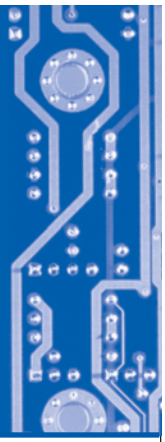
2 Documenting Business Processes and Information Systems



Wander through the offices of a group of systems analysts and you will likely see many flowcharts and other diagrams taped to the walls. These diagrams are roadmaps for the systems and processes that run the business. The analysts themselves may have created them, but more than likely business process owners or business process experts provided the description or narrative of the existing or proposed process. Business professionals who work with complex information systems can benefit greatly from knowing how to understand and create flowcharts and narratives of their business processes. These professionals may be users, designers, or evaluators of business processes, as well as systems professionals.

A recent graduate described how he has used flowcharting and other documentation techniques in his job:

> Auditors and consultants at PricewaterhouseCoopers LLP use flowcharts and systems narratives in a variety of engagements, including financial audits, business process reengineering, and security reviews. During financial audits, auditors review business applications—such as sales, billing, and purchasing—and the processes associated with those applications. To document each process, the auditor conducts interviews with the process owner, writes a narrative, and prepares accompanying flowcharts. Then, the auditor reviews the narrative with the process owner for accuracy and completeness. These documents allow an auditor to design the audit, identify areas where controls may be needed, and prepare audit findings and recommendations.
>
> With the increasing use of computers in business today, flowcharting is essential in financial audits to allow the auditor—as well as consultants and the business process owners—to see information flows and identify areas where information may be changed, manipulated, or even lost. In addition, with the reliance on automated processing systems for financial information, the IRS now requires flowcharts and narratives to be created and maintained for all automated processing systems used by businesses.[1]
>
> In professional services firms, individuals may work on many different types of jobs at many different clients. It is rare that auditors

[1] Rev. Proc. 97–22

and consultants work with the same systems year after year. This has made it necessary for documentation of information systems to be created and maintained for all clients serviced by such professional services firms and carried forward for each subsequent audit or other engagement. Such documentation is usually kept as part of the audit bundle and on disk, or in the automated working papers."[2]

Synopsis

This chapter discusses reading and preparing documentation to portray aspects of business processes and related information systems. The text describes how to read data flow diagrams, systems flowcharts, and entity-relationship diagrams and, in the appendices, how to prepare data flow diagrams and systems flowcharts. In Chapter 3 we show you how to prepare entity-relationship diagrams. Proficiency with these tools should help you to read and prepare systems documentation, which will help you understand and evaluate business processes and their information systems.

Consultants, auditors, systems analysts, business process owners, students, and others use documentation to understand, explain, and improve complex business processes and information systems, such as an *enterprise system.* First, consider a typical enterprise system. This system probably includes all of the activities associated with receiving a customer order, picking the goods off a warehouse shelf, packing and shipping the goods, and billing the customer. Further, the Information System supporting this business process is likely to be used by dozens of people within and outside the organization. Enterprise systems have hundreds of programs that perform functions for virtually every department in the organization, process thousands of transactions and hundreds of requests for management information, and have people throughout the organization preparing inputs and receiving system outputs within the company and over the Internet.

For such complex systems, we require maps or pictures, rather than a detailed 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 will be able to explain the system to someone else. For example, with a systems flowchart we can understand and analyze document flows (electronic and paper) through the business process, including its management system and information system. Perhaps our analysis will lead to system improvements. 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, demonstrates this fact.

Review Question

Why do we need to document an Information System?

In addition to using documentation to understand and improve a system, an organization can use it for other important purposes. For example, managers use documentation to explain systems and to train personnel. Auditors also use documentation to understand systems and to evaluate the systems' controls.

[2] Jeffrey S. Trent, PricewaterhouseCoopers LLP, prepared this section. Jeff graduated from Bentley College with a BS in Accountancy.

Learning Objectives

- To read and evaluate data flow diagrams
- To read and evaluate systems flowcharts
- To read and evaluate entity-relationship diagrams
- To prepare data flow diagrams from a narrative
- To prepare systems flowcharts from a narrative

Introduction

When you learn to read, you first learn individual letters, then string them together in words, and finally the words collectively make sentences. It is only when you practice reading that real understanding occurs, and you open up a new path to learning. These diagramming techniques are another pathway, one that gives a visual overview of complex organizational relationships.

This chapter begins by showing you how to read data flow diagrams, systems flowcharts, and entity-relationship diagrams. Then, in the appendices, you see how to prepare data flow diagrams and systems flowcharts. You will use these documentation tools throughout the remainder of the textbook. Don't be a passive observer; work along with the text and practice these tools to develop your skills.

Although we discuss drawing diagrams as if you were to draw them with pencil and paper, keep in mind that professionals using these techniques prefer using specialized flowcharting or documenting software. Specialized tools produce highly professional-looking diagrams that are much easier to update and share. You may have access to one of these tools through your instructor or workplace.

Reading Systems Documentation

This chapter shows you how to read and interpret three types of systems documentation: data flow diagrams, systems flowcharts, and entity-relationship diagrams. We will look at data flow diagrams first.

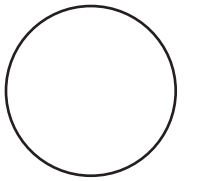
Reading Data Flow Diagrams

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 2.1 shows the four symbols used in a DFD.

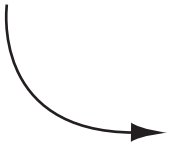
Context Diagram

Figure 2.2 (page 28) 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. The diagram describes data flows into and out of the system

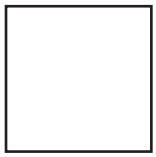
Figure 2.1 Data Flow Diagram (DFD) Symbols



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 entity-wide database.

and into and out of external entities. **External entities** are items such as persons, places, or things outside a system that send data to, or receive data from, a system.[3]

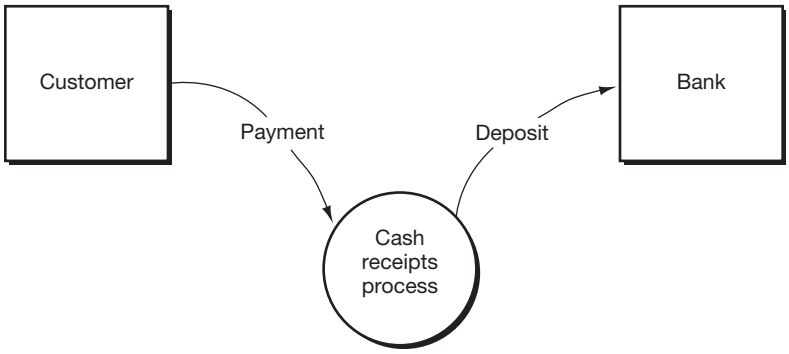
Physical Data Flow Diagram

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.[4] Internal entities include, for example, sales clerks (persons), departments (places), and computers (things). Therefore, physical DFDs specify *where, how,* and by *whom* a system's

[3] Used in this manner, *entities* is a narrower concept than that used in Chapter 1. *External* entities must be able to send or receive data.

[4] Used in this manner, *entities* is a narrower concept than that used in Chapter 1. *Internal* entities must be able to transform data.

Figure 2.2 A Context Diagram



processes are accomplished. A physical DFD does not tell us *what* is being accomplished, though. For example, in Figure 2.3 we see that the Sales clerk receives cash from the Customer and sends cash, along with a register tape, to the Cashier. So, we see where the cash goes and how the cash receipts data are captured on the register tape, but we don't know exactly what was done by the Sales clerk.

Notice that the physical DFD's bubbles are labeled with nouns and that the data flows are labeled to indicate how data are transmitted between bubbles. For example, the Sales clerk sends cash and a register tape to the Cashier. Also, see that a data store's location indicates exactly *where* (in the Computer) and a data store's label indicates *how* (in the sales data store) a system maintains sales records. Finally, while the entity boxes on the context diagram define external entities in the relevant environment, the bubbles in the physical DFD define internal entities.

Review Question

What is a physical data flow diagram (DFD)?

Logical Data Flow Diagram

A **logical data flow diagram** is a graphical representation of a system showing the system's processes and the flows of data into and out of the processes. We use logical DFDs to document information systems because we can represent the logical nature of a system—what tasks the system is doing—without having to specify how, where, or by whom the tasks are accomplished. What a system is doing will change less over time than will how it is doing it. For example, a cash receipts system will typically receive customer payments and post them to the customer's account. Over time, however, the form of the payment—cash, check, electronic funds—and the method of recording—manual, computer—may change.

Review Question

What is a logical data flow diagram (DFD)?

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 2.4 (page 30), 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 "Sales data" a book, card, or records stored on a computer? Again, we don't know. What we do know is that customer payments are received, recorded in a sales data store, verified for accuracy, and deposited in the bank. So, a logical DFD portrays a system's activities, while a physical DFD depicts a system's infrastructure. We need both pictures to understand a system completely.

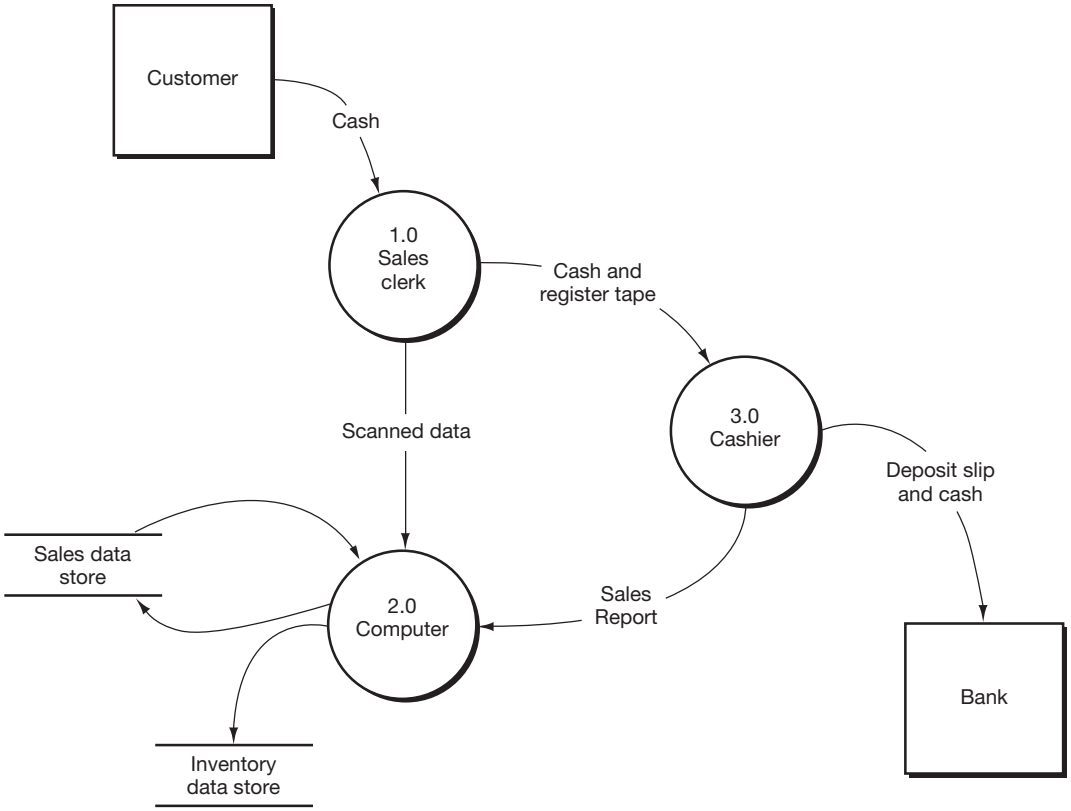
Review Question

Describe the symbols used in constructing data flow diagrams.

Finally, note that the processes in Figure 2.4 are labeled with verbs that describe the actions being performed, rather than with the nouns we saw in the physical DFD.

Figure 2.4 is a top-level view of the single bubble in Figure 2.2, the context diagram. Because all of the bubbles in Figure 2.4 are numbers followed by a decimal

Figure 2.3 A Physical Data Flow Diagram



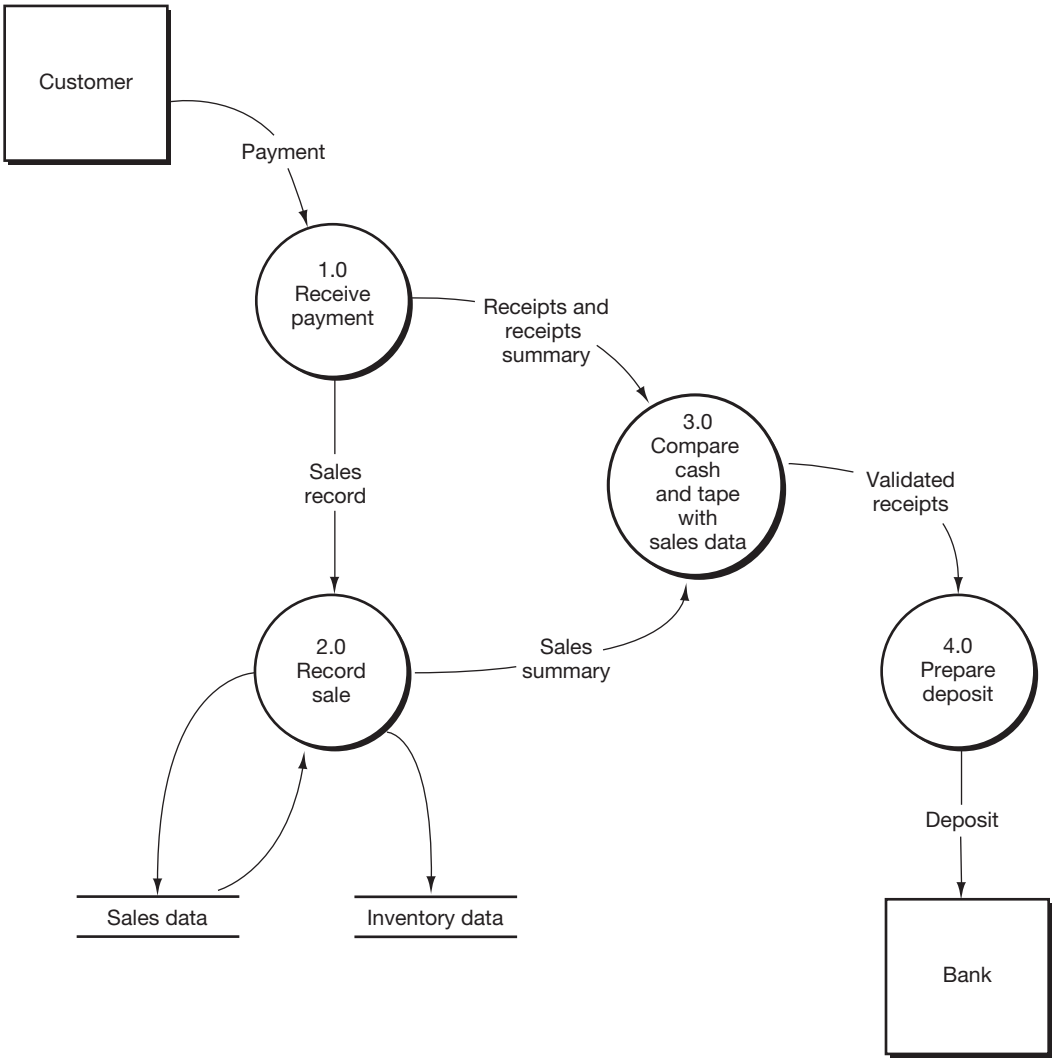
point and a zero, this diagram is often called a "level 0" diagram.[5] You should notice that each of the data flows into and out of the context bubble in Figure 2.2 also flow into and out of the bubbles in Figure 2.4 (except for the flows between bubbles, such as "Sales record," which were contained *within* the bubble in Figure 2.2). 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 2.4, we have "exploded" the context diagram in Figure 2.2 into its top-level components. We have looked inside the context diagram bubble to see the 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 2.5 (page 31), 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 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

[5] 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 2.4 A Logical Data Flow Diagram (Level 0 Diagram)



Review Question

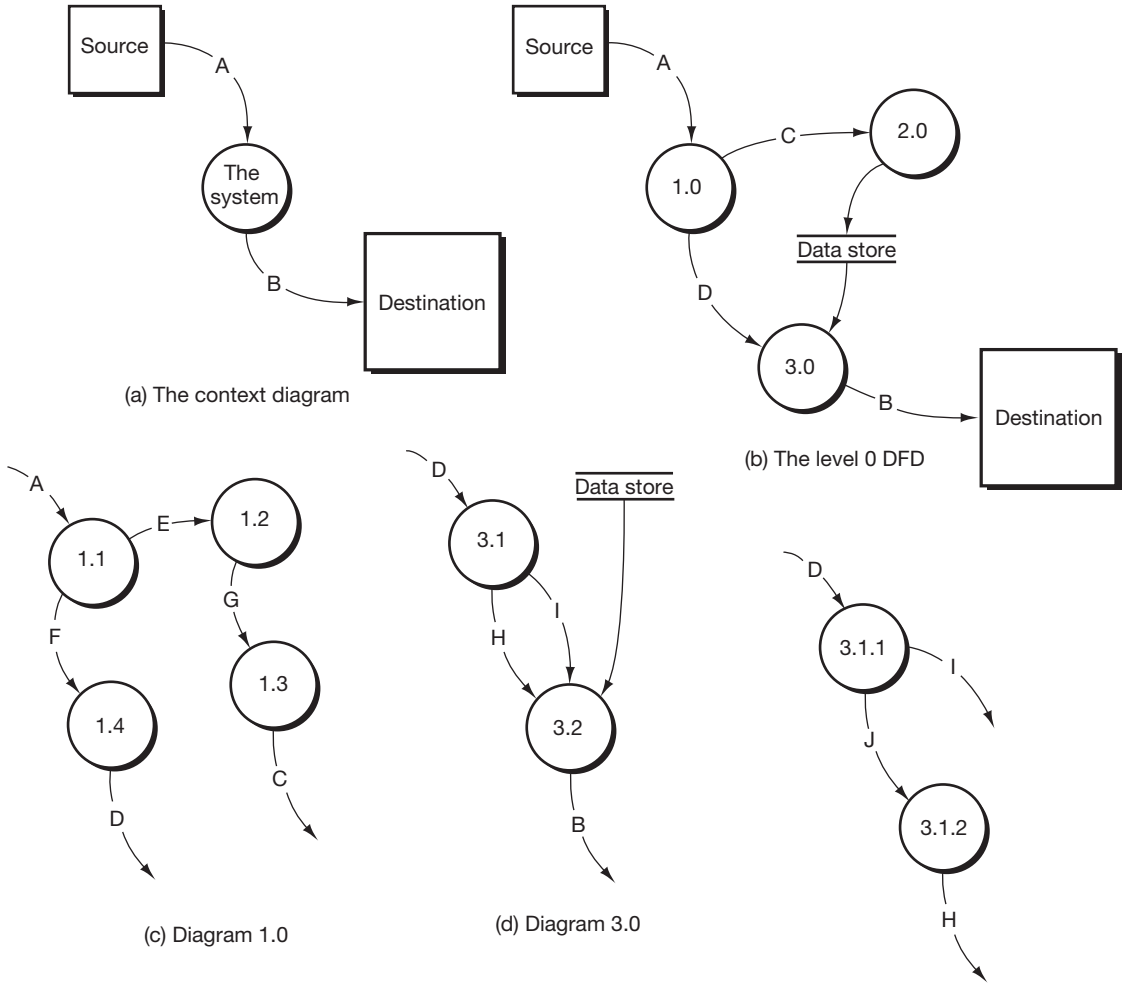
What is the difference between a context diagram, a logical DFD, and a physical DFD?

bubble 3.0. Finally, part e shows diagram 3.1, a partitioning of bubble 3.1 in part d. Study Figure 2.5 to make sure you understand the relationships among levels in this set of DFDs. While you are studying the figure, you might also notice the convention used to number the bubbles at each level. Also, see that the entity boxes appear in the context diagram and the level 0 diagram but do not usually appear in diagrams below the level 0.

Reading Systems Flowcharts

A **systems flowchart** is a graphical representation of *information processes* (activities, logic flows, inputs, outputs, and data storage), as well as the related *operations processes* (entities, physical flows, and operations activities). Including both manual and com-

Figure 2.5 A Set of Balanced DFDs



NOTES:
1. There is no Diagram 2.0, as process 2.0 is an elementary process (i.e., it cannot be exploded further).
2. Assume that bubbles 1.1, 1.2, 1.3, 1.4, 3.1.1, 3.1.2, and 3.2 are elementary processes.

puter activities, the systems flowchart presents a logical and physical rendering of the who, what, how, and where of business processes and Information Systems.

Systems flowcharts can be complex and cumbersome when they depict a large or complicated process. DFDs can be drawn at many levels of complexity, so someone needing only a high level view or a picture of only a part of the process doesn't need to work through the complexities of a systems flowchart. However, for detailed analysis of business processes, the complexity of a systems flowchart is invaluable.

By combining the physical and logical aspects of a system, the systems flowchart gives us a complete picture of a system. Physical and logical DFDs each depict different aspects of a system. In addition, the systems flowchart includes the business process and management context for a system, aspects ignored in DFDs. Like DFDs,

Review Question

What is a systems flowchart?

Review Question

What are the similarities and differences between a systems flowchart and a DFD?

systems flowcharts represent a system to identify parts that could be improved or streamlined, and to analyze a system's controls. Taken together, DFDs and flowcharts provide multiple, complementary methods for describing a system.

Systems Flowcharting Symbols

Figure 2.6 shows systems flowcharting symbols used in this textbook. This is a limited set to illustrate flowcharting principles. Use this set as a key to interpreting later diagrams.

Common Systems Flowcharting Routines

Figure 2.7 (pages 34–35) contains routines often found on systems flowcharts. Follow along with us as we describe each of these routines.

Figure 2.6 Systems Flowcharting Symbols

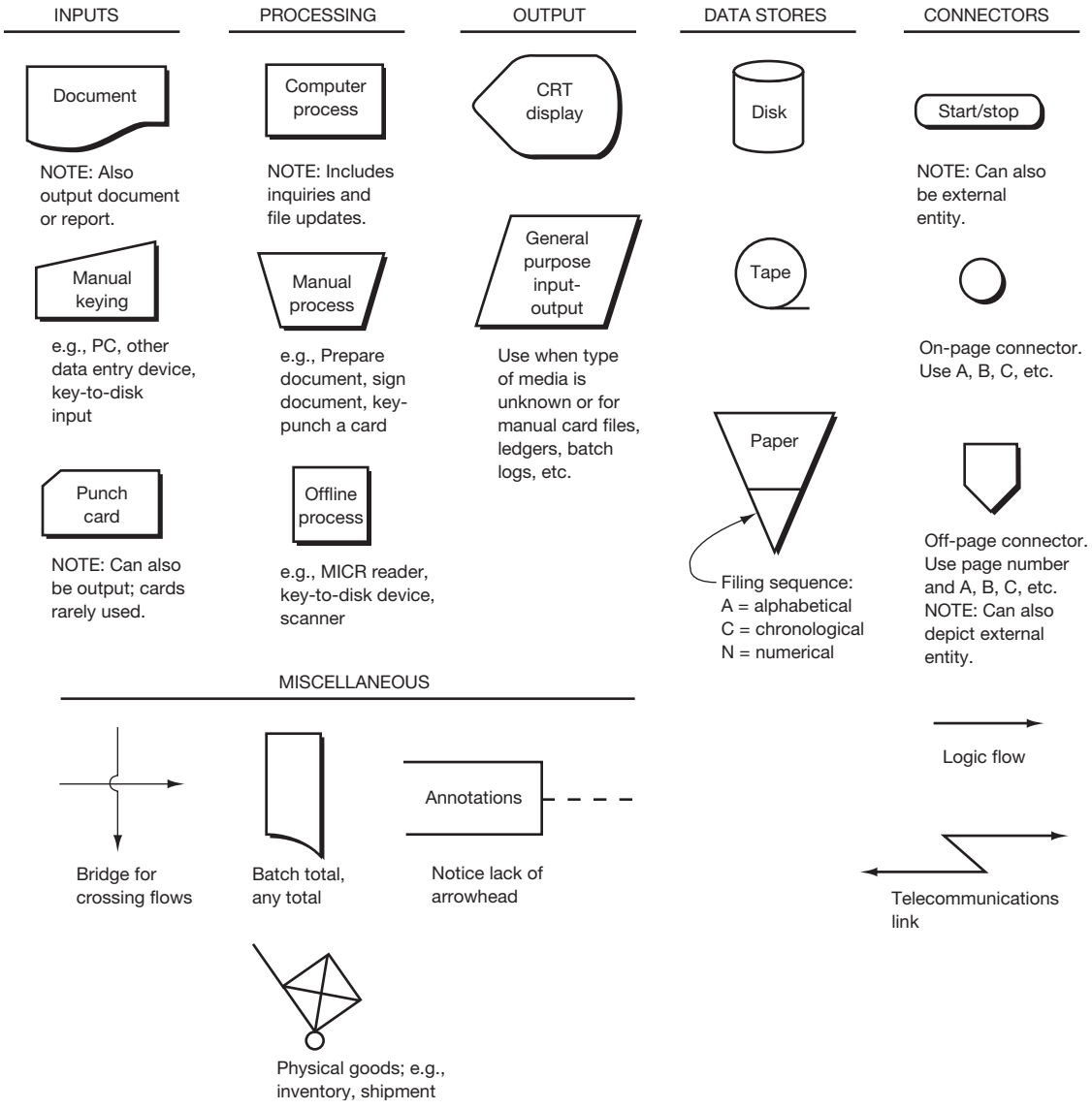


Figure 2.7, part (a), depicts a typical two-step data entry process which might be described as follows:

The data entry clerk (such as a telephone sales clerk) keys a sales input document while online. 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 in 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 2.7, 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—rather than two—steps without losing much detail about the activities being performed.
- 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 2.7, part (b), depicts a typical online computer query, which might be described as follows:

A user keys a query request online 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 2.7, part (b):

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

Figure 2.7, part (c), depicts the update of master data stored in a sequential data store and might be described as follows:

New data (a customer address change, for example) previously recorded on disk are input to the computer, along with the existing (old) master data (customer 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 2.7, part (c):

- When sequential master data is 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 2.7 Common Systems Flowcharting Routines

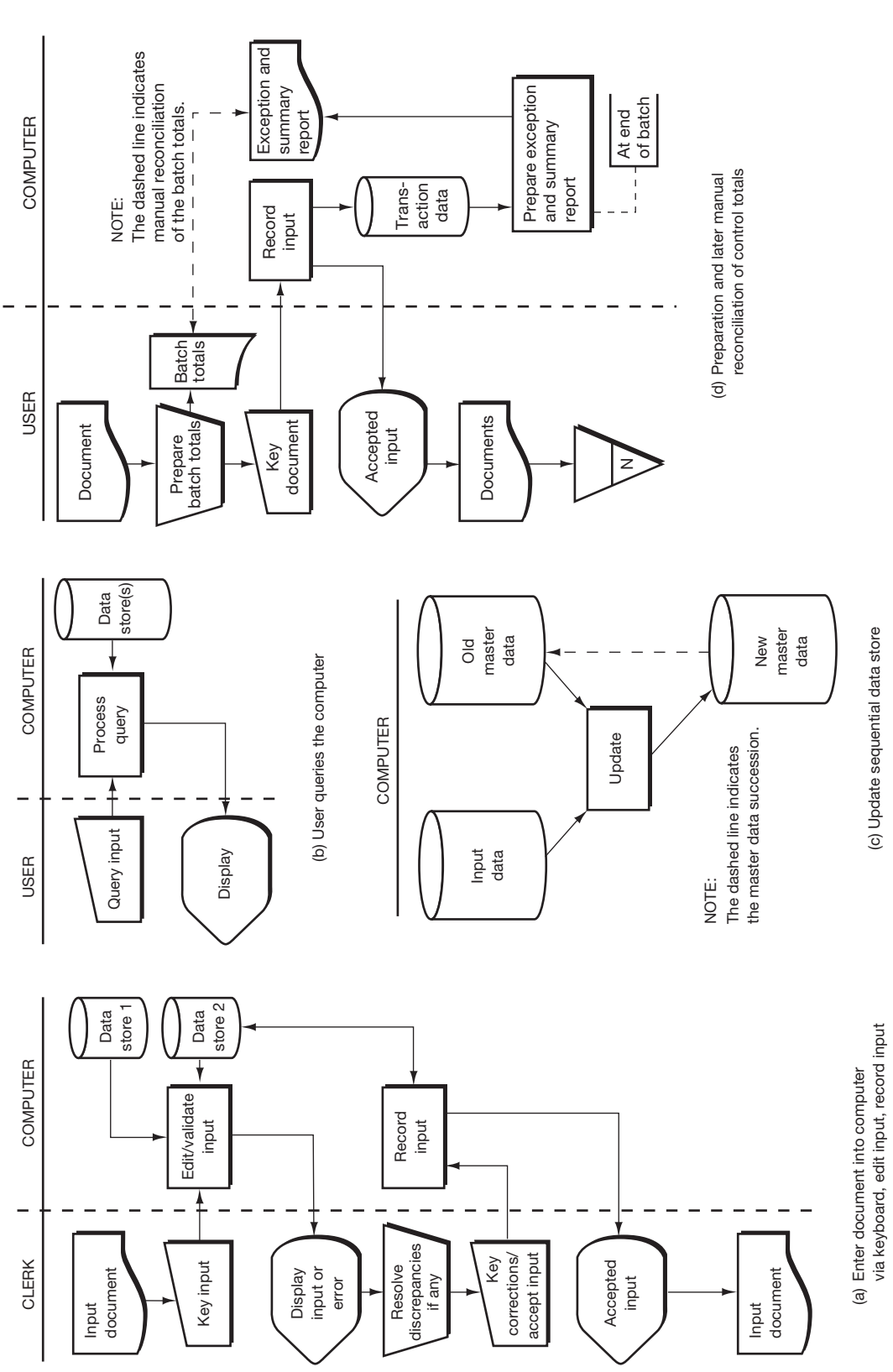


Figure 2.7 Common Systems Flowcharting Routines *(continued)*

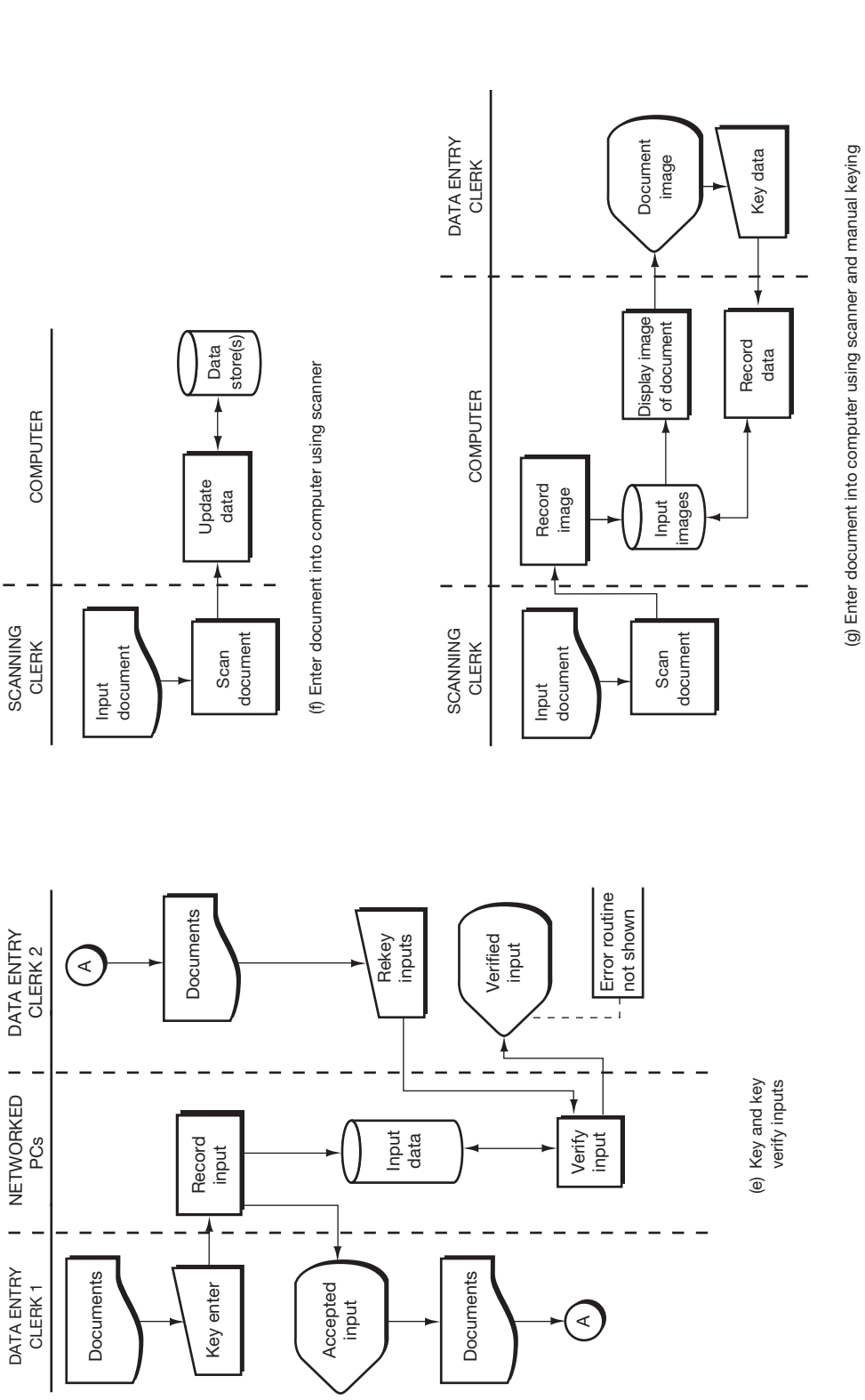


Figure 2.7, part (d), depicts the input and reconciliation of computer inputs and might be described as follows:

The user collects a number of input documents in a "batch" (such as a week's worth of time cards), prepares batch totals, and enters 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 (a list of inputs accepted and rejected by the system) that includes batch totals. The user compares the computer batch totals to those prepared prior to entry of the documents to make sure the data were entered correctly.

Notice the following about Figure 2.7, 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—rather than a manual process.
- If the batch totals had been input with the batch, the computer—rather than the user—could compare the batch totals.

Figure 2.7, part (e), depicts entry of data to a data entry system and might be described as follows:

A data entry clerk (perhaps clerk 1) enters documents into a PC (client) connected to a data entry 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*.[6] Differences are resolved and the transaction data are updated to reflect the verifications and corrections.

Notice the following about Figure 2.7, part (e):

- The key-to-disk unit is an offline device and should be depicted with a square—rather than a rectangle—and in a column separate from the computer.
- We show the data entry clerks in two columns to emphasize that the keying and two different clerks perform verification steps.
- Clerk 2 probably follows an established procedure to reconcile differences found during the verification step. We use the annotation about error routine to suggest the existence of these procedures.

Figure 2.7, part (f), depicts the entry and recording of an input using a scanner and might be described as follows:

A clerk scans a document (e.g., a customer's billing stub) into the computer. Using the data from the scanned document, the computer updates the data located on one or more data stores.

[6] 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.

Notice the following about Figure 2.7, 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.[7]

Figure 2.7, 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.

Reading Entity-Relationship Diagrams

Review Question

Distinguish the aspects of systems depicted by DFDs from those depicted by E-R diagrams.

As a professional you will likely be performing one or more of four functions. You might be (1) a business process *owner*; (2) a *designer* of an IS; (3) an IS *user*; or (4) an *evaluator* of an IS. To effectively perform these roles, you must be aware of the procedures used to develop and install an IS. Systems development procedures include two concurrent and often inseparable processes: the development of the system procedures and the design of the database. DFDs often portray system procedures, and entity-relationship diagrams often depict specifications for the database.

As you will see in Chapter 3, a *data model* depicts user requirements for data in the database. The model is expressed as a structure of entities and relationships among those entities. Figure 2.8 (page 38) depicts a data model expressed as an entity-relationship diagram. An **entity-relationship diagram** (also called an **E-R diagram**) reflects the system's key entities and the relationships among those entities and is commonly used to represent a data model. The rectangles are called "entities" and the diamonds are called "relationships." We use the E-R diagram because it helps us develop a *logical* model of the data—the entities and relationships—in a way that is independent of the way that we will physically implement the database.[8]

Review Question

What is an E-R diagram?

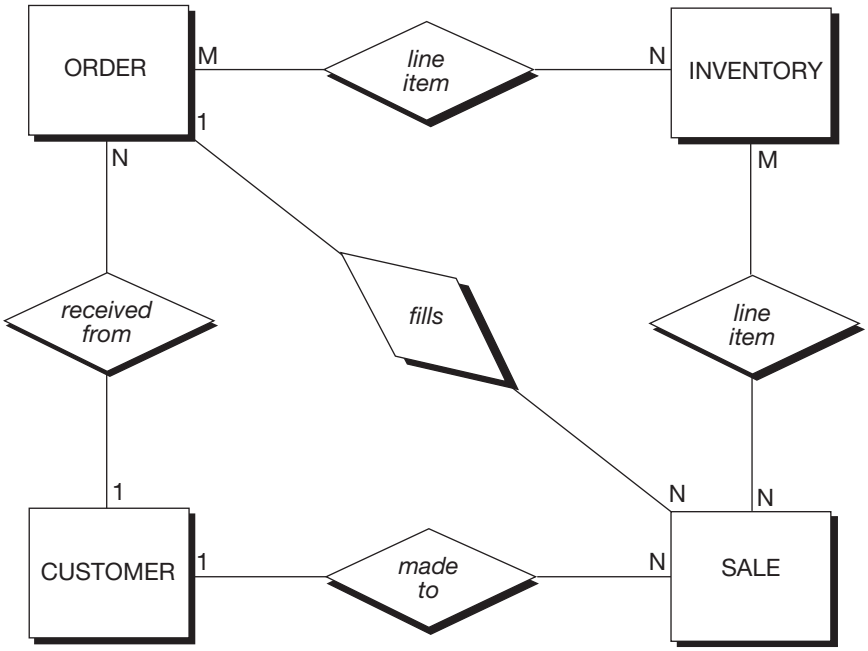
Let's see how to read an E-R diagram. The diamond (i.e., *relationship*) on the left side of the diagram tells us that an order is received from a customer. The formal notation is ORDER *received from* CUSTOMER. We might be confused by the diagram and want to say "CUSTOMER *received from* ORDER." But we can usually interpret the diagram correctly by knowing the sense of the relationship.

In Figure 2.8, the "N" beneath the ORDER rectangle tells us that each customer may have more than one order; the "1" above the CUSTOMER rectangle tells us that

[7] Document scanning and OCR are discussed in Chapter 4.

[8] Logical versus physical is a common theme in systems work. Earlier we introduced logical and physical DFDs. In Chapters 3, 6, and 7 (systems development), we emphasize the notion that to develop good systems—including good databases—logical design must *precede* physical design and implementation.

Figure 2.8 Entity-Relationship (E-R) Diagram



each order is from only 1 customer. This, the first of three relationship categories, is called "*one-to-N*," and the notation is 1:*N* (or "*N-to-one*" and noted as *N*:1).

The second relationship category is called "*M-to-N*," and the notation is *M:N*. In Figure 2.8, we see that each INVENTORY item has many ORDERs, and each ORDER has many INVENTORY items (a many-to-many relationship). Figure 2.8 also tells us that there are many SALES (shipments) for each INVENTORY item and that each SALE (shipment) can consist of many line items of inventory.

There is a third relationship category, called "*one-to-one*," and it uses the notation *1:1*. If, in Figure 2.8, only one SALE (shipment) filled an ORDER, there would be a 1:1 relationship between ORDER and SALE. In Chapter 3, we explore how to prepare an E-R diagram.

Review Question

Describe the symbols used in constructing E-R diagrams.

Conclusions

The diagramming tools introduced in this chapter illustrate common techniques business professionals encounter when seeking a pictorial representation of business processes and data relationships. Each technique has its own purpose, strengths, and weaknesses, which is why you have been shown a variety of them. After all, an architect would not use the same representation technique for house plans as a programmer would for computer code! 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 yourself. 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.

Appendix 2A

Preparing Data Flow Diagrams

We use DFDs in two main ways. We may draw them to document an existing system, or we may create them from scratch when developing a new system. Construction of DFDs for new systems will be described in the systems development chapters (Chapters 6 and 7). In this section, we explain a process for deriving a set of DFDs from a narrative that describes an existing system.

The Narrative

Figure 2.9 (page 40) contains a narrative describing the cash receipts system for the Causeway Company. The first column indicates the paragraph number; the second column contains the line number for the text of the narrative. We describe here an orderly method for drawing the DFDs for the Causeway system. You will get the most benefit from this section if you follow the instructions carefully, perform each step as directed, and don't read ahead. Draw your diagrams by hand or use the software package of your choice.

Table of Entities and Activities

Review Question

What is a 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.

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 entity* or an *external entity*. Activities can include actions related to data (originate, transform, file, or receive) or to a business process. Business 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 2.1 (page 41). Notice that the narrative refers to some entities in more than one way. For example, we have "accounts receivable" and the "clerk" on line 16. 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 itself. However, it is better to list doubtful activities than to miss an activity. See how we listed activity 11, found on lines 23 and 24. 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 continuing, resolve any differences between your list of entities and activities and those in Table 2.1.

Drawing the Context Diagram

We are now ready to draw the context diagram. Since a context diagram consists of only one circle, we can begin our context

Figure 2.9 Narrative of the Causeway Cash Receipts System

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

diagram by drawing one circle in the center of our paper. Next, we must draw the external entity boxes. To do this, we must decide which of the entities in Table 2.1 are external and which are internal to the system.

DFD guideline 1:

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

Information processing activities are those activities that 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 rec-

Table 2.1 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. Endorses checks.
Mailroom (clerk)	1	3. Writes the amount paid and the check number on the remittance advice.
Mailroom (clerk)	1	4. Prepares a batch total of the remittance advices.
Mailroom (clerk)	1	5. Sends the batch of remittance advices and the batch total to the accounts receivable clerk.
Mailroom (clerk)	1	6. Sends the batch of checks to the cashier.
Accounts receivable (clerk)	2	7. Enters the batch into the computer.
Accounts receivable (clerk)	2	8. Keys the batch total, the customer number, the invoice number, the amount paid, and the check number.
Computer	2	9. Verifies that the invoice is open and that the correct amount is being paid.
Computer	2	10. Updates the accounts receivable master data.
Computer	2	11. Notifies the clerk of errors.
Computer	4	12. Logs check number and amount paid.
Computer	3	13. Prints a deposit slip.
Cashier	3	14. Compares the deposit slip with the batch of checks.
Cashier	3	15. Takes the deposit to the bank.
Computer	4	16. Creates a cash receipts listing.
Computer	4	17. Prints a summary of customer accounts paid.
Accounts receivable (clerk)	4	18. Compares the computer reports with the remittance advices and batch totals.
Accounts receivable (clerk)	4	19. Sends the total of cash receipts to the general ledger office.

eiving of data between entities are not information processing activities because they do not transform data. If we send data to another entity, we do not process data. If, however, we file data, we do perform an information processing activity. Likewise, if we receive data from another entity, we do not perform an information processing activity. But, if we retrieve data from a file or table, we do perform an information processing activity. Operational, or physical, business process activities are not information processing activities.

To discover which entities perform no information processing activities, we 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 will be *external* entities; the remaining entities will be *internal*. Go through your table of entities and activities and mark all the activities that do not perform information processing activities. These marked activities—mostly sends and receives—indicate data flows.

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

Review Question

Which entities in a narrative are included in the context diagram as internal and which are shown as external?

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.

Since 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 non-information processing activities marked, should now indicate that the mailroom, accounts receivable, the cashier, and the 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 is an external entity.

Are there other external entities to be included in our diagrams? To answer this question, go through the narrative one more time and put a box around those entities not yet marked. You should find the bank (line 30) and the general ledger office (line 40) that, 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 three external entities, four internal entities, and 19 activities. *No other entities or activities are to be added* because of the following guideline:

DFD guideline 3:

Include on the systems documentation all (and only) activities and entities described in the system narrative—no more, no less.

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. It should be reviewed and revised by working with all participating internal entity representatives. When you have verified that your narrative is complete and that it accurately reflects reality, you must then follow DFD guideline 3.

Review Question

When do we have a choice as to what will be included in a context diagram?

Because there are three entities external to the Causeway cash receipts system—the customer, the bank, and the general ledger office—you must draw 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 usually 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 2.10 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 2.10 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:

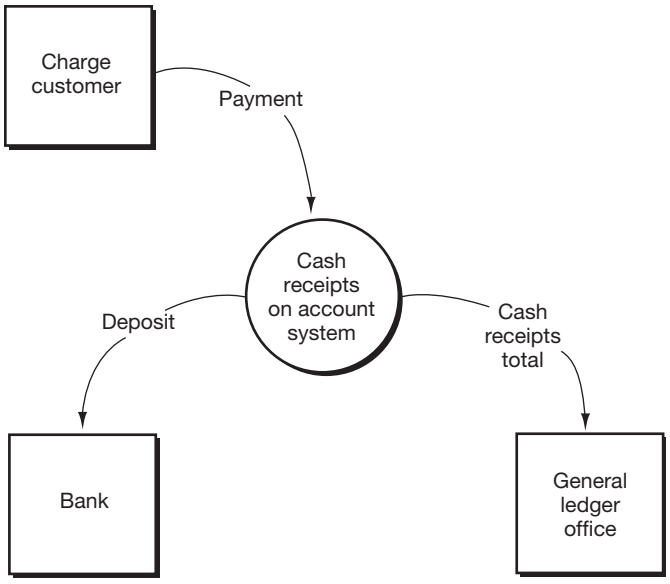
DFD guideline 4:

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 a current physical DFD by drawing the three external entities from the context diagram near the edges of a piece

Figure 2.10 Causeway Context Diagram



of paper. 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 we will sketch the rest of the diagram, as open as possible. As 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 the table of entities and activities (Table 2.1) becomes a bubble in our physical DFD, we know that our current physical DFD will contain four bubbles: one each for the mailroom, the cashier, accounts receivable, and the computer. We will start adding these four bubbles by first drawing the bubbles on our 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 to connect each of these three bubbles to its related external entity.

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. 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. To perform activity 18, accounts receivable must receive the reports from the computer. Draw and label one or two flows (we chose two flows) from the computer to accounts receivable. To perform activity 14, the cashier must receive the deposit slip from the computer. Activity 16 implies that the table of accounts receivable master data must be read so that the open invoice record can be retrieved. 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. Also, notice that we did not show a flow from the accounts receivable data store directly to the accounts receivable bubble. Because the accounts receivable data store is on a computer disk, only the computer can read from or write to that disk. 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.

Because the open invoice record must be read into the computer, updated, and then written back to the accounts receivable master table, activity 10 requires a data flow from *and* to the accounts receivable data store. But, since we drew a flow from the data store for activity 9, 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. Finally, 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. You may think that all the flows into and out of the data stores aren't necessary. Here is a guideline:

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").

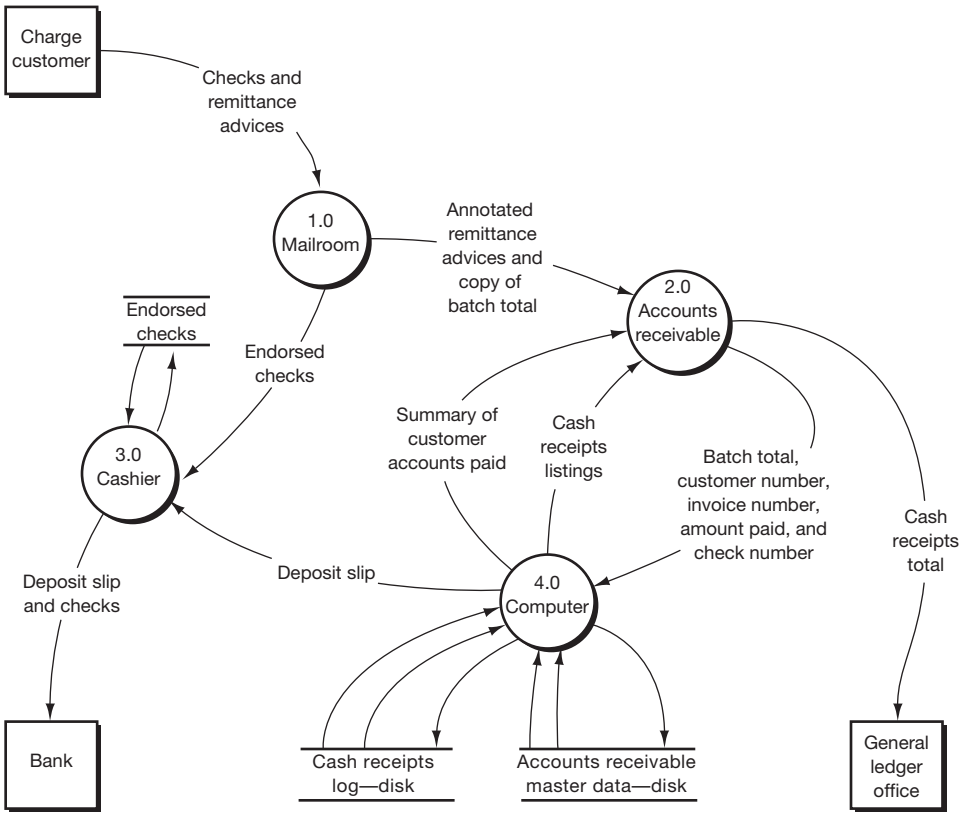
Figure 2.11 is the completed Causeway current physical DFD. Compare it to your diagram and, before continuing, resolve any differences. You should notice that there is a data store of endorsed checks connected to the cashier. This file, not mentioned in the narrative, was added to show that the cashier must hold on to batches of checks until the deposit slip is printed on the computer terminal. This format leads to another 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, whether or not it is 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 files and are therefore difficult to read. You 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; while DFD guideline 6 tells you to describe those activities completely. 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? Because they are *outside the context* of this particular system, the following activities are not described in the narrative (Figure 2.9) and should not be included in the diagrams:

Figure 2.11 Causeway Current Physical DFD



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

Review Question

Which activities can be included in the logical processes on a logical DFD?

Drawing the Current Logical Data Flow Diagram

The current logical DFD portrays the logical activities performed within the system. Because level 0 DFDs depict a particular grouping of the logical activities, we start the level 0 DFD by enumerating the activities in the system; then, we group those activities. You already have a list of the activities to be included in the level 0 DFD. Do you know what that list is? The activities to be included in the level 0 DFD are the *unmarked* activities on the table of entities and activities, Table 2.1. 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, are actions that merely send or receive data rather than transform data, or are business process activities, such as picking goods off the shelf. Several guidelines will help us to group the activities remaining in our 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.

Review Question

What are the guidelines for grouping logical activities for a logical DFD?

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.[9]

To start preparing your logical DFD, try bracketing the activities in Table 2.1 as you believe 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. Since 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 activities 8 with 9, 10, and 12; 13 with 14; and 16 and 17 with 18. This solution is also fine, and is a little better than our first solution because we now have five bubbles and we have 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.

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 transaction 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.

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

Table 2.2 Table of Entities and Activities for Causeway Cash Receipts System (Annotated)

Entities	Para	Activities	
Mailroom (clerk)	1	2. Endorses checks.	*1.0 Capture cash receipts*
	1	3. Writes the amount paid and the check number on the remittance advice.	
	1	4. Prepares a batch total of the remittance advices.	
Accounts receivable (clerk)	2	8. Keys the batch total, the customer number, the invoice number, the amount paid, and the check number.	*2.0 Record customer collections*
Computer (online terminal)	2	9. Verifies that the invoice is open and that the correct amount is being paid.	
	2	10. Updates the accounts receivable master data.	
	4	12. Logs check number & amount paid.	
Computer (online terminal)	3	13. Prints a deposit slip.	*3.0 Prepare deposit checks*
Cashier	3	14. Compares the deposit slip with the batch of	
Computer (online terminal)	4	16. Creates a cash receipts listing.	*4.0 Prepare cash receipts total*
	4	17. Prints a summary of customer accounts paid.	
Accounts receivable (clerk)	4	18. Compares the computer reports with remittance advices and batch totals.	

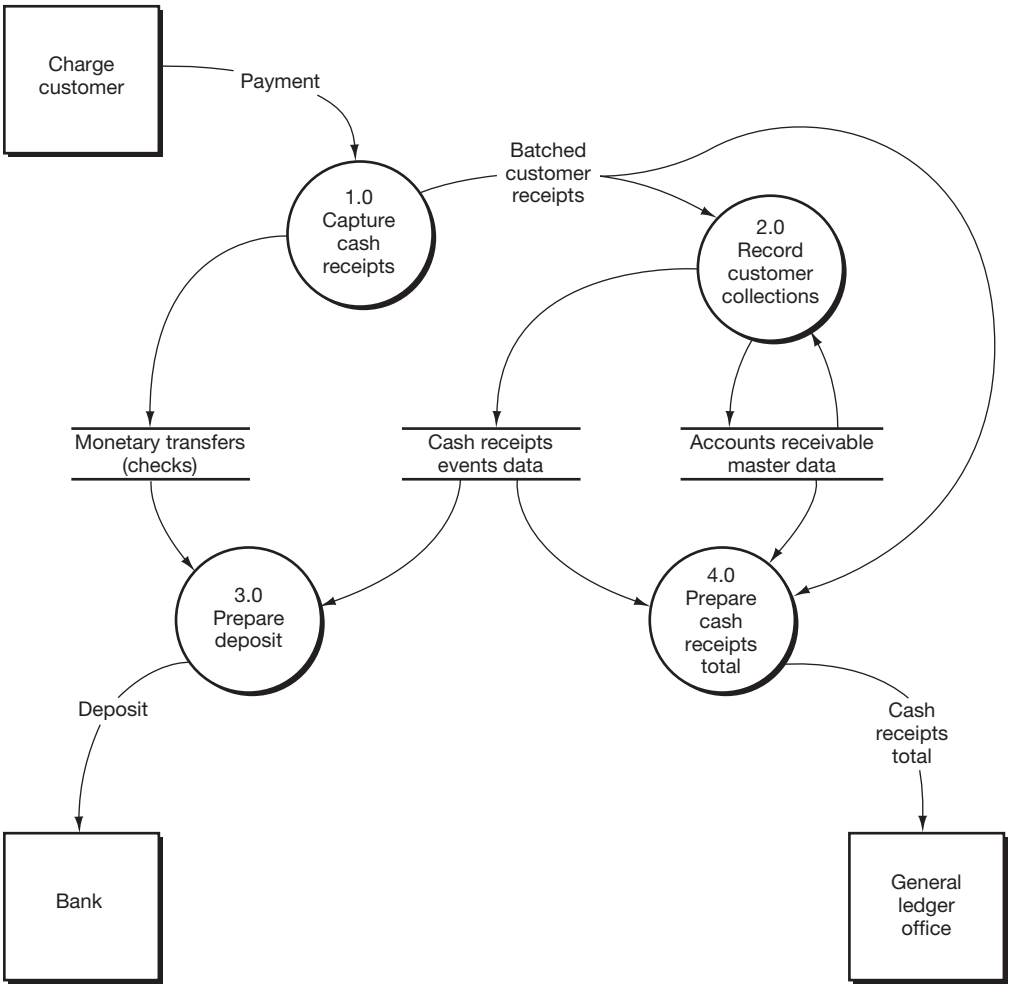
Mark these groups and labels on Table 2.1.

Table 2.2 demonstrates how you should annotate your table of entities and activities. (Notice that we have not carried forward from Table 2.1 the marked activities.) Now draw the current logical DFD for Causeway. You'll need paper and pencil (or your computer), the Causeway context diagram (Figure 2.10), the Causeway current physical DFD (Figure 2.11), your annotated table of entities and activities (Table 2.2), and your original table of entities and activities (Table 2.1). To draw the logical DFD, begin in the same manner that you began to draw the current physical DFD. Draw the external entities near the edges of a piece of paper. 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. Since 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 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 2.1). For the logical DFD, we'll call this flow "Monetary transfers." The other data flow out from bubble 1.0 was called "Annotated remittance advices and copy of batch total" (see activity 5 on Table 2.1). For the logical DFD, let's call it "Batched customer receipts." Before moving on, compare your drawing to bubble 1.0 in Figure 2.12 (page 48).

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 data store. Draw the data store for this table (remember, use a logical label) and a flow *from* the data store into bubble 2.0. Activity 9 occurs within the bubble. What are the outputs? Activity 10 indicates a flow *to* the accounts receivable master data store, and activity 12

Figure 2.12 Causeway Current Logical DFD (Level 0)



indicates a flow *to* the cash receipts events data store. Draw the data store for the event 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 2.12.

Now draw bubble 3.0. To accomplish activity 13, bubble 3.0 must obtain the records contained on the cash receipts events data store. 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 on Table 2.1 indicates that bubble 3.0 should be connected to the flow "Deposit" going into the Bank. Compare your drawing to bubble 3.0 in Figure 2.12.

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 data store. 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 data store. 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 RAs and batch totals. Where are those data? They are in the flow "Batched customer receipts" that went into bubble 2.0. Since 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 2.12. Resolve any discrepancies. Your diagram should look like that in Figure 2.12 *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.

There will be times when a *business operations* function performs information processing activities. For example, when the receiving department prepares a document indicating how many widgets have been received, the receiving department, which is primarily a business operations unit, is performing an information processing activity. The warehouse and the shipping department are other business operations units that often perform information processing activities. The following guideline applies:

DFD guideline 11:

A data flow should go to a business operations entity *square* when *only* business operations 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 external entity. A data flow should enter an entity *bubble* if the business operations entity is to perform an information processing activity.

For example, when the business operations entity is receiving goods, a physical DFD could show either a "receiving" box or a "receiving" bubble, whereas the logical DFD might show either a receiving department box 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.

Review Question

Where are error and exception routines shown on DFDs?

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.

Aren't there occasions when processing can't proceed as planned? Yes, and 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 transactions. 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.

Summary of Drawing DFD Diagrams

Although there are many ways to draw DFD diagrams, they all start with a careful examination of existing systems or processes, careful thinking about what really happens, and careful choices about how to accurately represent what happens using the diagrams. Our diagrams in this appendix were fairly simple, although a lot of thought went into making decisions about them.

The basic steps of the process are these:

- Create or obtain an accurate and reliable narrative.
- From the narrative, create a complete table of entities and activites.
- Draw a context diagram with external entity boxes by distinguishing carefully between internal and external entities.
- Draw current physical flow diagrams by creating bubbles for internal entities, and showing flows to and from all entities and data stores.
- Draw current logical flow diagrams by grouping activities that occur together, and naming the logical sub-processes each describes. Remember to balance this diagram with the other diagrams by matching their external entities and their data flows.

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

Appendix 2B

Preparing Systems Flowcharts

This section describes steps for preparing a systems flowchart. The following guidelines outline our basic flowcharting technique.

Systems flowcharting guideline 1:

Divide the flowchart into columns; one column for each internal entity and 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 so as 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. Do not glue, tape, staple, or otherwise "extend" your flowchart page to get the flowchart onto one page.

To use an off-page connector, draw the symbol shown in Figure 2.6 (page 32) 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 should be "P. 2, A" on page 1 and "P. 1, A" on page 2. That is, you point to page 2 from page 1 and you point back to page 1 from page 2. If you draft your flowchart on paper, discipline yourself to draw flowcharts on paper of limited size, as 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 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-enter 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 2.7 on p. 34].

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. The entities in our current physical DFD (Figure 2.11, page 45) should help us to set up and label our columns. Although we set up columns for each entity (systems flowcharting guideline 1), we do not have to include columns for the customer, the bank, or the general ledger office because these entities do not perform any information processing activities. Since 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. Since 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. 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 tells us that the mailroom clerk "endorses" the checks, and lines 6 and 7 tells 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 (and because our description of the actions would not fit in one process symbol), we'll use two processes. Draw these processes.

In lines 9 and 10, 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 2.6 (page 32) and annotate the batch total preparation process to describe the periodic nature of the process.

Lines 11 through 15 describe the three items exiting the mailroom and their destination. All three items should exit the batch total preparation process. Since 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. Since you'll probably have more room in the "Accounts receivable" column, draw these items at the top of that column. Your flow line will require arrows because your logic flow has gone up, rather than down! Did you find the symbol for batch totals on Figure 2.6?

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 when we described the current physical DFD (Figure 2.11, page 45). Notice that the on-page connector is shown where the process ends and again where the process begins. 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 2.13 (page 54) and compare it to your solution. Resolve any discrepancies.

Let's return now to drawing Figure 2.13. 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 table. Figure 2.7, part (a), page 34, 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 of Figure 2.7, while the computer files and computer process are located in the "Computer" column. Figure 2.7, 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 2.7, 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 screen, as shown in Figure 2.7, part (a)]. If the computer does not accept the input, we can assume

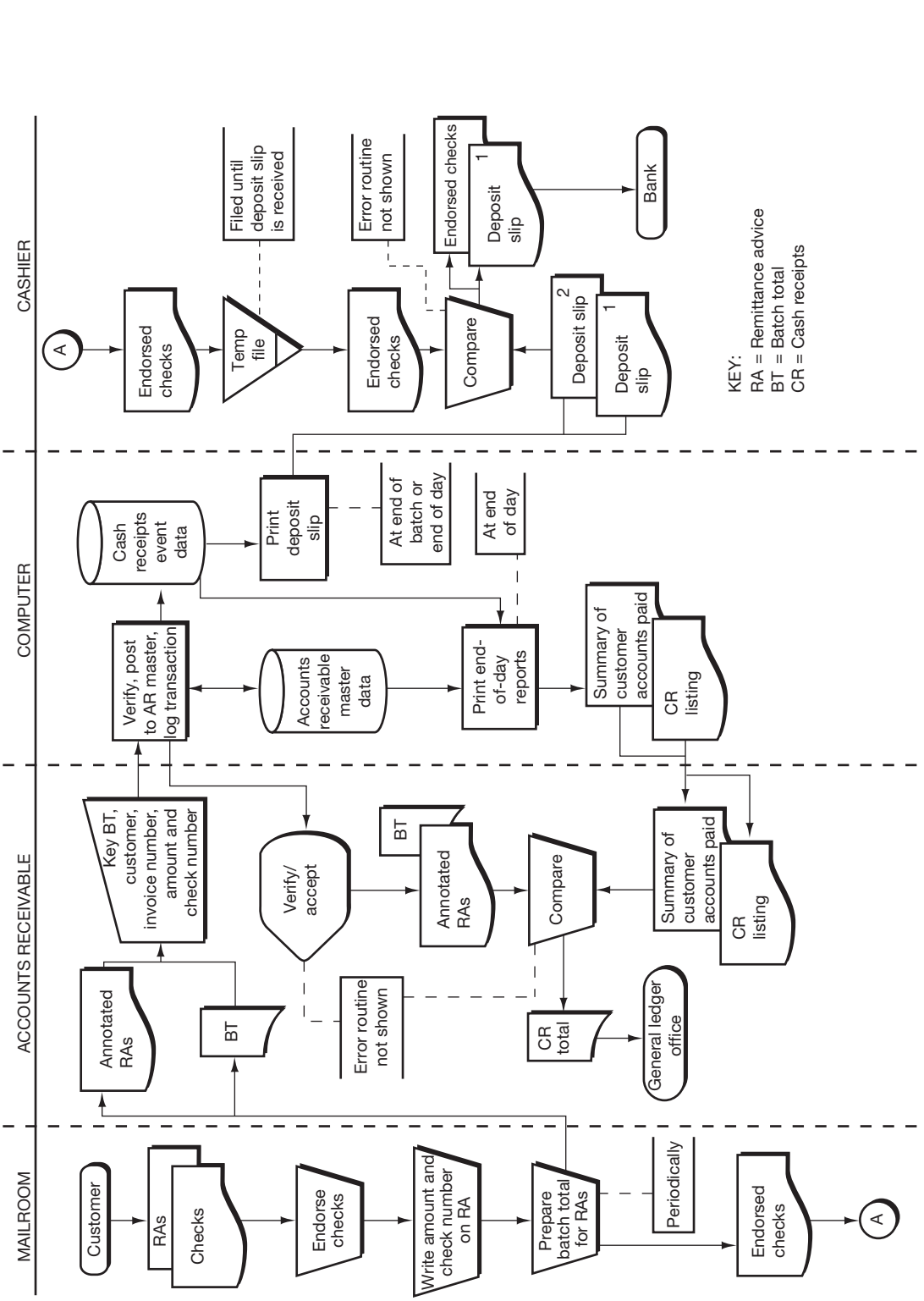


Figure 2.13 Causeway Systems Flowchart

that the accounts receivable clerk will correct and re-input 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 symbol. Lines 31 through 33 (paragraph 4) tell us that the transactions 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 2.13 and compare it to your solution. Resolve any discrepancies.

Let's return once again to drawing Figure 2.13. Narrative paragraph 3, lines 25 through 28, describes the process by which the computer prints the deposit slip in the cashier's office. What data must be accessed to get the information for the deposit slip? The cash receipts log has the check number and the amount, and is the only table that contains *only* 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 27 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. Since 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 2.13.

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 36 through 40. Since 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 2.6 shows that the symbol used for batch totals can be used for any total. However, as the narrative is not clear, you would not be wrong in using the general-purpose input-output file symbol (parallelogram). Since 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 through the table of entities and activities (Table 2.1, page 41) to make sure that each activity has been diagrammed. Compare your flowchart to the narrative (Figure 2.9, page 40) 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 2.13. Resolve any discrepancies.

Summary of Systems Flowcharting

As with DFDs, there may be numerous ways to create an accurate systems flowchart. The general process is to:

- ◇ Set up and label columns, one for each internal and one for each external entity.

- ◇ Use narratives, tables of entities and activities, and DFD physical and logical diagrams for source information for the flowchart.
- ◇ Show activities proceeding from top to bottom and left to right. Keep a flowchart as clear and simple as possible while representing activities fully. Keep the flowchart to a single page, using off-page connectors when necessary.
- ◇ Use appropriate flowcharting symbols to show all processing that occurs.
- ◇ 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.
- ◇ Compare the finished flowchart to narratives, activities and entities tables, and physical and logical DFDs to make sure all activities are accounted for fully.

Review Question

Where are error and exception routines shown on systems flowcharts?

Drawing flowcharts requires judgment, which you can develop through practice. You have seen a number of guidelines to help you as you learn how 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. We want to portray a system's logic and implementation *accurately*, and there can be many correct solutions. With practice, you can learn to use these techniques to create the most appropriate one.

REVIEW QUESTIONS

RQ2-1 Why do we need to document an Information System?

RQ2-2 What is a physical data flow diagram (DFD)?

RQ2-3 What is a logical data flow diagram (DFD)?

RQ2-4 Describe the symbols used in constructing data flow diagrams.

RQ2-5 What is the difference between a context diagram, a logical DFD, and a physical DFD?

RQ2-6 What is a systems flowchart?

RQ2-7 What are the similarities and differences between a systems flowchart and a DFD?

RQ2-8 Distinguish the aspects of systems depicted by DFDs from those depicted by E-R diagrams.

RQ2-9 What is an E-R diagram?

RQ2-10 Describe the symbols used in constructing E-R diagrams.

RQ2-11 What is a table of entities and activities?

RQ2-12 Which entities in a narrative are included in the context diagram as internal and which are shown as external?

RQ2-13 When do we have a choice as to what will be included in a context diagram?

RQ2-14 Which activities can be included in the logical processes on a logical DFD?

RQ2-15 What are the guidelines for grouping logical activities for a logical DFD?

RQ2-16 Where are error and exception routines shown on DFDs?

RQ2-17 Where are error and exception routines shown on systems flowcharts?

DISCUSSION QUESTIONS

DQ2-1 "Data flow diagrams and flowcharts provide redundant pictures of an Information System. We don't need both." Discuss.

DQ2-2 "It is easier to learn to prepare data flow diagrams, which use only a few symbols, than it is to learn to prepare flowcharts, which use a number of different symbols." Discuss.

DQ2-3 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.

DQ2-4 Why are there *many* correct logical DFD solutions? Why is there only *one* correct physical DFD solution?

DQ2-5 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.

DQ2-6 Compare and contrast the purpose of and techniques used in drawing physical DFDs and logical DFDs.

DQ2-7 "If we document a system with a systems flowchart, data flow diagrams, and E-R diagrams, we have over-documented the system." Discuss.

DQ2-8 "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? Why or why not?

DQ2-9 "In terms of the sequence used in documenting systems, it would be easier to prepare a systems flowchart *before* we prepare a data flow diagrams." Do you agree?

DQ2-10 "Since 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? Why or why not?

PROBLEMS

P2-1 Prepare a narrative to describe the system depicted in the physical DFD in Figure 2.14.

P2-2 Prepare a narrative to describe the system depicted in the logical DFD in Figure 2.15.

P2-3 Prepare a narrative to describe the system depicted in the flowchart in Figure 2.16 (page 60).

P2-4 a. List the entities and activities in Figure 2.17 (page 61).

b. Prepare a statement for *each* entity-relationship pair in Figure 2.17. (There are six pairs.) Each statement should explain the relationship category (e.g.,

Figure 2.14 Physical DFD for Problem 2-1

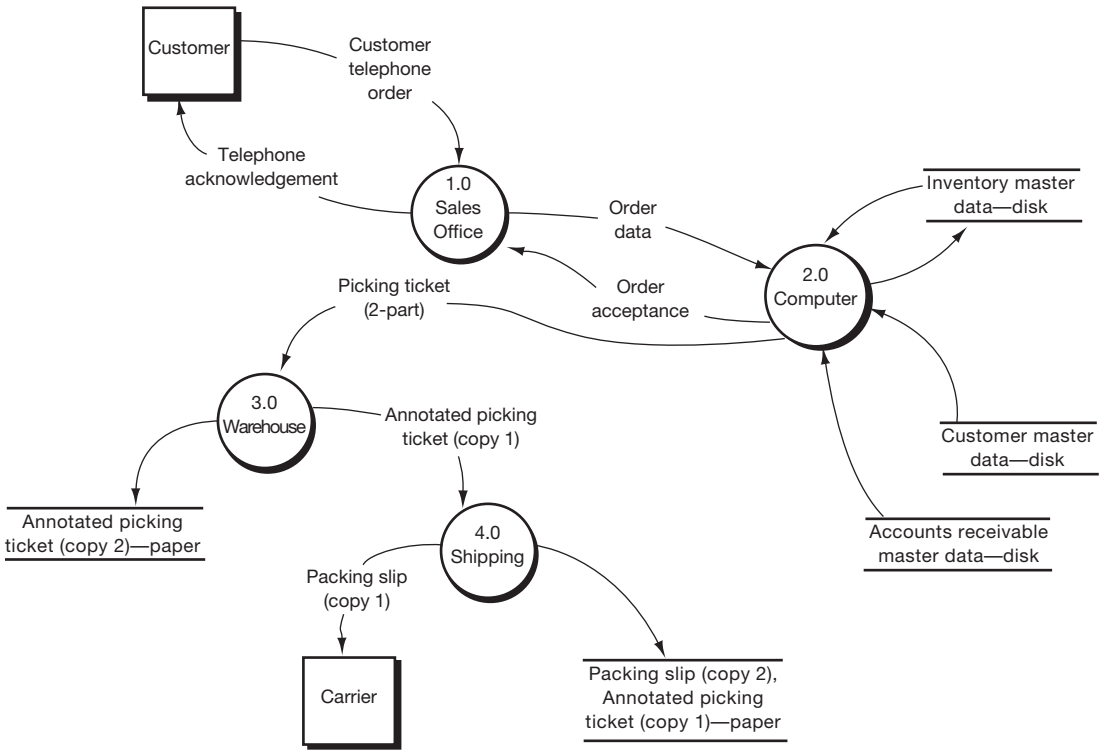
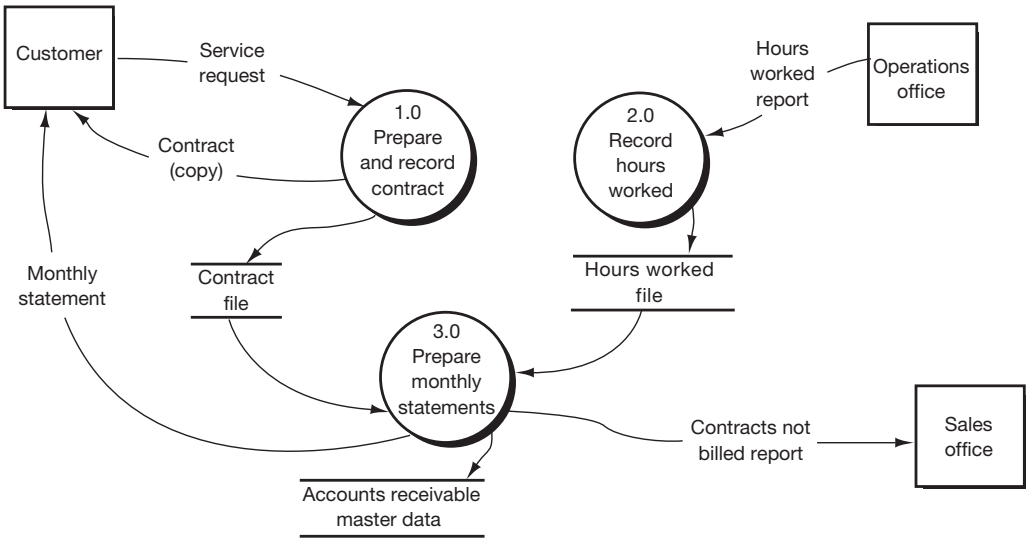


Figure 2.15 Logical DFD for Problem 2-2



"N-to-1," "1-to-N," "1-to-1," etc.). For example, to describe the order-customer relationship in Figure 2.8 on page 38, we might say: "Orders are received from customers. A customer may place many orders (N) but each order is from only one customer (1), an N-to-1 relationship."

APPENDICES 2A AND 2B.

P2-5 through P2-8. Problems 5 through 8 are based on the following two narratives. Lincoln Company describes sales and credit card billing systems. Bono Insurance describes an automobile insurance order entry and billing system. For those who wish to test their documentation skills beyond the problems below, there are narratives at the end of Chapters 10 through 12. Note that for the Lincoln case we do not discuss, and you should ignore, the handling of cash received at the time of a sale.

Lincoln Company

The Lincoln Company operates pet supply stores at many locations throughout New England. The company's headquarters are in Boston. The company accepts cash and its own Lincoln charge card (LCC). LCC billing and the treasury functions are located at headquarters.

At each store a customer presents the item(s) to be purchased along with cash or a LCC. Sales clerks prepare LCC slips and then all sales—cash and charge—are keyed into the cash register. At the end of the shift, the clerk forwards the LCC slips to the store cashier (again, as noted above, ignore the handling of the cash). The store cashier batches the LCC slips and sends the batches to the cash receipts department in Boston at 5:00 p.m. each day.

As each sale is keyed in by the sales clerks, Lincoln's central computer system captures the data and stores them on a disk ("sales data"). Each night, the computer prints a sales report summarizing each store's sales data. On the following

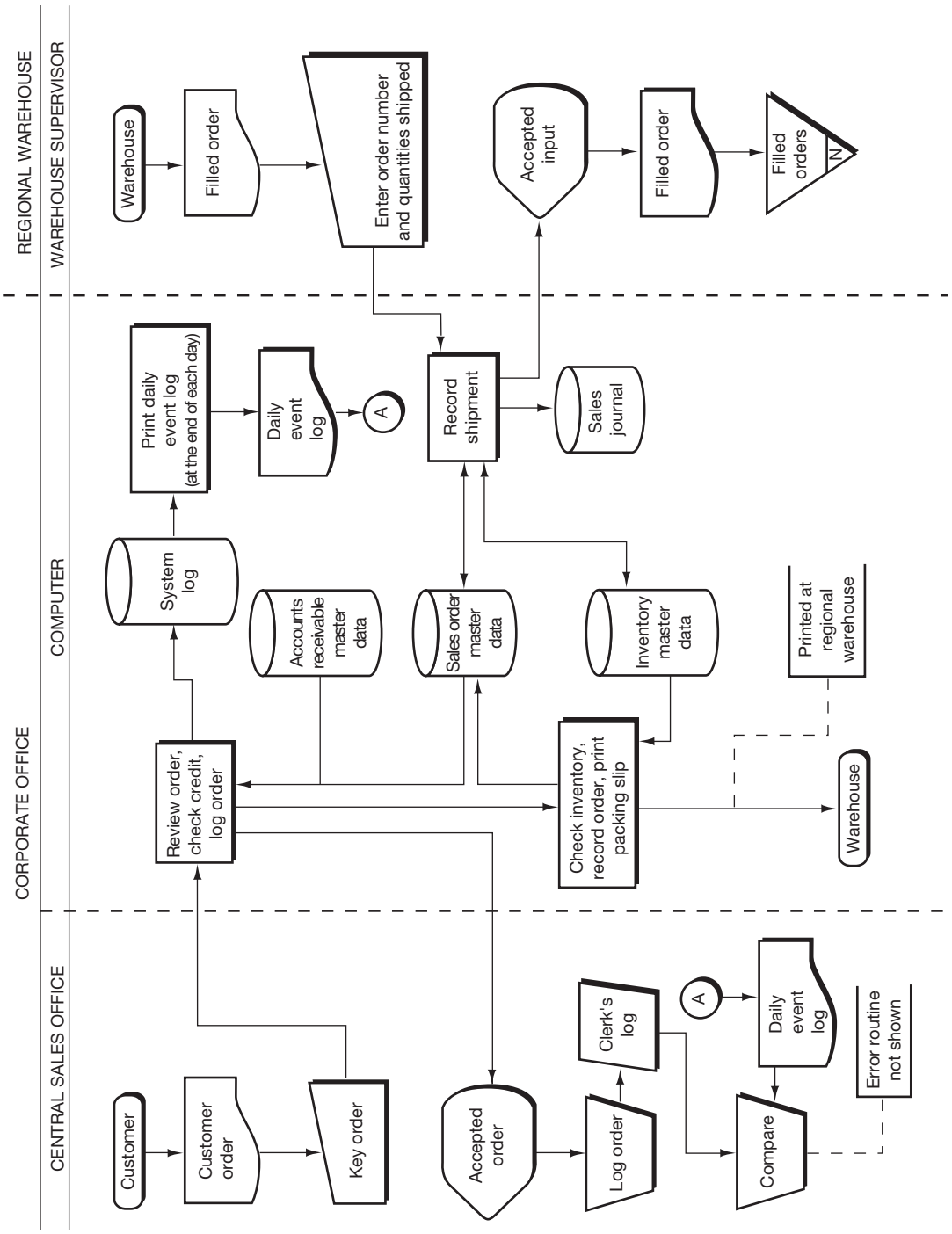
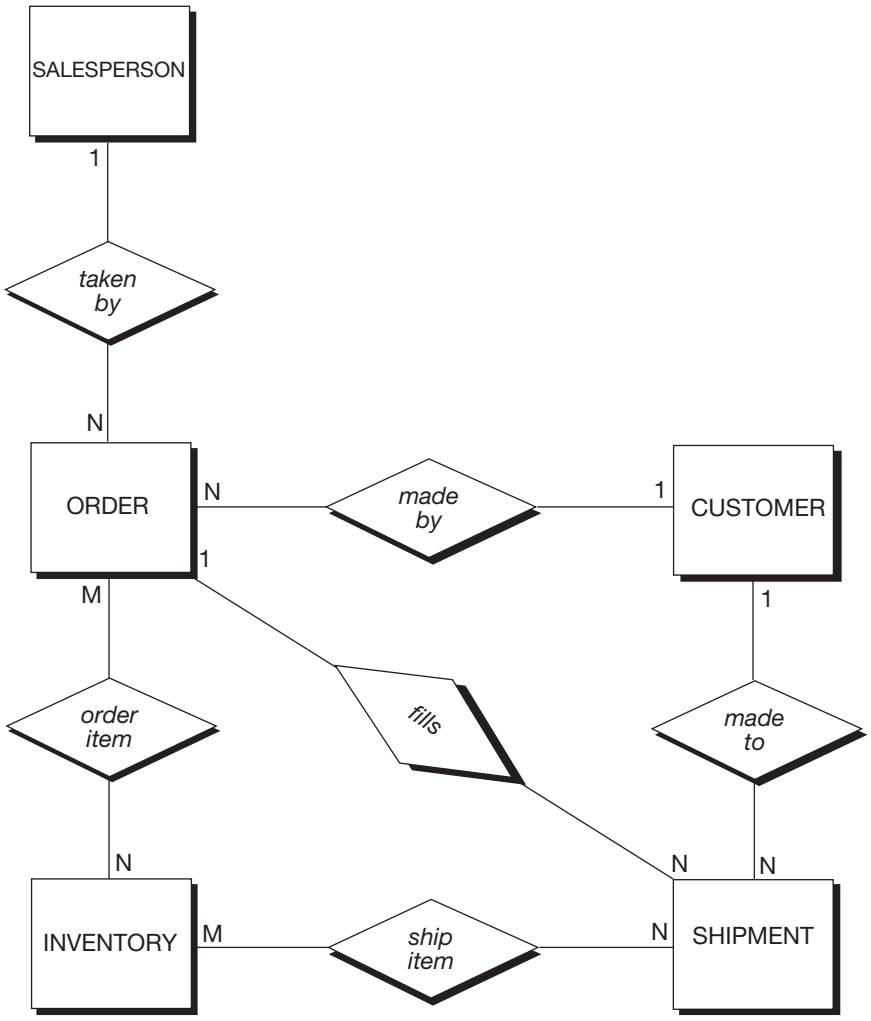


Figure 2.16 Flowchart for Problem 2-3

Figure 2.17 Entity-Relationship (E-R) Diagram for Problem 2-4



morning, the sales report is sent to the cash receipts department, where the LCC slips for each store are reconciled to the line on the sales report that totals LCC sales for that store. The LCC slips are then sent to Lincoln's IT division, where data preparation clerks scan the LCC slips to record the charges on a disk ("credit sales data"). At 9:00 p.m. each evening, the disk containing the credit sales data is e-mailed as an attachment to the computer room, where it is used to update the accounts receivable master data (also on disk). Each month, the computer prepares customer statements that summarize the LCC charges, and sends the statements to the customers.

Bono Insurance

The Bono Insurance Company of Needham, Massachusetts, processes its automobile insurance policies on a batch-oriented computer system. Customers send requests for auto insurance into the Needham sales office where sales clerks prepare

policy request forms. These documents are forwarded to the input preparation department where data entry clerks use networked PCs to key and key-verify the data contained on the documents to a disk ("policy events").

Each evening, the computer operations department retrieves the policy events data from the network and edits the data on the computer and then sorts the data in policy number sequence. Events data that do not pass the edits are deleted from the events data disk and printed on an error report. The error report is sent to the sales office where sales clerks review the report, correct the errors (contacting the customer, if necessary), and prepare another policy request form. These forms are submitted to data preparation each day along with other policy request forms.

In addition to the error report, the computer also prints a summary report listing the good events data. This report is sent to the sales office where the sales clerks compare the report to the copy of the policy request form that they had previously filed. If everything checks out, they notify computer operations to go ahead with processing. When notified, computer operations processes the correct events 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.

P2-5 a. Prepare a table of entities and activities based on either the Lincoln Company or the Bono Insurance narrative.

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

P2-6 Prepare a physical DFD based on the output from Problem 5.

P2-7 a. Prepare an annotated table of entities and activities based on the output from Problem 5 and Problem 6. 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.

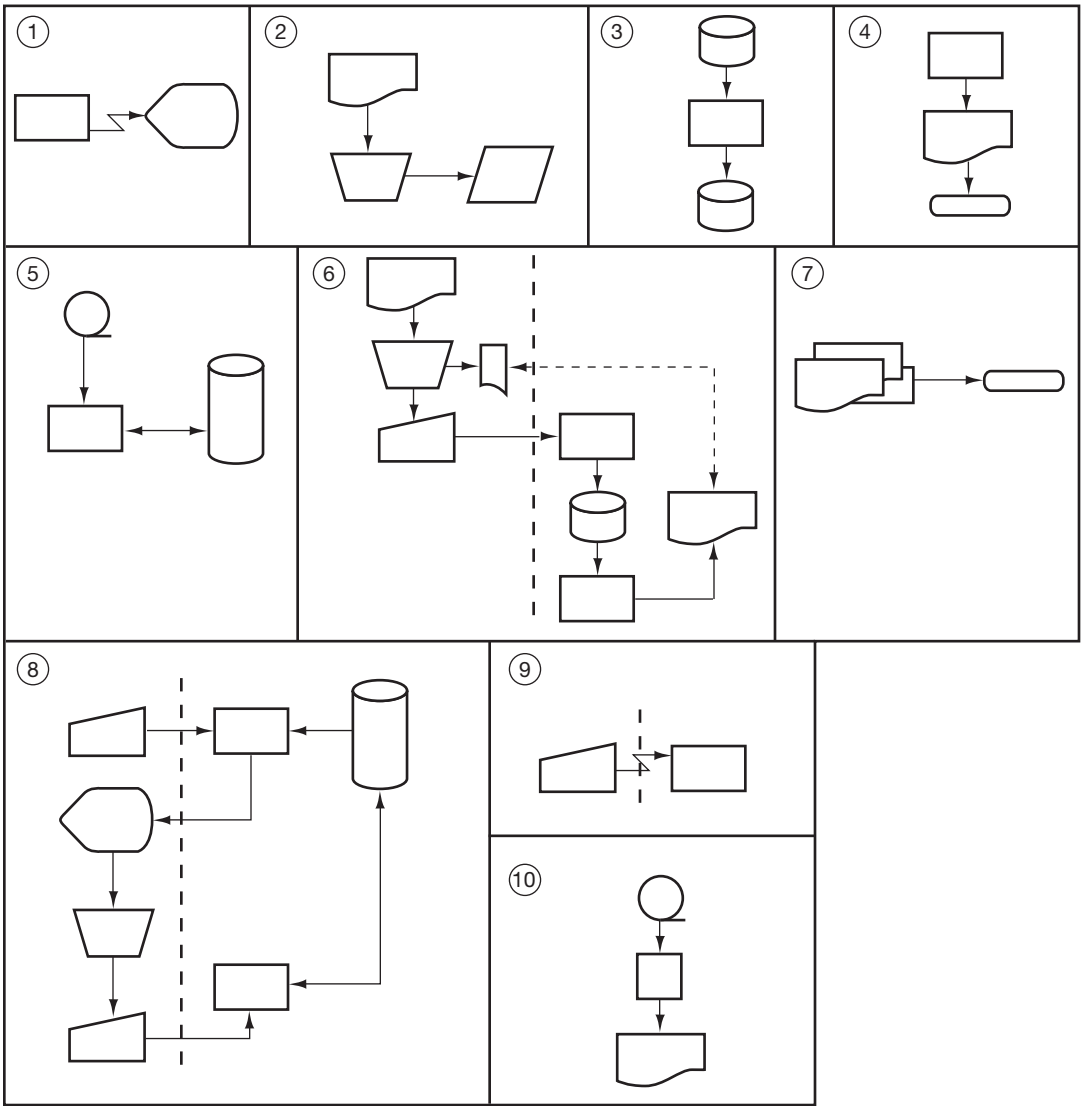
P2-8 Construct a systems flowchart based on the narrative and the output from Problems 5 through 7.

P2-9 A description of fourteen typical information processing routines is given here, along with ten numbered excerpts from systems flowcharts (see Figure 2.18).

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. A deposit slip and check are sent to a customer.
c. A printed output document is filed.
d. Output is sent to a computer screen at a remote location.
e. A clerk manually posts sales orders to the outstanding order data store.
f. A report is printed from the contents of a master data store.
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.

Figure 2.18 Flowchart Segments for Problem 2-9



i. Data are keyed from a terminal at a remote location.

j. A batch total is compared to the total reflected on an error and summary report.

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

l. The cash receipts summary report is sent by the accounts receivable department to the general ledger department.

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, then the master file is updated.

APPENDIX 2A P2-10 Refer to Figure 2.12 (see page 48), 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.