and a systems flowchart because it clarifies the information contained in a narrative and helps us to document the system correctly.

TABLE 4.1 Table of Entities and Activities for Causeway Cash Receipts System

Entities Para		Activities
Customers	1	1. Send checks and remittance advices.
Mailroom (clerk)	1	2. Endorse checks.
	1	3. Write the amount paid and the check number on the remittance advice.
	1	4. Prepare a batch total of the remittance advices.
	1	5. Send the batch of remittance advices and a copy of the batch total to the accounts receivable clerk.
	1	6. Send the batch of checks to the cashier.
Accounts receivable (clerk)	2	7. Enter the batch into the computer.
	2	8. Key the batch total, the customer number, the invoice number, the amount paid, and the check number.
Computer	2	9. Verify that the invoice is open and that the correct amount is being paid.
	2	10. Update the accounts receivable master data.
	2	11. Notify the clerk of errors.
	4	12. Log events.
	3	13. Print a deposit slip.
Cashier	3	14. Compare the deposit slip with the batch of checks.
	3	15. Take the deposit to the bank.
Computer	4	16. Create a cash receipts listing.
	4	17. Print a summary of customer accounts paid.
Accounts receivable (clerk)	4	18. Compare the computer reports with the remittance advices and batch totals.
	4	19. Send the total of cash receipts to the general ledger office.

To begin your table, go through the narrative line by line and circle each activity being performed. An **activity** is any action being performed by an internal or external entity. Activities can include actions related to data (send, transform, file, retrieve from a file, or receive) or to an operations process. Operations process activities might include picking goods in the warehouse, inspecting goods at the receiving dock, or counting cash. For each activity, there must be an entity that performs the activity. As you circle each activity, put a box around the entity that performs the activity.

Now you are ready to prepare your table. List each activity in the *order* that it is performed, regardless of the sequence in which it appears in the narrative. List the activity, along with the name of the entity that performs the activity and the paragraph number indicating the location of the activity in the narrative. After you have listed all activities, consecutively number each activity.

Compare your table to Table 4.1. Notice that the narrative refers to some entities in more than one way. For example, we have "accounts receivable" and the "clerk" on line 15. Notice that we listed both activity 7 and activity 8. It might be that activity 7 describes activity 8 and does not need to be listed. However, it is better to list doubtful activities than to miss an activity. See how we listed activity 11, found on lines 22 and 23. We changed to the active form of the verb "notify" so that we could show the activity next to the entity that performs the action. Before reading on, resolve any differences between your list of entities and activities and those in Table 4.1.

Drawing the Context Diagram

We are now ready to draw the context diagram. Because a context diagram consists of only one circle, begin the context diagram by drawing one circle in the center of your page (paper or computer). Next, you must draw the external entity boxes. To do this, you need to decide which of the entities in Table 4.1 are external and which are internal.

> **DFD guideline 1:** Include *within* the system context (bubble) any entity that performs one or more information processing activities.

Information processing activities retrieve data from storage, transform data, or file data. Information processing activities include document preparation, data entry, verification, classification, arrangement or sorting, calculation, summarization, and filing—both manual and automated. The sending and receiving of data between entities is not an information processing activity because it does not transform data. If you send data to another entity, you do not process data. If, however, you file data, you do perform an information processing activity. Likewise, if you receive data from another entity, you do not perform an information processing activity. However, if you retrieve data from a file or table, you do perform an information processing activity. Operations process activities are not information processing activities.

To discover which entities perform no information processing activities, you must inspect the table of entities and activities and mark those activities that are not information processing activities. Any entities that do not perform *any* information processing activities are external entities; the remaining entities are internal. Review your table of entities and activities, and mark all activities that do not perform information processing activities. These marked activities—mostly sends and receives—indicate your data flows.

You should have indicated activities 1, 5, 6, 15, and 19 because these activities only send or receive data. As mentioned earlier, activity 7 only describes activity 8 and can also be marked. Finally, activity 11 can be marked because of the following guideline:

> **DFD guideline 2:** For now, include only *normal* processing routines, not exception routines or error routines, on context diagrams, physical DFDs, and level 0 logical DFDs.

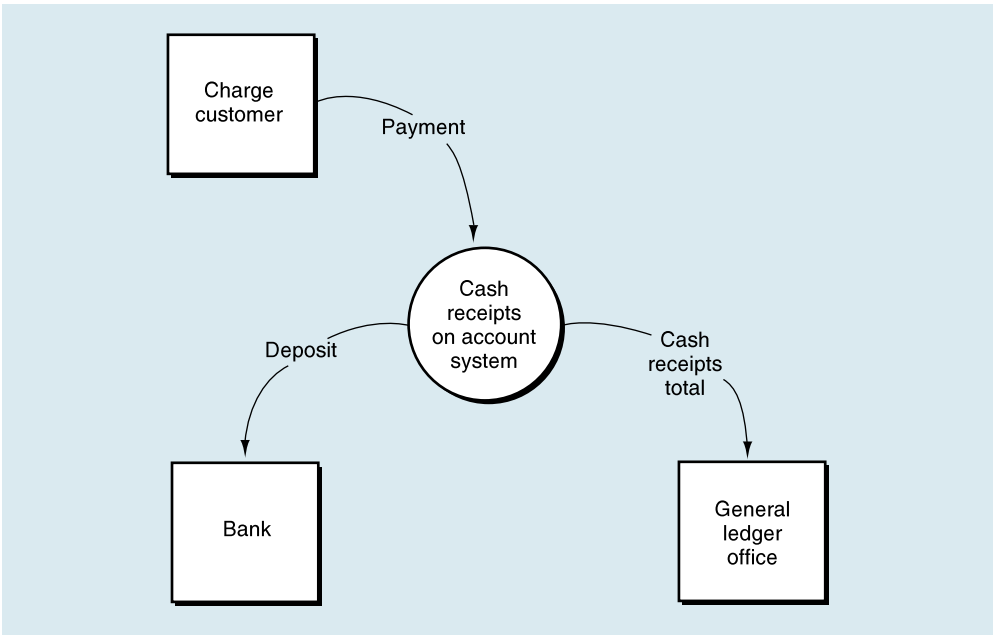
Because activity 11 occurs only when the payment data contain an error, we will not consider this activity *for now*.

Your table of entities and activities, with certain noninformation processing activities marked, should indicate that the mailroom, accounts receivable, cashier, and computer perform information processing activities and will be included in our diagrams as internal entities. The customer, on the other hand, does not perform any such activities and will be an external entity.

Are there other external entities to be included in our diagrams? To answer this question, you must go through the narrative one more time and put a box around those entities not yet marked. You should find that the bank (line 30) and the general ledger office (line 40), in this system, do not perform information processing activities. These entities, along with the customer, are external entities and are included in the context diagram as sources or destinations of data. We now have 3 external entities, 4 internal entities, and 19 activities. No other entities or activities are to be added because of the following guideline.

> **DFD guideline 3:** Include in the systems documentation all (and only) activities and entities described in the systems narrative—no more, no less.

FIGURE 4.9 Causeway Context Diagram



When we say "narrative," we are talking about the narratives that you will find as problem material in this book. You are to assume, in those cases, that the narrative is complete and accurate. However, when you prepare a narrative to document a real-world case, you cannot assume that your narrative is perfect. When you have verified that your narrative is complete and that it accurately reflects reality, you must then follow DFD guideline 3.

Because there are three entities external to the Causeway cash receipts system—the customer, the bank, and the general ledger office—you must draw on your page three boxes surrounding the one context bubble. Next, draw and label the data flows that connect the external entities with the bubble. Because logical (versus physical) labels are normally used on a context diagram, you should do your best to derive logical labels for the flows. The final step is to label the context bubble. Write a descriptive label that encompasses the processing taking place within the system. Our label in Figure 4.9 indicates the scope of the Causeway system—namely, cash receipts from charge customers. The Causeway system does not include cash receipts from any other source.

Figure 4.9 is the completed Causeway context diagram. Compare it to your context diagram, and resolve any differences. Notice that we include a single square for many customers. Likewise, although we may use several banks, we have a single bank square. The following guideline applies.

> **DFD guideline 4:** When multiple entities operate identically, depict only one to represent all.

Drawing the Current Physical Data Flow Diagram

To keep the current physical DFD balanced with the context diagram, start your current physical DFD by drawing the three external entities from the context diagram near the

edges of a page. Next, draw and label each data flow going into the two destinations and coming out of the single source. Leave the center of the page, into which you will sketch the rest of the diagram, blank. Because this is a physical DFD, the data flows should have labels that describe the means by which the flow is accomplished. For example, the "Payment" from the customer should now be labeled "Checks and remittance advices," and the "Deposit" should now be labeled "Deposit slip and checks."

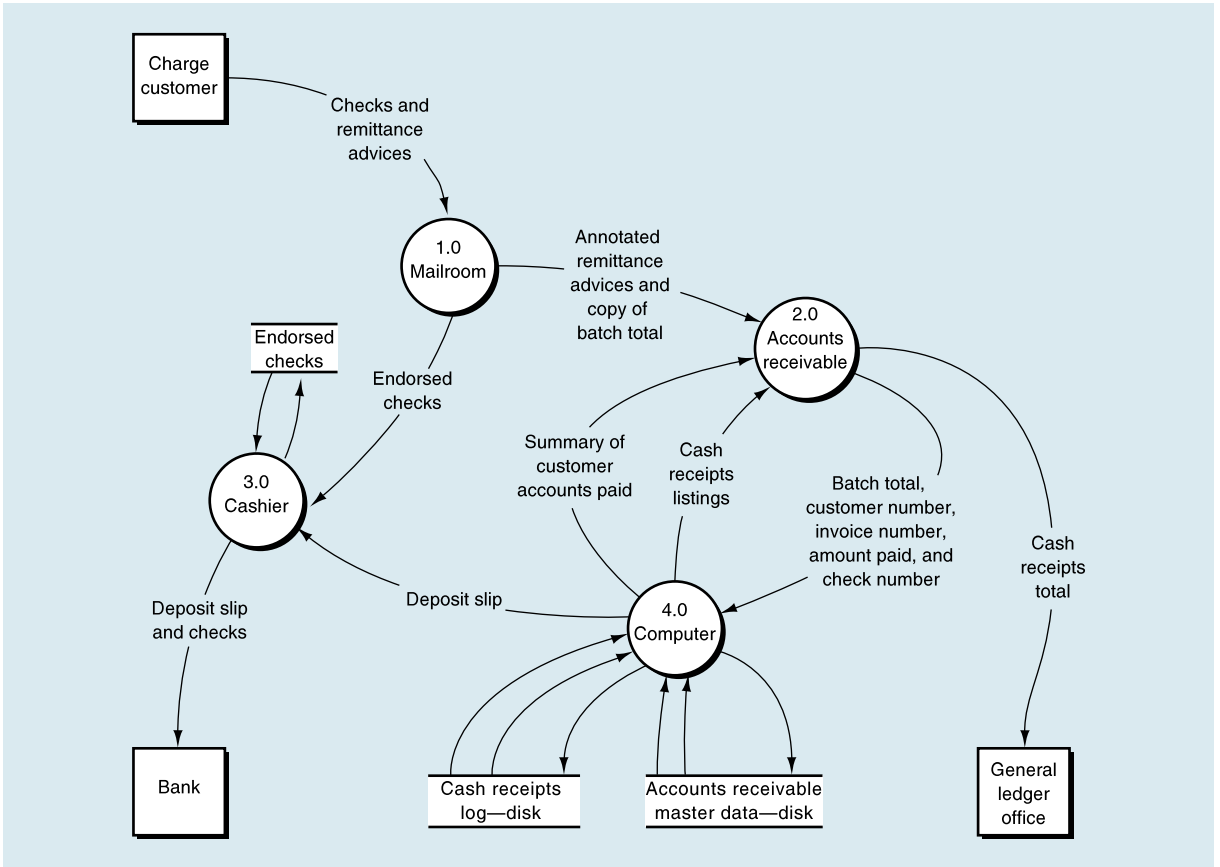
Because each internal entity listed in Table 4.1 (pg. 112) becomes a bubble in the physical DFD, we know that our current physical DFD will contain four bubbles: one each for the mailroom, cashier, accounts receivable, and computer. You will add these four bubbles by first drawing the bubbles on the diagram that are connected to the sources and destinations. During this process, you must consider all send and receive activities and the implied reciprocal activities. (Many of these were marked earlier to indicate that they were not data processing activities.) For example, activity 1 indicates that the customer sends the checks and remittance advices. Draw and label a mailroom bubble, an accounts receivable bubble, and a cashier bubble. Use a data flow symbol (i.e., a curved line with an arrowhead) to connect these bubbles to their related external entities.

To complete the physical DFD, we must go through the table of entities and activities once again and draw all the remaining entities and flows. Follow along with us as we complete the diagram. Activities 2, 3, and 4 are performed *within* the mailroom bubble. Activity 5 indicates a connection between the mailroom and accounts receivable. Activity 6 indicates a connection between the mailroom and the cashier. Activity 8 tells us that the accounts receivable clerk enters data into the computer. Draw the computer bubble, label it "4.0," and connect it to accounts receivable. For the computer to verify that the invoice is open (activity 9), the computer must retrieve the applicable open invoice record from the accounts receivable master data. Draw the data store for the accounts receivable master table and a flow from the data store to the computer bubble. Notice that the label on the data store shows that the physical storage medium is a disk. We draw a flow only from the data store because a data request is not a flow of data. Therefore, we do not show the request for the open invoice record. The movement of the record out of the data store in response to this request is a flow of data and is shown.

To perform activity 10, the open invoice record must be read into the computer, updated, and then written back to the accounts receivable master table. This requires a data flow *from* and a data flow *to* the accounts receivable data store. Because we already drew a flow from the data store for activity 9, however, we need only draw a flow back to the data store. Activity 12 requires that we draw a data store for the cash receipts log and that we draw a data flow from the computer into that data store, whereas activity 13 requires that we draw a flow from the data store to obtain the data for the deposit slip. To perform activity 14, the cashier must receive the deposit slip from the computer.

To perform activity 18, accounts receivable must receive the reports from the computer. To depict the flow of data required to print the reports indicated in activities 16 and 17, we need to draw flows from both data stores into the computer. Draw and label two flows (one for each report) from the computer to accounts receivable. Notice that we did not show a flow from the data stores directly to the accounts receivable bubble. Because the accounts receivable cash receipts data stores are on a computer disk, only the computer can read from or write to them. This also excludes any direct connection between computerized data stores. To update the data on one computerized data store from another, you must go through a computer bubble. In case you think that all the flows into and out of the data stores aren't necessary, consider the following guideline.

FIGURE 4.10 Causeway Current Physical DFD



> **DFD guideline 5:** For clarity, draw a data flow for each flow into and out of a data store. You may, also for clarity and to help you determine that you have included all necessary flows, label each flow with the activity number that gives rise to the flow or with a description of the flow (e.g., "retrieve accounts receivable master data").

Figure 4.10 is the completed Causeway current physical DFD. Compare it to your diagram and resolve any differences before reading on. You should notice that a data store of endorsed checks is connected to the cashier. This file, not mentioned in the narrative, was added to show that the cashier must retain batches of checks until the deposit slip is printed on the computer terminal. We offer the following guideline.

> **DFD guideline 6:** If a data store is logically necessary (that is, because of a delay between processes), include a data store in the diagrams, even if it is not mentioned in the narrative.

Should we draw a data store to show that the remittance advice batches and batch totals are retained in accounts receivable until the computer reports are received? We could. You must use DFD guideline 6 carefully, however, so that you don't draw DFDs that are cluttered with data stores and are therefore difficult to read. You will need to use your judgment. Does this guideline contradict DFD guideline 3? No. DFD guideline 3 tells you to include in your diagrams only those activities included in your narrative, whereas DFD guideline 6 tells you to completely describe those activities. So, if the

narrative implies an activity or data store, include it in the diagrams. How about an example that would violate DFD guideline 6? Activities *outside the context* of a system (not described in the system narrative) should not be included in the diagrams. For example, the following activities are not in Figure 4.8 (pg. 111) and should not be included:

- The actual update of the general ledger data
- Cash receipts from cash sales
- Customer billing

Drawing the Current Logical Data Flow Diagram

The current logical DFD portrays the logical activities performed within the system. Level 0 DFDs depict a particular grouping of the logical activities, so we start the level 0 DFD by enumerating the activities in the system and then group those activities. If you have been following along with us, you already have a list of the activities to be included in the level 0 DFD. The list of the activities to be included in the level 0 DFD are the *unmarked* activities on the table of entities and activities, Table 4.1 (pg. 112). Our list includes activities 2, 3, 4, 8, 9, 10, 12, 13, 14, 16, 17, and 18. Recall that, at this time, we don't consider any other activities because the other activities either are actions performed in other-than-normal situations and therefore not included on a level 0 DFD, are actions that merely send or receive data rather than transform data, or are operations process activities, such as picking goods. Several guidelines will help you group the activities remaining in the list.

DFD guideline 7: Group activities if they occur in the same place and at the same time. For example, the clerk performs activities 2 and 3 in the mailroom as each payment is received.

DFD guideline 8: Group activities if they occur at the same time but in different places. For example, the cashier performs activity 14 "immediately" after the computer prints the deposit slip in activity 13.

DFD guideline 9: Group activities that seem to be logically related.

DFD guideline 10: To make the DFD readable, use between five and seven bubbles.[10]

To start preparing your logical DFD, try bracketing the activities in Table 4.1 (pg. 112) as you think they should be grouped (do not consider the marked activities). For example, if we apply DFD guideline 7 (that is, same time and same place), we could combine activities 2 and 3; activities 9, 10, and 12; and activities 16 and 17. Although this would provide a satisfactory solution, there would be eight bubbles, and there would be several bubbles containing only one activity. Because we prefer not to have too many single-activity bubbles until we get to the lowest-level DFDs, we proceed with further groupings.

If we apply DFD guideline 8 (that is, same time but different place) to the preceding grouping, we could combine activity 8 with 9, 10, and 12; 13 with 14; and 16 and 17 with 18. This solution is better than our first solution because we now have five bubbles and only one single-activity bubble.

If we apply DFD guideline 9 (that is, logically related activities), we can combine activities 2, 3, and 4. Although this leaves us with only four bubbles, this solution is superior to the first two because we have no single-activity bubbles.

10 For very simple systems, such as those described in the narratives in this textbook, your solutions may have fewer than five bubbles.

In summary, our groups are

- Group 1: activities 2, 3, 4
- Group 2: activities 8, 9, 10, 12
- Group 3: activities 13, 14
- Group 4: activities 16, 17, 18

After we choose our groupings, we must give each group a name that describes the logical activities within the group. For Causeway, we chose the following labels:

- Group 1 (activities 2, 3, 4) is bubble 1.0 and is labeled "Capture cash receipts" because that bubble comprises all the activities after the payment is sent by the customer until the payment is keyed into the computer.
- Group 2 (activities 8, 9, 10, 12) is bubble 2.0 and is labeled "Record customer collections" because the activities in bubble 2.0 record the payment in the cash receipts events table and the accounts receivable master table.
- Group 3 (activities 13 and 14) is bubble 3.0 and is labeled "Prepare deposit" because the activities generate a deposit slip and send the deposit to the bank.
- Group 4 (activities 16, 17, 18) is bubble 4.0 and is labeled "Prepare cash receipts total" because that is the main purpose of the reporting and comparison that takes place.

Mark these groups and labels on Table 4.1 (pg. 112).

Table 4.2 demonstrates how you should annotate your table of entities and activities. (Notice that we have not carried forward the marked activities from Table 4.1.) Follow along now as we draw the current logical DFD for Causeway. You'll need paper and pencil (or your computer), the Causeway context diagram (Figure 4.9, pg. 114), the Causeway current physical DFD (Figure 4.10, pg. 116), your annotated table of entities and activities (Table 4.2), and your original table of entities and activities (Table 4.1, pg. 112). To draw the logical DFD, you should begin in the same manner that you

TABLE 4.2 Entities and Activities for Causeway Cash Receipts System (Annotated)

Entities Para		Activities	Processes
Mailroom (clerk)	1	2. Endorse checks.	1.0 Capture cash receipts
	1	3. Write the amount paid and the check number on the remittance advice.	
	1	4. Prepare a batch total of the remittance advices.	
Accounts receivable (clerk)	2	8. Key the batch total, the customer number, the invoice number, the amount paid, and the check number.	2.0 Record customer collections
Computer	2	9. Verify that the invoice is open and that the correct amount is being paid.	
	2	10. Update the accounts receivable master data.	
	4	12. Log events.	
Computer	3	13. Print a deposit slip.	3.0 Prepare deposits
Cashier	3	14. Compare the deposit slip with the batch of checks.	
Computer	4	16. Create a cash receipts listing.	4.0 Prepare cash receipts total
	4	17. Print a summary of customer accounts paid.	
Accounts receivable (clerk)	4	18. Compare the computer reports with remittance advices and batch totals.	

began to draw the current physical DFD. Draw the external entities near the edges of a page. Draw and label flows to and from the external entities while leaving the center of the page blank to receive the remainder of the diagram. Because this is a logical DFD, the data flows to and from the entities must have logical descriptions (for example, the descriptions used on the context diagram).

After we have completed the external flows, we can begin to draw the internal bubbles and flows. The "Payment" from the "Charge customer" is the input to bubble 1.0. Activities 2, 3, and 4 happen within the bubble. What are the outputs? The endorsed checks leave bubble 1.0 (see activity 6 in Table 4.1 on pg. 112) and are stored (see "Endorsed Checks" data store in Figure 4.10, pg. 116). For the logical DFD, we'll call this store "Monetary transfers." The other data flow out from bubble 1.0 was called "Annotated remittance advices and copy of batch total" (see activity 5 in Table 4.1 on pg. 112). For the logical DFD, let's call it "Batched customer receipts." Before moving on, compare your drawing to bubble 1.0 in Figure 4.11 (pg. 120).

The batched customer receipts are the input to bubble 2.0. In response to the keying action (activity 8), a record is read from the accounts receivable master table to perform activity 9. Draw the data store for this table (remember, use a logical label) and a flow from the data store into bubble 2.0. What are the outputs? Activity 10 indicates a flow to the accounts receivable master table, and activity 12 indicates a flow to the cash receipts events table. Draw the data store for the events data and the flows into that data store and into the accounts receivable data store. Before moving on, compare your drawing to bubble 2.0, Figure 4.11.

Now we must draw bubble 3.0. To accomplish activity 13, bubble 3.0 must obtain the records contained in the cash receipts events table. Draw a flow from that table's data store into bubble 3.0. To perform activity 14, bubble 3.0 must obtain the records stored in the monetary transfers data store. Draw a flow from that data store into bubble 3.0. What are the outputs from bubble 3.0? Activity 15 in Table 4.1 (pg. 112) indicates that bubble 3.0 should be connected to the flow "Deposit" going into the bank. Before moving on, compare your drawing to bubble 3.0 in Figure 4.11.

Finally, let's draw bubble 4.0. To create a cash receipts listing (activity 16), bubble 4.0 must obtain the records contained in the cash receipts events table. Draw a flow from that table's data store into bubble 4.0. To print a summary of customer accounts paid (activity 17), bubble 4.0 must obtain the records stored in the accounts receivable master table. Draw a flow from that table's data store into bubble 4.0. To perform activity 18, bubble 4.0 must obtain the data contained on the remittance advices and batch totals. Those data are in the flow "Batched customer receipts" that went into bubble 2.0. Because bubble 4.0 must also obtain those data, we must split that flow and connect it to both bubble 2.0 and to bubble 4.0.

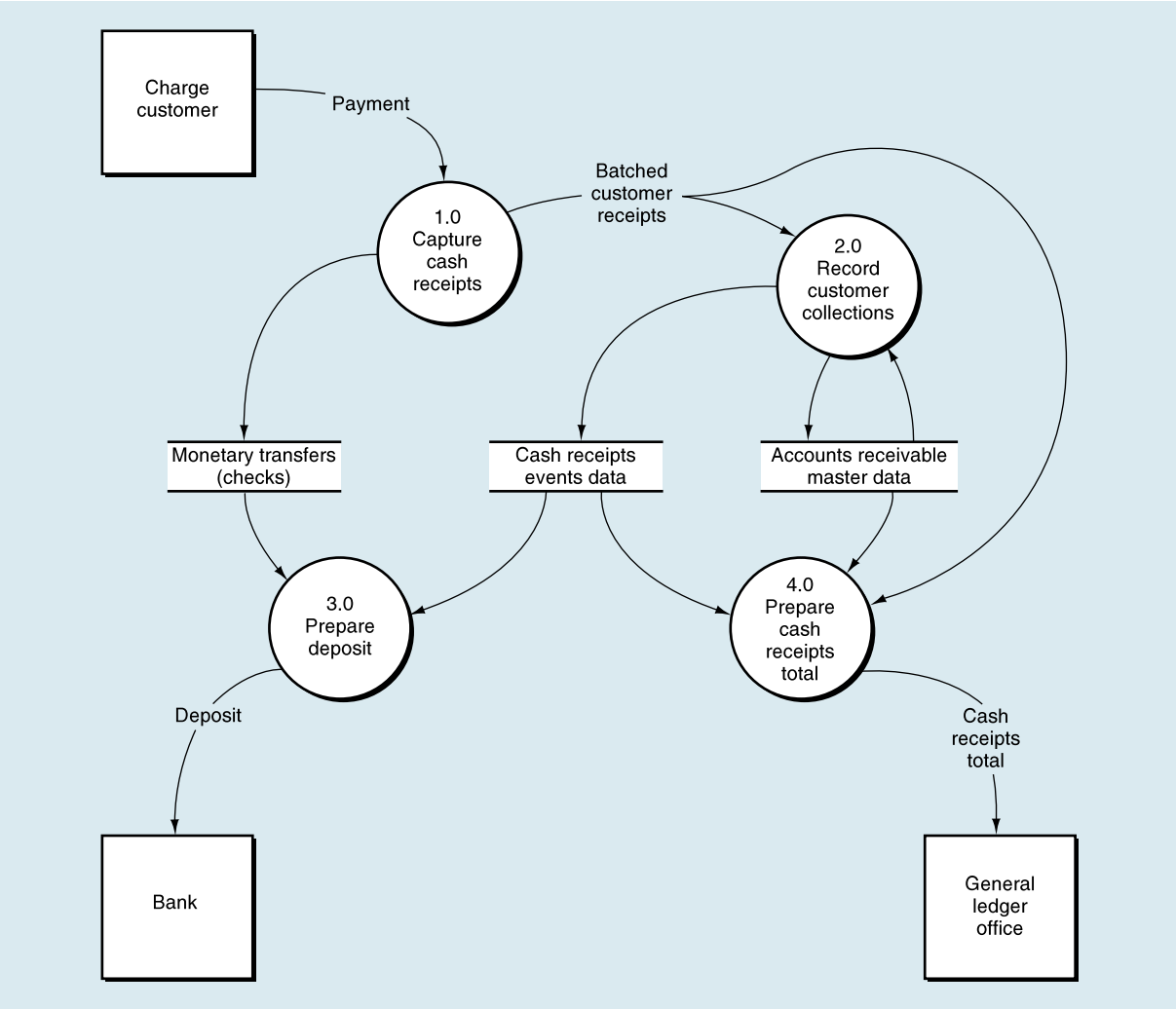
We have finished drawing the Causeway current logical DFD. Compare your diagram to the solution in Figure 4.11. Resolve any discrepancies. Your diagram should look like that in Figure 4.11 *if you use the groupings we described*. Many other groupings are possible within the guidelines. Each different grouping should lead to a different logical DFD.

Summary of Drawing Data Flow Diagrams

First and foremost, don't let the rigor of the documentation get in the way of using the diagrams to understand the system. We have presented many guidelines, hints, and instructions to help you draw DFDs. Use your judgment in applying this information.

There will be times when an operations process function performs information processing activities. Here are a few new DFD guidelines and examples that didn't

FIGURE 4.11 Causeway Current Logical DFD (Level 0)



come up when we drew the Causeway DFDs. For example, when the receiving department (primarily an operations process unit) prepares a document indicating how many widgets have been received, it is performing an information processing activity. The warehouse and the shipping department are other operations process units that often perform information processing activities. The following guidelines apply:

> **DFD guideline 11:** A data flow should go to an operations process entity *square* when only operations process functions (that is, work-related functions such as storing goods, picking goods from the shelves, packaging the customer's order, and so on) are to be performed by that entity. A data flow should enter an entity *bubble* if the operations process entity is to perform an information processing activity.

For example, when an operations process entity is receiving goods, a physical DFD could show either a "receiving" square or a "receiving" bubble, whereas the logical

DFD might show either a receiving department square or a "Complete receiving report" bubble.

DFD guideline 12: On a physical DFD, reading computer data stores and writing to computer data stores must go through a computer bubble.

DFD guideline 13: On a logical DFD, data flows cannot go from higher- to lower-numbered bubbles.

If on a logical DFD you have a data flow going back to a previous processing point (that is, to a lower-numbered bubble), you have a physical representation of the flow or process. Flows may, however, flow backwards to a data store.

There are occasions when processing can't proceed as planned. In such cases, processes called **exception routines** or **error routines** handle the required actions. These are processes for out-of-the-ordinary (exceptional) or erroneous events data. Processing that is performed in other-than-normal situations should be documented below the level 0 DFD with reject stubs that indicate that exceptional processing must be performed. A **reject stub** is a data flow assigned the label "Reject" that leaves a bubble but does not go to any other bubble or data store. These reject stubs, which are shown only in lower-level diagrams, may be added without bringing the set of diagrams out of balance.

Preparing Systems Flowcharts

In this section, we describe the steps for preparing a systems flowchart. The following guidelines outline our basic flowcharting technique. Study each guideline before proceeding.

Systems flowcharting guideline 1: Divide the flowchart into columns: one column for each internal entity, and, optionally, one for each external entity. Label each column.

Systems flowcharting guideline 2: Flowchart columns should be laid out so that the flowchart activities flow from left to right, but you should locate columns to minimize crossed lines and connectors.

Systems flowcharting guideline 3: Flowchart logic should flow from top to bottom and from left to right. For clarity, put arrows on all flow lines.

Systems flowcharting guideline 4: Keep the flowchart on one page. If you can't, use multiple pages and connect the pages with off-page connectors.

To use an off-page connector, draw the symbol shown in Figure 4.6 (pg. 106) at the point where you leave one page and at the corresponding point where you begin again on the next page. If you leave page 1 for the first time, and you are going to page 2, then the code inside the symbol on page 1 should be "P. 2, A"; on page 2, the code inside the symbol should be "P. 1, A." That is, you point to page 2 from page 1, and you point back to page 1 from page 2. Disciplining yourself to draw flowcharts on pages of limited size is essential when you must draw flowcharts on standardized forms for work papers and systems documentation. Also, as you might expect, computerized flowcharting packages will print your flowcharts only on paper that will fit in your printer!

Systems flowcharting guideline 5: Within each column, there must be at least one manual process, keying operation, or data store between documents. That is, do not directly connect documents within the same column.

This guideline suggests that you show all the processing that is taking place. For example, if two documents are being attached, include a manual process to show the matching and attaching activities.

Systems flowcharting guideline 6: When crossing organizational lines (i.e., moving from one column to another), show a document at both ends of the flow line unless the connection is so short that the intent is unambiguous.

Systems flowcharting guideline 7: Documents or reports printed in a computer facility should be shown in that facility's column first. You can then show the document or report going to the destination unit.

Systems flowcharting guideline 8: Documents or reports printed by a centralized computer facility on equipment located in another organizational unit (e.g., a warehouse or a shipping department) should not be shown within the computer facility.

Systems flowcharting guideline 9: Processing within an organizational unit on devices such as a PC or computerized cash register should be shown within the unit or as a separate column next to that unit but not in the central computer facility column.

Systems flowcharting guideline 10: Sequential processing steps (either computerized or manual) with no delay between them (and resulting from the same input) can be shown as one process or as a sequence of processes.

Systems flowcharting guideline 11: The only way to get data into or out of a computer data storage unit is through a computer-processing rectangle.

For example, if you key data from a source document, you must show a manual keying symbol, a rectangle or square, and then a computer storage unit (see, for example part a of Figure 4.7, pg. 108).

Systems flowcharting guideline 12: A manual process is not needed to show the sending of a document. The sending should be apparent from the movement of the document itself.

Systems flowcharting guideline 13: Do not use a manual process to file a document. Just show the document going into the file.

Drawing Systems Flowcharts

We are now ready to draw the Causeway flowchart. Get some paper (or your computer) and follow along with us. The entities in our current physical DFD (Figure 4.10, pg. 116) should help us set up and label our columns. Although we set up columns for each entity, we do not have to include columns for the customer, bank, or general ledger office because these entities do not perform any information processing activities (systems flowcharting guideline 1). Because accounts receivable and the cashier both interact with the computer, let's locate them on either side of the "Computer" column (see systems flowcharting guideline 2). So, from left to right, your columns should be "Mailroom," "Accounts Receivable," "Computer," and "Cashier."

We usually start a flowchart in the top-left corner with a start symbol. Because we have eliminated the Customer column, we must start the flowchart with a start symbol labeled "Customer," followed by two documents labeled "Remittance advices" (RAs) and "Checks." To show that they are together, we can place the RAs and the checks on top of each other with the back document a little above and to the right of the front document. We place all these symbols in the Mailroom column because lines 3 and 4 of

the narrative tell us that the customer sends checks and remittance advices, and line 5 infers that these are received in the Causeway mailroom. This technique makes it clear where the flowchart starts and the source of the document that starts the process. Draw this portion of your flowchart.

Lines 5 and 6 of the narrative tell us that the mailroom clerk endorses the checks, and lines 6 and 7 tell us that the clerk writes the amount paid and the check number on the RA. "Endorse" and "write" are manual processes that, being performed by the mailroom clerk, should be documented with a manual process symbol (or two symbols) placed in the Mailroom column. Systems flowcharting guideline 10 tells us that sequential processes may be documented in one or more process symbols. Because one action is directed at the checks and the other action at the RAs, we'll use two processes. Draw these processes.

In lines 8 and 9, we find a process—preparing the batch total—that is performed periodically by the mailroom clerk. So, still working in the Mailroom column, draw another manual process for the batch total preparation. Find the annotation symbol on Figure 4.6 (pg. 106) and annotate the batch total preparation process to describe the periodic nature of the process.

Lines 10 through 14 describe the three items exiting the mailroom and their destination. All three items should exit the batch total preparation process. Because the RAs and the batch total are going to the next column, they can exit from either the right side or the bottom of the process. Systems flowcharting guideline 6 tells us that we do not need to show the RAs and the batch total in both the Mailroom and the Accounts Receivable columns. Because you'll probably have more room in the Accounts Receivable column, draw these items at the top of that column. Did you find the symbol for batch totals in Figure 4.6 (pg. 106)?

Send the endorsed checks to the cashier using an on-page connector. Systems flowcharting guideline 6 dictates showing the endorsed checks in the sending and receiving columns. In the Cashier column, the endorsed checks must be filed awaiting the receipt of the deposit slip. We introduced this file ("Endorsed checks") when we described the current physical DFD (Figure 4.10, pg. 116). Notice that we show the on-page connector where the process flow leaves the Mailroom column and again where the process flow enters the Cashier column. The same letter is shown in both places. Use letters, starting with the letter "A," and restart with A on each page. Review the Mailroom column of Figure 4.12 (pg. 124) and compare it to your solution. Resolve any discrepancies.

Let's return now to drawing Figure 4.12. Narrative paragraph 2 describes the process by which the RAs are entered into the computer by the accounts receivable clerk and are edited and posted to the accounts receivable master data. Figure 4.7 part a on pg. 108 depicts a method for documenting such a process. Notice that the keying symbols, the manual process symbols, and the display symbols are located in the Clerk column, whereas the computer process and computer storage devices are located in the Computer column. Figure 4.7 part a, indicates a two-step process in which input errors are displayed on the display screen, and a clerk corrects the errors and notifies the computer that the input is acceptable. Because paragraph 2 of the Causeway narrative implies but does not directly require a two-step process such as that in Figure 4.7 part a, we can draw the flowchart with a one-step process. Draw the activity included in narrative paragraph 2 using a one-step input process. Send the RAs and the batch total out of the "bottom" of the input process, that is, out of the bottom of the display screen, as shown in Figure 4.7 part a. If the computer does not accept the

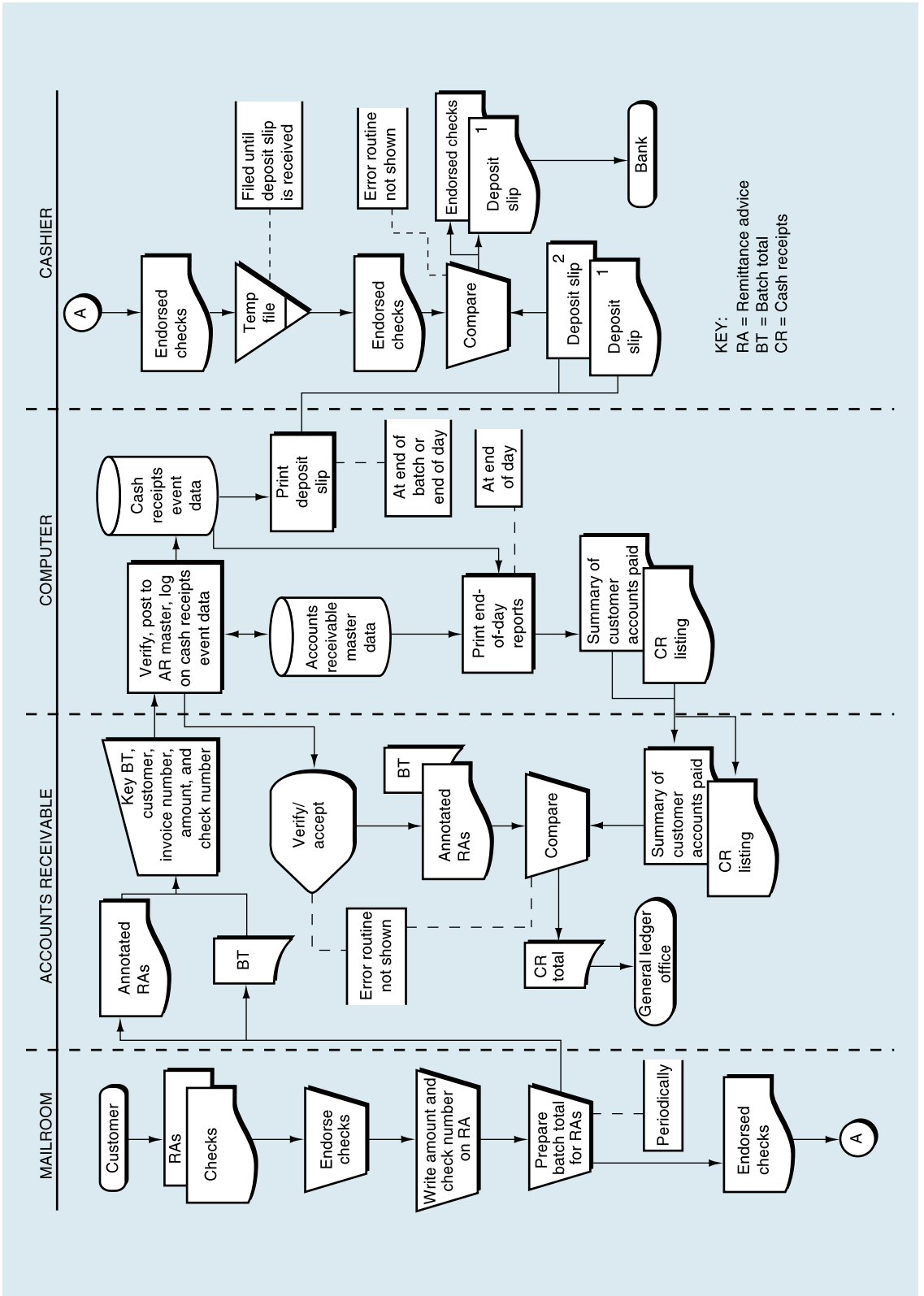


FIGURE 4.12 Causeway Systems Flowchart

input, we can assume that the accounts receivable clerk will correct and rekey the erroneous RA. To show this, connect—with a dashed line—an annotation symbol to the display screen. Include the phrase "Error routine not shown" within the annotation symbol. Lines 31 through 33 (paragraph 4) tell us that the events are logged as they are input. Include a disk symbol for this data store in the computer column of your flowchart. Connect it to the same computer process block with which you updated the accounts receivable data store.

We have completed flowcharting the accounts receivable clerk's activities for now. Review the upper portion of the Accounts Receivable column in Figure 4.12 and compare it to your solution. Resolve any discrepancies.

Let's return once again to drawing Figure 4.12. Narrative paragraph 3, lines 24 through 27, describes the process by which the computer prints the deposit slip on a printer in the cashier's office. What data must be accessed to get the information for the deposit slip? The cash receipts event data table has the check number and the amount and is the only table that contains the most recent payments—the accounts receivable master table summarizes all billings and payments. Read systems flowcharting guidelines 7 and 8, and draw this section of the flowchart. We have used an annotation to indicate that this process is performed only periodically. If you have laid out your flowchart well, the file of endorsed checks—previously sent from the mailroom—and the deposit slip printed by the computer should be near each other in the Cashier column. Now, to flowchart lines 28 through 30, we need only a manual process for comparing these two items and then, coming out of the process, we have the endorsed checks and a copy of the deposit slip going to the bank. If we had a Bank column, these items would go to that column. Because we have no such column, we send these items to a start/stop symbol labeled "Bank." Complete your own flowchart, and then review these sections of Figure 4.12.

To complete our flowchart, we need to chart the end-of-day report generation described on lines 33 through 36 and the use of these reports in accounts receivable described on lines 37 through 40. Because both reports are generated at the same time, we can depict this with one computer process symbol. Access to both computer data stores is required for the report generation, and the reports must be shown in the Computer column and then go to accounts receivable where they are compared to the RAs and to the batch total. A total of cash receipts must be sent to the general ledger office. Figure 4.6 (pg. 106) shows that the symbol used for batch totals can be used for any total. However, because the narrative is not clear, you would not be wrong in using the general-purpose input-output file symbol (parallelogram). Because we're not sure how the total is prepared, just send the total to the general ledger office directly from the process where the batch totals, RAs, and reports are compared. Again, without a General Ledger column, we send the cash receipts total to a stop symbol labeled "General ledger office."

We have now completed the flowchart. Verify your work by checking the table of entities and activities (Table 4.1, pg. 112) to make sure that each activity has been diagrammed. Compare your flowchart to the narrative (Figure 4.8, pg. 111) to see that the system has been accurately documented, and compare your flowchart to the DFDs to see whether the flowchart and DFDs are consistent. Finally, compare your flowchart to the solution in Figure 4.12. Resolve any discrepancies.

Summary of Systems Flowcharting

Drawing flowcharts requires judgment, which you can develop through practice. We have provided you with a number of guidelines that will help you as you learn to

draw flowcharts. Before you get locked into the guidelines and the details of flowcharting, or of drawing DFDs, remember that the purpose of creating this documentation is to simplify and clarify a narrative. We draw these diagrams so that we can better analyze and understand a system. Because we want to portray a system's logic and implementation accurately, there can be many correct solutions. With practice, you can learn to use these techniques to create many correct solutions.

We leave you with the following flowcharting hints, which should help you to develop your flowcharting skills:

- Strike a balance between clarity and clutter by using annotation judiciously and by using on-page connectors whenever flow lines might create clutter.
- Avoid crossing lines wherever possible. If you must cross lines, use a "bridge."
- Flowchart normal routines, and leave exception routines for another page of the flowchart.

Documenting Enterprise Systems

ENTERPRISE SYSTEMS

In Chapter 2, we described *enterprise systems* and how they integrate the business processes from all of an organization's functional areas and have a central enterprise database, such as the one we see at the center of the AIS Wheel. How else will an enterprise system manifest itself? The answer is "it depends." It depends on how the organization chooses to reengineer the business processes when it installs the enterprise system. Let's look at Figure 4.12 (pg. 124), the Causeway systems flowchart, and see what would definitely change. As mentioned previously, we would have one data store/disk symbol that would be labeled "Enterprise database," not the two computer data stores that are in Figure 4.12.

What else *might* change if we had an enterprise system? In general, an enterprise system facilitates the streamlining of business processes, the replacement of paper reports with online "electronic reports," and the automation of manual processes. How will this affect our systems documentation, the DFDs and flowcharts? Figure 4.13 depicts the Causeway system with the only change that must be made if Causeway employed an enterprise system—the computer data stores have been replaced by an enterprise database. Other changes could be made if we knew how else the business processes would be changed if Causeway installed an enterprise system.

How would the DFDs change? The data stores connected to the computer in the physical DFD (see Figure 4.10 on pg. 116) would be replaced by one data store labeled "Enterprise database." The context diagram and the logical DFD would not change, unless there were changes to the business processes. The data stores would not change. In a logical DFD, we want to see each table of data that is part of the process.

In conclusion, let us repeat DFD guideline 3: "Include in the systems documentation all (and only) activities and entities described in the systems narrative." So, don't be tempted to depict improvements to a system as you document its existing processes and data flows. Document what is there! Only after you have done that can you move on to analysis and improvements. So, the Causeway system, as it is described in Figure 4.8 (pg. 111), is documented in Figure 4.9 (the context diagram on pg. 114), Figure 4.10 (the physical DFD on pg. 116), Figure 4.11 (the logical DFD on pg. 120), and Figure 4.12 (the systems flowchart on pg. 124).

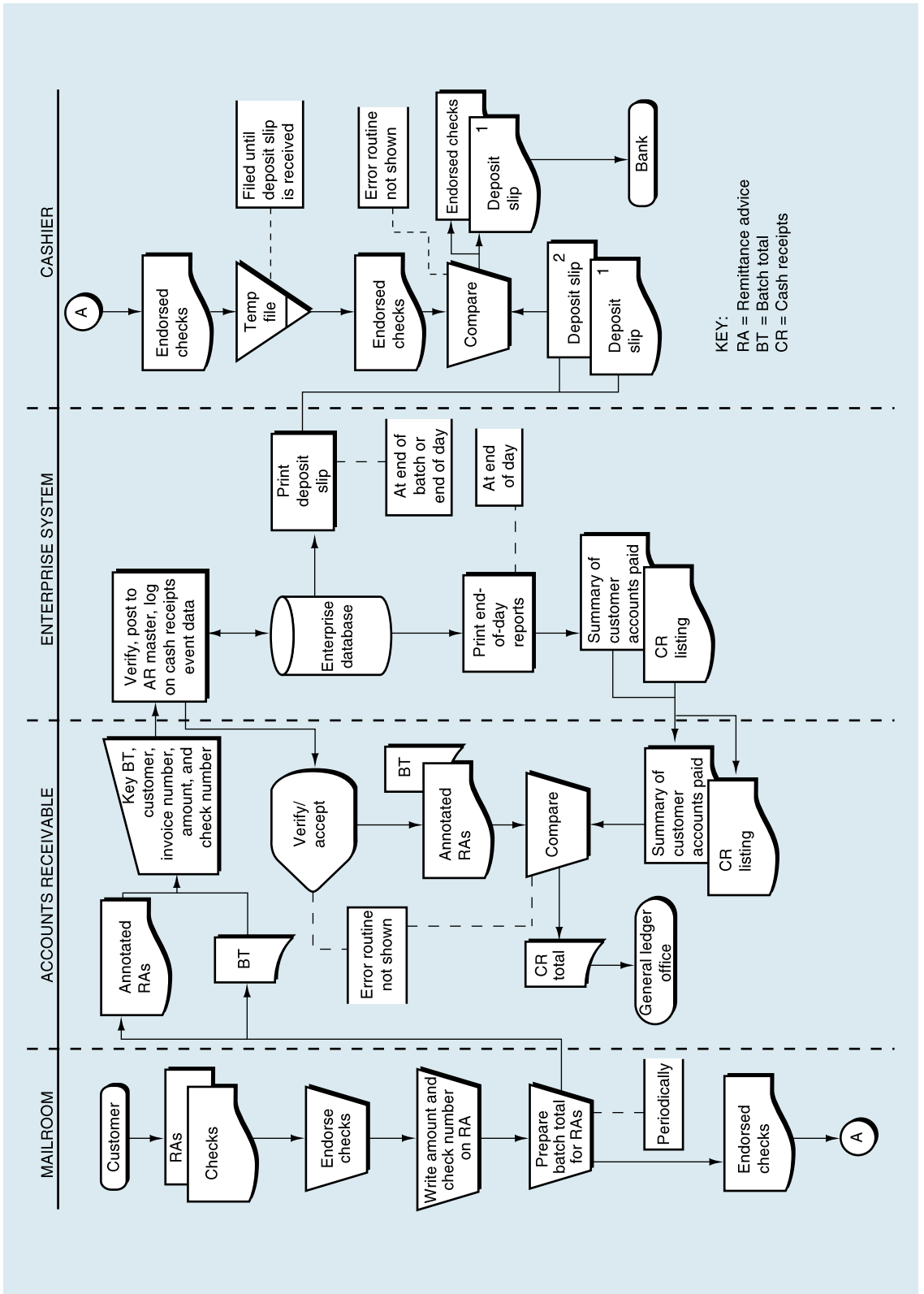


FIGURE 4.13 Causeway Systems Flowchart with an Enterprise Database

Summary

The diagramming tools introduced in this chapter illustrate common techniques business professionals encounter when seeking a pictorial representation of business processes. Each technique has its own purpose, strengths, and weaknesses. The chapters that follow include many examples of each technique to help you understand how to read them, when to use them, and how to create them. If ever there was a good example of "practice makes perfect," this is one. The more you use the techniques, the better prepared you will be to work with them later in your professional career.

Key Terms

data flow diagram (DFD)
bubble symbol
data flow symbol
external entity symbol
source
destination
data store symbol
context diagram
external entities
physical data flow diagram
internal entity
logical data flow diagram
balanced
top-down partitioning
systems flowchart
activity
information processing activities
exception routines
error routines
reject stub

Review Questions

RQ 4-1 Why do we need to document an information system?

RQ 4-2 What is a data flow diagram (DFD)?

RQ 4-3 Describe each symbol used in constructing data flow diagrams.

RQ 4-4 What is a context diagram?

RQ 4-5 What is a physical data flow diagram (DFD)?

RQ 4-6 Distinguish internal and external entities.

RQ 4-7 What is a logical DFD?

RQ 4-8 What are the differences among a context diagram, a logical DFD, and a physical DFD?

RQ 4-9 When is a set of DFDs balanced?

RQ 4-10 What is a systems flowchart?

RQ 4-11 What is a table of entities and activities? What uses does it serve?

RQ 4-12 What are information-processing activities?

RQ 4-13 Why are some entities found in a narrative included in the context diagram as external entities, whereas others are included as internal entities?

RQ 4-14 What are the guidelines for grouping logical activities for a logical DFD?

RQ 4-15 Where are error and exception routines shown on DFDs?

RQ 4-16 Where are error and exception routines shown on systems flowcharts?

RQ 4-17 How will systems documentation differ between business processes that employ an enterprise system and those that do not?

Discussion Questions

DQ 4-1 ''Data flow diagrams and systems flowcharts provide redundant pictures of an information system. We don't need both.'' Discuss.

DQ 4-2 ''It is easier to learn to prepare data flow diagrams, which use only a few symbols, than it is to learn to prepare systems flowcharts, which use a number of different symbols.'' Discuss.

DQ 4-3 Describe the *who, what, where,* and *how* of the following scenario: A customer gives his purchase to a sales clerk, who enters the sale in a cash register and puts the money in the register drawer. At the end of the day, the sales clerk gives the cash and the register tape to the cashier.

DQ 4-4 Why are *many* correct logical DFD solutions possible? Why is only one correct physical DFD solution possible?

DQ 4-5 Explain why a flow from a higher- to a lower-numbered bubble on a logical DFD is a physical manifestation of the system. Give an example.

DQ 4-6 Compare and contrast the purpose of and techniques used in drawing physical DFDs and logical DFDs.

DQ 4-7 ''If we document a system with a systems flowchart and data flow diagrams, we have overdocumented the system.'' Discuss.

DQ 4-8 ''Preparing a table of entities and activities as the first step in documenting systems seems to be unnecessary and unduly cumbersome. It would be a lot easier to bypass this step and get right to the necessary business of actually drawing the diagrams.'' Do you agree? Discuss fully.

DQ 4-9 ''SOX Section 404 has required that management, business process owners, and auditors prepare and analyze systems documentation. However, organizations, internal audit departments, and public accounting firms have developed their own methods for documenting systems. Therefore, I am not going to learn to prepare systems documentation until I know exactly what technique I will need to use in my job.'' Do you agree? Discuss fully.

DQ 4-10 ''Because there are computer-based documentation products that can draw data flow diagrams and systems flowcharts, learning to draw them manually is a waste of time.'' Do you agree? Discuss fully.

Problems

P 4-1 Prepare a narrative to describe the system depicted in the physical DFD in Figure 4.14 (pg. 130).

P 4-2 Prepare a narrative to describe the system depicted in the logical DFD in Figure 4.15 (pg. 130).

P 4-3 Prepare a narrative to describe the system depicted in the flowchart in Figure 4.16 (pg. 131).

Problems 4-4 through 4-7 are based on the following three narratives. Wonderful Stuff Inc. describes the sales process at wonderful-stuff.com. Erickson, Inc. is a monthly cash receipts process. Trillium Insurance Company describes an automobile insurance order entry and billing system. If

FIGURE 4.14 Physical DFD for Problem 4-1

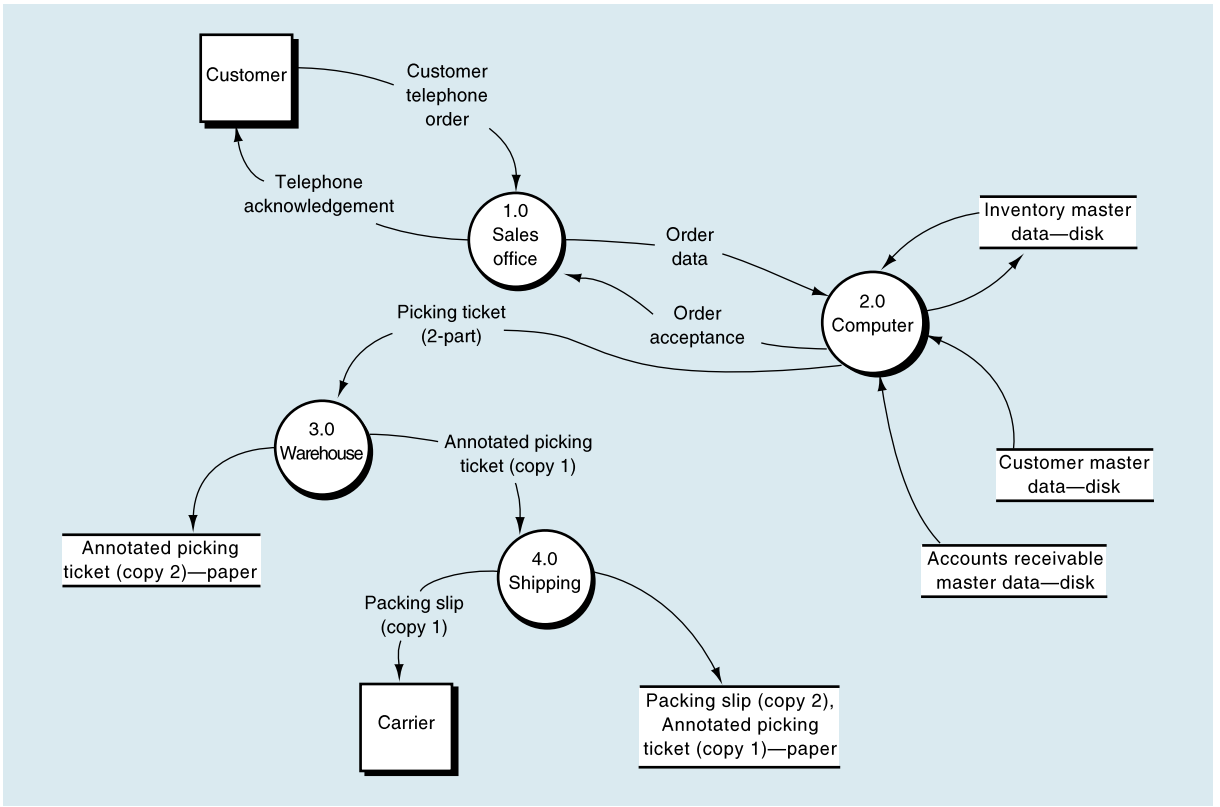
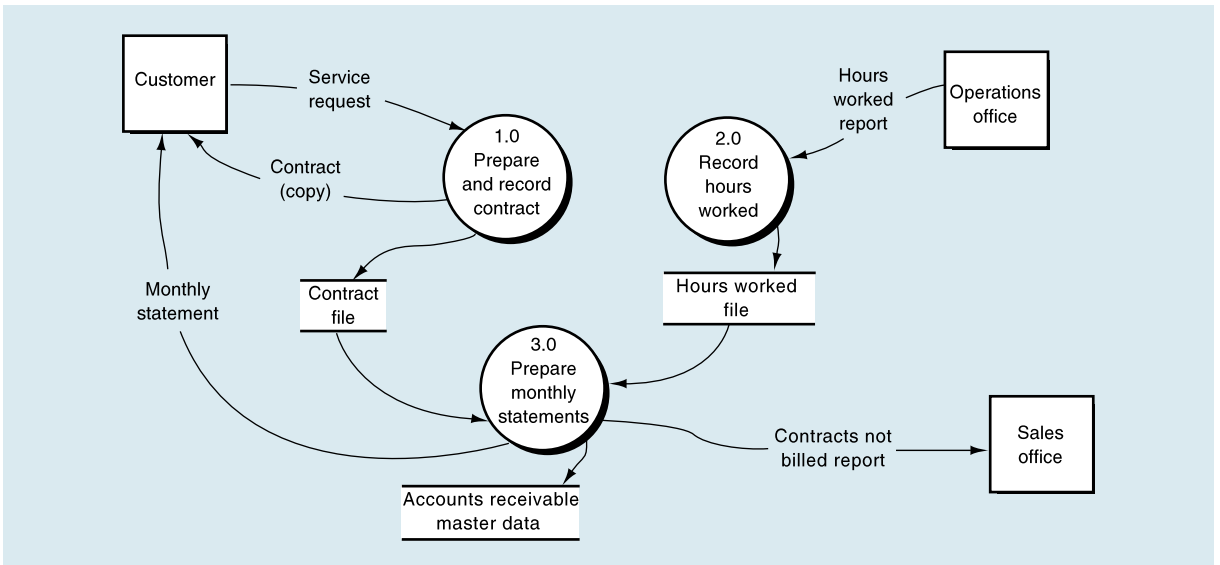


FIGURE 4.15 Logical DFD for Problem 4-2



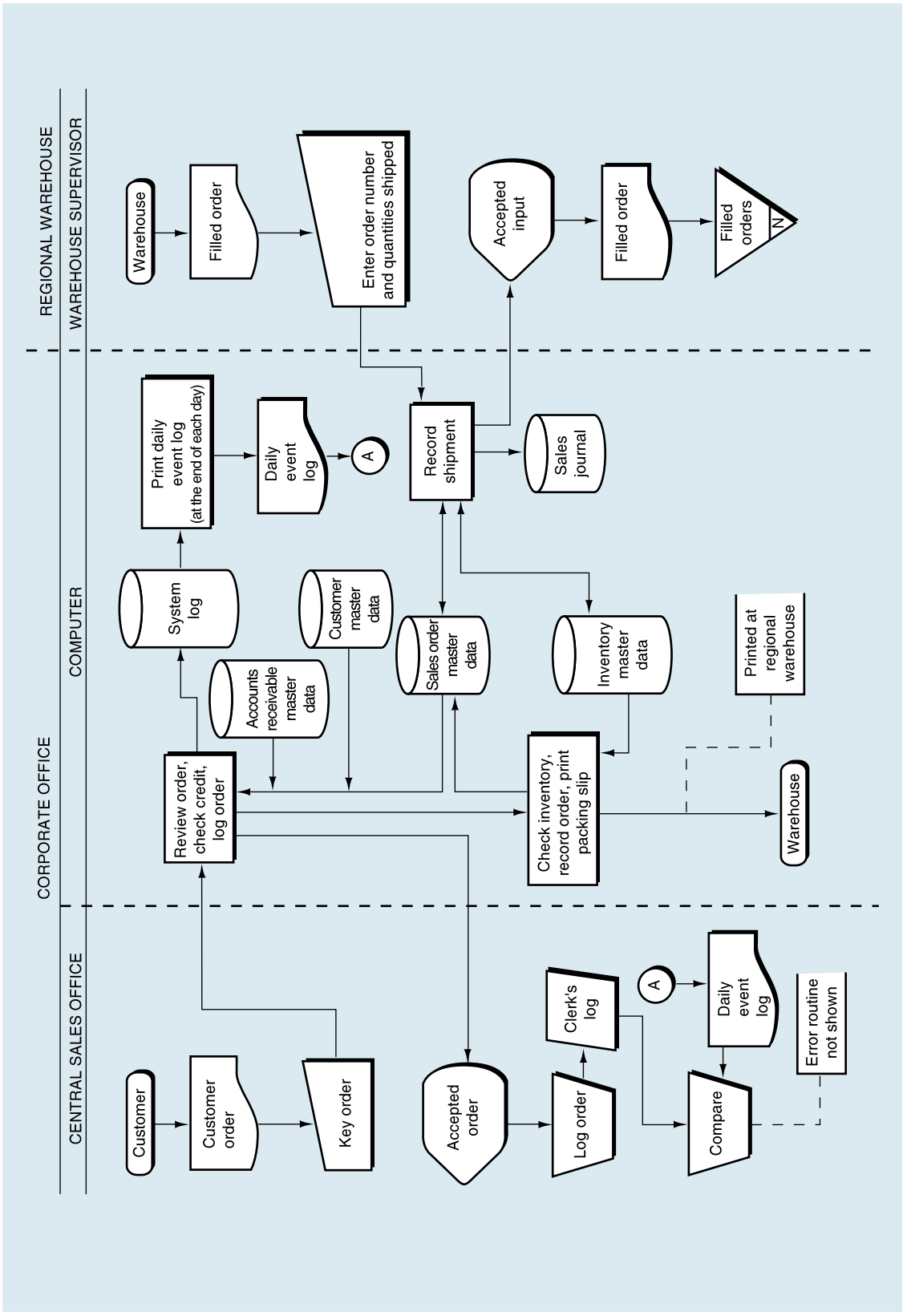


FIGURE 4.16 Flowchart for Problem 4-3

you want to test your documentation skills beyond these problems, there are narratives at the end of Chapters 10 through 14.

Wonderful Stuff, Inc. (wonderful-stuff.com)

Wonderful Stuff, Inc. (a fictitious company) sells a variety of consumer products through its Web site, wonderful-stuff.com. Wonderful Stuff's IT infrastructure consists of a front-end Web server that interacts with customers and a back-end ERP system that manages the inventory and performs other typical ERP functions. The sales order process begins when a customer logs on to the wonderful-stuff.com Web site. The Web server requests the current Wonderful online catalog from the ERP system, which sends the catalog to the Web server, and the server displays it to the customer. The customer selects the items and quantities that he wants to purchase; the Web server edits the customer input for accuracy (e.g., ensures that all required fields have been selected or filled in) and sends this list on to the ERP system where the requested quantities of inventory are allocated for the sale. The ERP sends back to the Web server the quantities that have been allocated, and the Web server displays this information on the customer's screen. The customer verifies that the order is correct and completes the sale by entering his shipping and credit card information. The Web server edits this data for accuracy (e.g., ensures that all required fields have been selected or filled in and that the length of entered credit card number is correct) and sends the credit card information and amount of the sale on to the credit card company. The credit card company sends back a verification number, and the Web server notifies the customer that the sale has been completed by displaying a confirmation number on the customer's screen. The Web server also notifies the ERP system that the sale has been completed, and the ERP system changes the status of the inventory from allocated to sold, prints a picking ticket/packing slip in the warehouse, and records, on the enterprise database, a sale and an accounts receivable from the credit card company.

Erickson, Inc.

Erickson, Inc. sells plumbing supplies to contractors in the northeast region of the United States. Each month, the IT division at Erickson prints monthly statements and sends them to the accounts receivable (AR) department where a clerk mails them to the customers. Erickson's customers mail their payments back to Erickson where a clerk in AR batches the checks and sends them to the cashier. The AR clerk then uses the payment stub to enter the payments into the computer where the AR master data is updated to record the payment.

Trillium Insurance Company

Trillium Insurance Company of Newton, Massachusetts, processes its automobile insurance policies on a batch-oriented computer system with magnetic disk storage. Customers send requests for auto insurance into the Newton sales office where sales clerks prepare policy request forms. They file a copy of the form and forward the original to the input preparation section where data entry clerks use networked PCs to key and key-verify the data contained on the documents to a disk (''policy requests'').

Each evening, computer operations retrieves the policy request data from the network, edits the data on the computer for accuracy (e.g., all required fields completed), sorts the data in policy number sequence, and prints a summary report listing the edited policy requests (there is an error routine,

not described here, for those requests that do not pass the computer edits). The summary report is sent to the sales office where the sales clerks compare the report to the copy of the policy request form that they previously filed. If everything checks out, they notify computer operations to go ahead with processing. When notified, computer operations processes the correct policy request data against the policyholder master data to create a new policy record. Each evening, a disk, which was created during the processing run, is used to print premium notices that are sent to the customer.

P 4-4 a. Prepare a table of entities and activities for the Wonderful Stuff, Inc., Erickson, Inc., or Trillium Insurance Company.

b. Construct a context diagram based on the table you prepared in part a.

P 4-5 Prepare a physical DFD based on the output from Problem 4-4.

P 4-6 a. Prepare an annotated table of entities and activities based on the output from Problems 4-4 and 4-5. Indicate on this table the groupings, bubble numbers, and bubble titles to be used in preparing a level 0 logical DFD.

b. Prepare a logical DFD (level 0 only) based on the table you prepared in part a.

P 4-7 Construct a systems flowchart based on the narrative and the output from Problems 4-4 through 4-6.

P 4-8 A description of 14 typical information-processing routines is given here, along with 10 numbered segments from systems flowcharts (see Figure 4.17).

Match the flowcharting segments with the descriptions to which they correspond. Four descriptions will be left blank.

a. Data on source documents are keyed to an offline disk.

b. Two documents are sent to an external entity.

c. A printed output document is filed.

d. Output is provided to a display device at a remote location.

e. Documents are manually posted to a paper ledger.

f. A report is printed from the contents of a disk.

g. Data stored on a disk is sorted and placed on another disk.

h. Data on a magnetic tape are printed during an offline operation.

i. Data are keyed from a remote location.

j. A batch total of input documents is compared to the total reflected on an error and summary report produced after the documents were recorded.

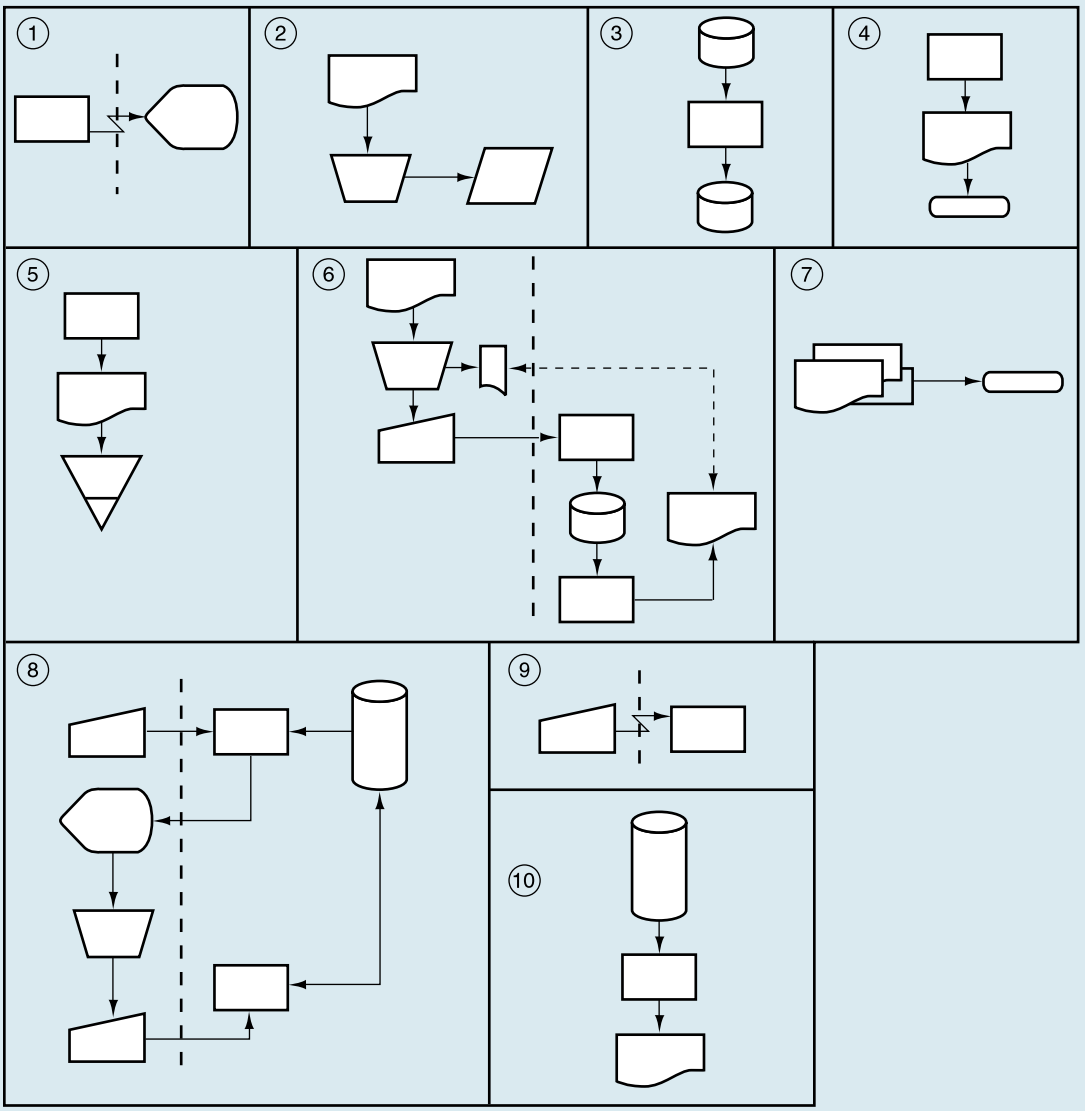
k. Magnetic tape input is used to update master data kept on a disk.

l. The computer prepares a report that is sent to an external entity.

m. Input stored on two magnetic disks is merged.

n. Programmed edits are performed on key input, the data entry clerk investigates exceptions and keys in corrections, and then data on the disk are updated.

FIGURE 4.17 Flowchart Segments for Problem 4-8



P 4-9 Refer to Figure 4.11 (pg. 120), the level 0 DFD of Causeway's cash receipts system.

a. Construct a diagram 1, which ''explodes'' process 1.0, ''Capture cash receipts,'' down to the next level.

b. Construct a diagram 2, which ''explodes'' process 2.0, ''Record customer collections,'' down to the next level.

c. Construct a diagram 3, which ''explodes'' process 3.0, ''Prepare deposit,'' down to the next level.

d. Construct a diagram 4, which ''explodes'' process 4.0, ''Prepare cash receipts total,'' down to the next level.