In the early 1980s Ford Motor Company decided to reduce its Accounts Payable staff from 500 to 400. Before paying a supplier, Accounts Payable verified that invoices from suppliers were consistent with what the Purchasing Department ordered and what the Receiving Department actually received. Ford representatives visited its Japanese affiliate, Mazda, to look for fresh ideas and were amazed that only five people performed Mazda's Accounts Payable function. Mazda had to be doing something totally different to account for the staffing difference.

The main difference involved the business process. When a shipment arrived at Mazda, the Receiving Department staff looked up the purchase order. If the material matched the purchase order completely, the Receiving Department entered a receipt confirmation into the database. Accounts Payable now had a very simple job of paying the supplier because Mazda had ordered the material and the supplier had delivered it. If the material did not match the purchase order completely, the shipment was simply returned. Refusing to accept an incorrect shipment meant that Accounts Payable never had to figure out how to reconcile inconsistencies between the purchase order, material delivered, and the invoice sent by the supplier.

Ford had used a very different method. The Receiving Department accepted some orders that did not match the purchase order exactly. The subsequent arrival of an invoice triggered Accounts Payable to try to verify how much material had been ordered and had arrived. Cases where the material received didn't match the purchase order required looking in several places and possibly making phone calls to figure out what to do.

After comparing their version and Mazda's version of the same business process, Ford decided to change its process by creating a shared database, changing its Receiving Department rules. In 1986, Ford employed 500 people paying bills in the old way. By 1990, only 125 were needed. Notice how the new information system was only part of the solution and succeeded only because of the reorganized workflow. Before changing its information systems Ford fixed its business process by eliminating steps that did not add value.

Data Flow Diagrams

Data flow diagrams (DFDs) represent the flows of data between different processes within a system. They provide a simple, intuitive method for describing business processes without focusing on the details of computer systems. Virtually anyone who works in a business can understand a carefully designed DFD and can point out errors or omissions. DFDs are an attractive technique because they describe what users do rather than what computers do and involve only four symbols: the process, data flow, data store, and external entity (see Figure 3.1).

The four DFD symbols focus the analysis on flows of data between subprocesses, rather than on the information technology used. This approach makes sense to business professionals, whose main concern is to make sure the information system supports or enforces a specific set of activities performed using specific methods.

An important limitation of DFDs is that they focus only on flows of information. There is no symbol for flows of material, such as the physical things actually ordered by Ford using its Purchasing system. In addition, DFDs do not include the symbols used in flowcharts for expressing decision points, sequences of operations, and other things that must be clarified before writing a computer program. The advantages of DFDs mirror their limitations. The fact that so few symbols are included makes it easy for users to understand DFDs and helps them focus on the business process. Other techniques such as flowcharts are used later to document decision criteria, timing of subprocesses, and other details not handled by DFDs.

Describing Business Process Organization and Hierarchy Figure 3.2 shows that the starting point when using DFDs is to create a context diagram, which verifies the
Symbols used in data flow diagrams

- **Process**: A process transforms inputs into outputs, and is represented by a rounded box. Processes are usually described by verbs such as select, purchase, calculate, decide, adjust, hire, and update.

- **Data flow**: A data flow represents movement of data between processes, data stores, and external entities. Data flows are represented by arrows, with the data identified along the arrow.

- **Data store**: A data store is a location where data is stored. It can be a file cabinet, diskette, hard disk, answering machine, or any other place that would be the answer to the question “Where is the data?” The symbol for a data store is an open rectangle.

- **External entity**: An external entity is any person or organization that provides data to a process in the system or receives data from a process. The symbol for an external entity is a square.

Data flow diagrams use only four symbols but can be applied to aid in understanding how the structure of a business process depends on the storage and flow of data.

The scope of the system by showing the sources and destinations of data used and generated by the system being modeled. At the center of the context diagram, the Purchasing system is represented as a single process. Surrounding that process are boxes representing the external entities that provide data for the Purchasing system or receive data from it. The external entities in this case are the Material Planning Department and the supplier. They are considered external to the business process because we are focusing on the flows of information related to ordering material, receiving it, and paying the supplier. System boundaries would be different for a different analysis.

In addition to bounding the system and summarizing flows of data, the context diagram might convey significant organizational issues and even surprises for some of the participants. First of all, it says that the system is called “Purchasing” even though it generates payments and therefore must include a payables process. Just this concept of

**Context diagram for the Ford purchasing system**

- **Material Planning Department**
- **Supplier**
- **Purchasing system**
- **Receiving Department**

This context diagram says that the system we are considering is the purchasing system, and that external entities include the supplier and two internal departments.
3.3 Data flow diagram showing the main processes in Ford's original purchasing system

This top-level data flow diagram breaks the business process into three separate processes: PCH 1, order the material; PCH 2, decide what to pay; PCH 3, pay the vendor. (PCH is an abbreviation for “purchasing.”)

A more integrated system might be very controversial. It also says that the material requirement comes from only one source, the Material Planning Department. People reviewing it might object that other groups should be able to submit orders. This example shows how using data flow diagrams helps in identifying and resolving issues about responsibility and authority before the technical system design begins.

After using the context diagram to establish the scope of the system, the next step is to identify processes and break them down into subprocesses to describe exactly how work is done. DFDs make it possible to look at business processes at any level of detail by breaking them down into successively finer subprocesses. This type of analysis is needed to understand what an information system should do in this situation.

Figure 3.3 shows what might have been the first step toward breaking down the original Purchasing system into its constituent processes. The original Purchasing system might be divided into three major processes: PCH 1, order the material; PCH 2, decide what to pay; PCH 3, pay the vendor. Notice how the second process involves reconciling data generated from three different places at three different times. This is a hint that a more effective process could be used. As is described in Box 3.1, the new business process gave the Receiving Department access to the purchase order file. If the material received matched the purchase order precisely, they accepted it and added a receipt confirmation to the purchase order file. Otherwise they simply returned it and the complex reconciliation process disappeared.

Compared to the context diagram, Figure 3.3 provides more information about how the business process operates but still doesn’t give enough information to understand it fully. Doing that would require breaking each of the three processes into subprocesses. For example, depending on how Ford truly ordered material, the process PCH 1 might be broken into the four subprocesses in Figure 3.4. Each of these subprocesses could be broken down into smaller subprocesses until drawing additional diagrams added no further understanding. The completed analysis would cover many pages but would permit a person to look at the business process in whatever level of detail was important for thinking about a particular issue.

You might wonder whether all this detail is necessary, especially for a manager or end user. In fact, it is absolutely necessary because managers and users are the ones who understand how processes operate in the organization. For example, Ford’s man-
This DFD divides business process PCH 1 into four possible subprocesses: PCH 1.1, identify qualified suppliers; PCH 1.2, negotiate prices and delivery terms; PCH 1.3, decide which supplier to use; PCH 1.4, create the purchase order.

Managers would certainly find fault with Figure 3.4 because much of Ford’s purchasing is done through long-term agreements. However, this is the point. Much of the value in developing DFDs results from resolving disagreements about how work is done currently or how it should be done in the future. If users and managers cannot or will not describe things at this level of detail, any attempt to build a new information system will probably fail due to disagreements about what it should do.

The data flow diagram is only one of many process-modeling techniques. This technique is easily understood by both system users and system developers, and it is used widely during the initial phases of information system development to clarify the boundaries and internal operation of the business process being studied. It is also incorporated directly into most computer-aided software engineering (CASE) systems (discussed in Chapter 9).

Flowcharts and Structured English

Even when DFDs are used extensively, other techniques often are used to fill in the details not adequately expressed by DFDs. For example, although they express data flows between processes, DFDs express neither the sequence and timing of processes nor the detailed logic of processes, such as the precise rules for selecting among alternative actions such as accept or reject. Furthermore, they do not represent the physical devices used by the data processing system. Flowcharts and structured English are two techniques used to document these essential details.