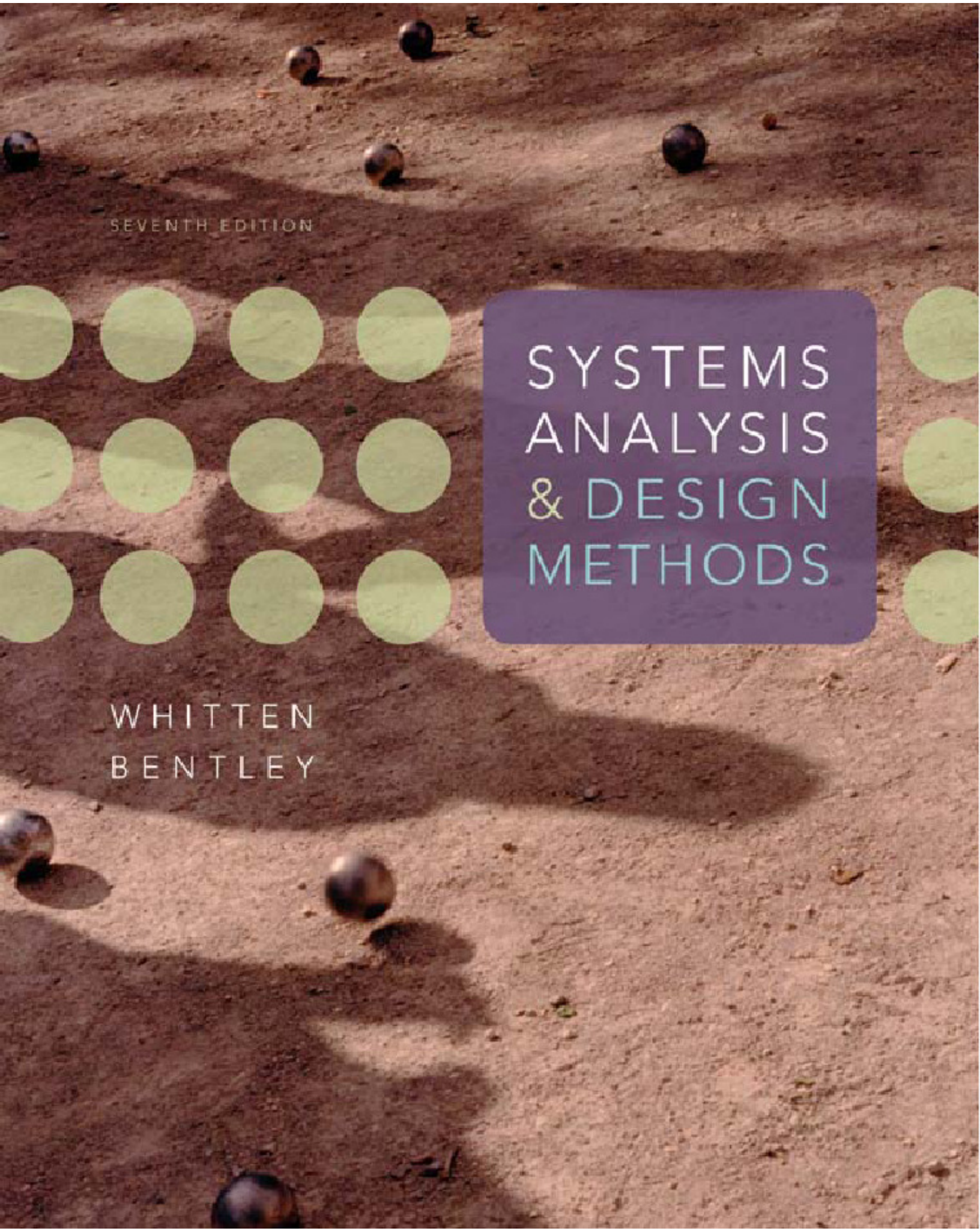

SEVENTH EDITION
SYSTEMS ANALYSIS & DESIGN METHODS
WHITTEN
BENTLEY

2 Information System Building Blocks

Chapter Preview and Objectives

Systems analysis and design methods are used to develop information systems for organizations. Before learning the *process* of building systems, you need a clear understanding of the *product* you are trying to build. This chapter takes an architectural look at information systems and applications. We will build a framework for information systems architecture that will subsequently be used to organize and relate all of the chapters in this book. The chapter will address the following areas:

- Differentiate between *front-* and *back-office* information systems.
- Describe the different classes of information system applications (*transaction processing, management information, decision support, expert, communication and collaboration,* and *office automation systems*) and how they interoperate to supplement one another.
- Describe the role of information systems architecture in systems development.
- Identify three high-level goals that provide system owners and system users with a perspective of an information system.
- Name three goal-oriented perspectives for any information systems.
- Identify three technologies that provide system designers and builders with a perspective of an information system.
- Describe four building blocks of the KNOWLEDGE goal for an information system.
- Describe four building blocks of the PROCESS goal for an information system.
- Describe four building blocks of the COMMUNICATIONS goal for an information system.
- Describe the role of network technologies as it relates to KNOWLEDGE, PROCESSES, and COMMUNICATIONS building blocks.

Introduction

The SoundStage member services system project is getting underway. Bob Martinez has been assigned the task of conducting initial meetings with groups of system users to gain their perspective on the system and what it must accomplish. He quickly discovered that everyone had a different perspective and expressed that perspective in a different language. In college, majoring in computer information systems technology, Bob tended to think about information systems in terms of programming languages, networking technologies, and databases. He found that the others didn't think in those terms. The system users talked about manual forms and how they were routed. They talked about policies and procedures and reports they needed. As he met with managers he heard them talk about strategic plans and how the system could give the organization a competitive edge.

It reminded Bob of the old story he had heard about three blind men who came upon an elephant. One felt the trunk and concluded that an elephant was like a snake. Another felt a leg and concluded that an elephant was like a tree. The third felt an ear and concluded that an elephant was like a fan. It didn't take Bob long to realize that the owners' and users' perspectives were just as valid as his. An information system is more than technology. It is mainly a tool that serves the goals of the organization.

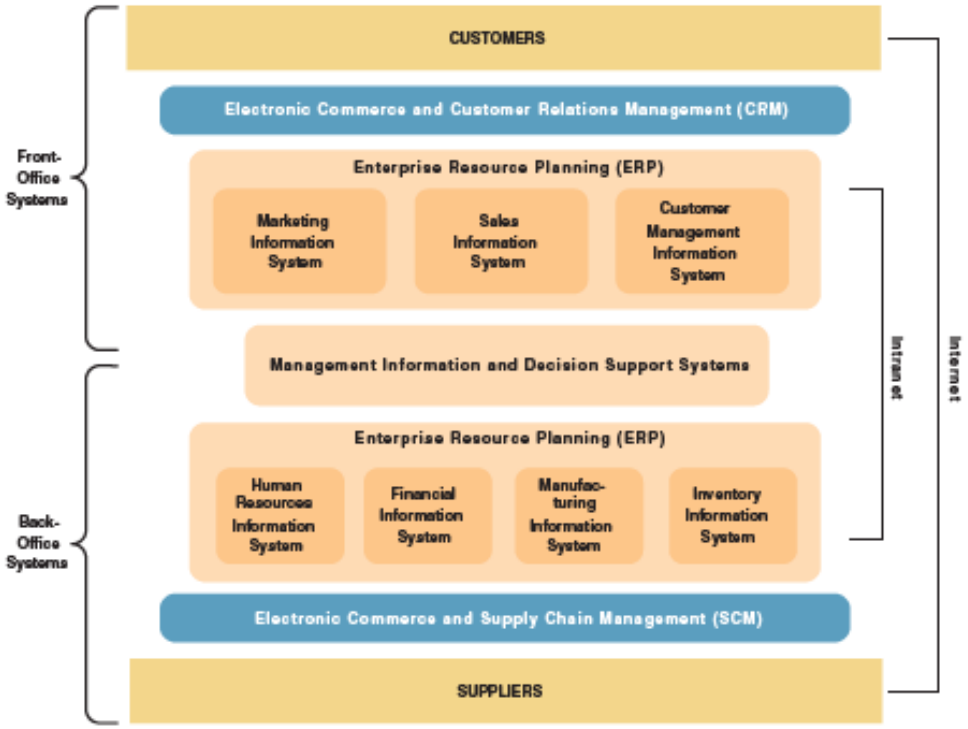
The Product—Information Systems

front-office information system an information system that supports business functions that extend out to the organization's customers.

In Chapter 1 you were introduced to information systems from four different perspectives, including stakeholders, business drivers, technology drivers, and the process of systems development. As suggested by the *home page* (see p. 42), this chapter will more closely examine the information system "product."

Organizations are served not by a single information system but, instead, by a federation of information systems that support various business functions. This idea is illustrated in Figure 2-1. Notice that most businesses have both **front-office**

FIGURE 2-1
A Federation of Information Systems



information systems that support business functions that reach out to customers (or constituents) and **back-office information systems** that support internal business operations as well as interact with suppliers. These front- and back-office information systems feed data to management information systems and decision support systems that support management needs of the business. Contemporary information systems are interfacing with customers and suppliers using electronic commerce technology, customer relations management (CRM), and supply chain management (SCM) applications (see descriptions in Chapter 1) over the Internet. Finally, most companies have some sort of intranet (internal to the business) to support communications between employees and the information systems.

back-office information system an information system that supports internal business operations of an organization, as well as reaches out to suppliers.

In Chapter 1 you learned that there are several classes of information system applications (see opposite page). Each class serves the needs of different types of users. In practice, these classes overlap such that it isn't always easy to differentiate one from another. The various applications should ideally interoperate to complement and supplement one another. Take a few moments to study Figure 2-2, which illustrates typical roles of information systems in an organization. The rounded rectangles represent various information systems. Notice that an organization can and will have multiple transaction-processing systems, office automation systems, and the like. The "drum" shapes represent stored data. Notice that an organization has multiple

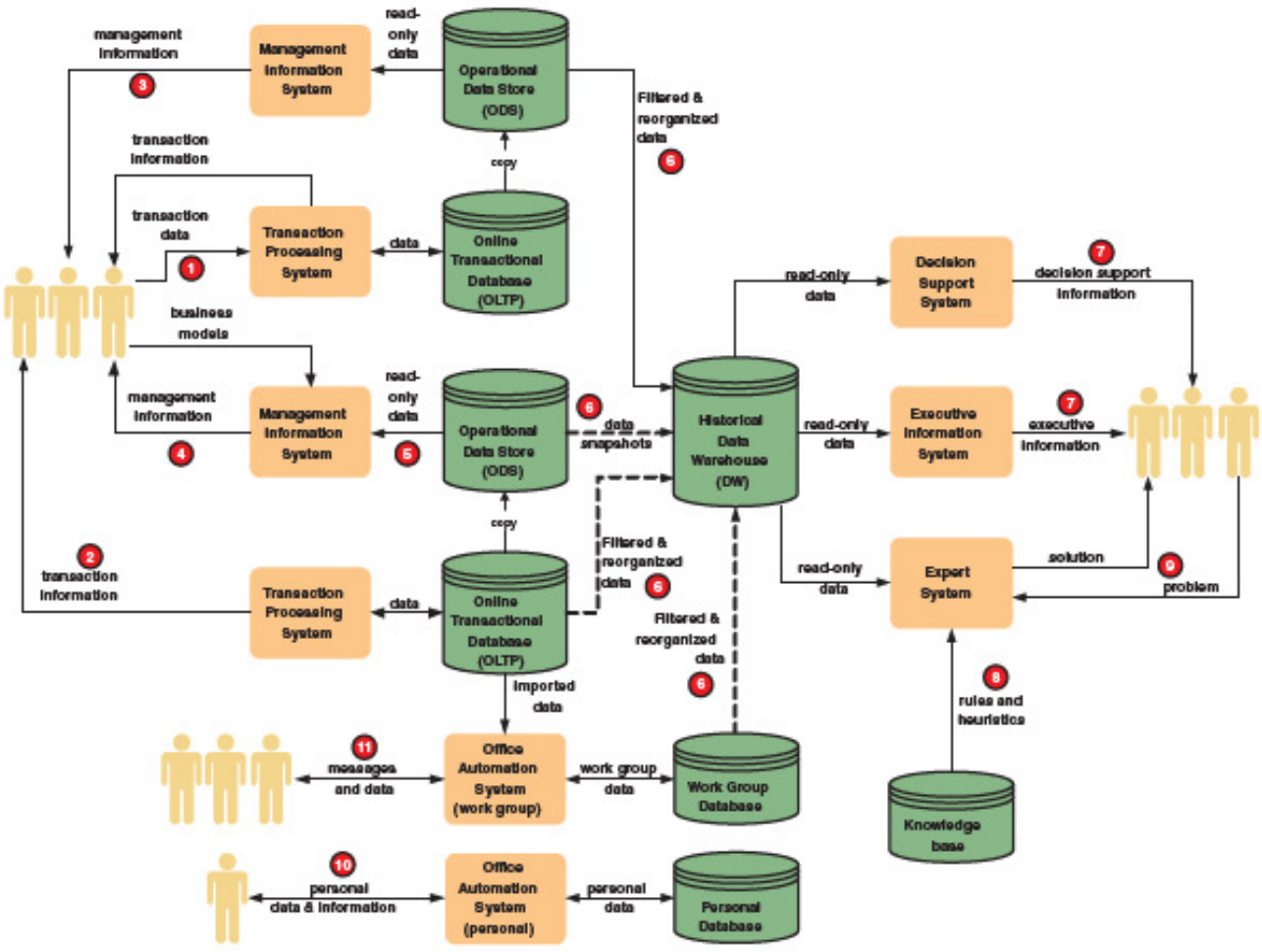


FIGURE 2-2 Information Systems Applications

CLASSES OF INFORMATION SYSTEM APPLICATIONS

- Transaction Processing System (TPS)
- Management Information System (MIS)
- Decision Support System (DSS)
- Executive Information System (EIS)
- Expert System
- Communication and Collaboration System
- Office Automation System

sets of stored data, and only some of them work together. We call your attention to the following number annotations on the diagram:

1. The first transaction processing system responds to an input transaction's data (e.g., an order). It produces transaction information to verify the correct processing of the input transaction.
2. The second transaction processing system merely produces an output transaction (e.g., an invoice). Such a system may respond to something as simple as the passage of time (e.g., it is the end of the month; therefore, generate all invoices).
3. The first management information system simply produces reports or information (e.g., sales analysis reports) using data stored in transactional databases (maintained by the aforementioned transaction processing systems).
4. The second management information system uses business models (e.g., MRP) to produce operational management information (e.g., a production schedule).
5. Notice that an MIS may use data from more than one transactional database.
6. Notice that snapshots of data from the transactional databases populate a data warehouse. The snapshots may be taken at various time intervals, and different subsets of data may be included in various snapshots. The data in the warehouse will be organized to ensure easy access and inquiry by managers.
7. Decision support and executive information systems applications will typically provide read-only access to the data warehouses to produce decision support and executive management information.
8. An expert system requires a special database that stores the expertise in the form of rules and heuristics.
9. An expert system either accepts problems as inputs (e.g., Should we grant credit to a specific customer?), or senses problems in the environment (e.g., Is the lathe producing parts within acceptable specifications?), and then responds to a problem with an appropriate solution based on the system's expertise.
10. Personal office automation systems tend to revolve around the data and business processing needs of an individual. Such systems are typically developed by the users themselves (and run on personal computers).
11. Work group office automation systems are frequently message-based (e.g., e-mail-based) and are smaller-scale solutions to departmental needs. As shown in the figure, they can access or import data from larger, transaction processing systems.

In the average business, there will be many instances of each of these different applications.

A Framework for Information Systems Architecture

information systems architecture a unifying framework into which various stakeholders with different perspectives can organize and view the fundamental building blocks of information systems.

It has become fashionable to deal with the complexity of modern information systems by using the term *architecture*. Information technology professionals speak of data architectures, application architectures, network architectures, software architectures, and so forth. An **information systems architecture** serves as a higher-level framework for understanding different views of the fundamental building blocks of an information system. Essentially, information systems architecture provides a foundation for organizing the various components of any information system you care to develop.

Different stakeholders have different perspectives on or views of an information system. System owners and system users tend to focus on three common business goals of any information system. These goals are typically established in response to

one or more of the business drivers you read about in Chapter 1. These goal-oriented perspectives of an information system include:

- The goal to improve *business knowledge.* Knowledge is a product of information and data.
- The goal to improve *business processes* and services.
- The goal to improve *business communications* and people collaboration.

The role of the system designers and builders is more technical. As such, their focus tends to be placed more on the technologies that may be used by the information system in order to achieve the business goal. The system designers' and builders' perspectives of an information system tend to focus more on:

- The *database technologies* that support business accumulation and use of business knowledge.
- The *software technologies* that automate and support business processes and services.
- The *interface technologies* that support business communications and collaboration.

As shown in Figure 2-3, the intersection of these perspectives (rows and columns) defines *building blocks* for an information system. In the next section, we will describe all these information system building blocks.

> *NOTE:* Throughout this book, we use a consistent color scheme for both the framework and the various tools that relate to, or document, the building blocks. The color scheme is based on the building blocks as follows:
>
> represents something to do with KNOWLEDGE
> represents something to do with PROCESSES
> represents something to do with COMMUNICATIONS

The information system building blocks do not exist in isolation. They must be carefully synchronized to avoid inconsistencies and incompatibilities within the system. For example, a database designer (a *system designer*) and a programmer (a *system builder*) have their own architectural views of the system; however, these views must be compatible and consistent if the system is going to work properly. Synchronization occurs both horizontally (across any given row) and vertically (down any given column).

In the remainder of this chapter, we'll briefly examine each focus and perspective—the building blocks of information systems.

> KNOWLEDGE Building Blocks

Improving business knowledge is a fundamental goal of an information system. As you learned in Chapter 1, business knowledge is derived from data and information. Through processing, data is refined to produce information that results in knowledge. Knowledge is what enables a company to achieve its mission and vision.

The KNOWLEDGE column of your framework is illustrated in Figure 2-4. Notice at the bottom of the KNOWLEDGE column that our goal is to capture and store business data using DATABASE TECHNOLOGIES. Database technology (such as *Access, SQL Server, DB2,* or *Oracle*) will be used to organize and store data for all information systems. Also, as you look down the KNOWLEDGE column, each of our different stakeholders has different perspectives of the information system. Let's examine those views and discuss their relevance to the KNOWLEDGE column.

System Owners' View of KNOWLEDGE The average system owner is not interested in raw data. The system owner is interested in information that adds new business knowledge. Business knowledge and information help managers make

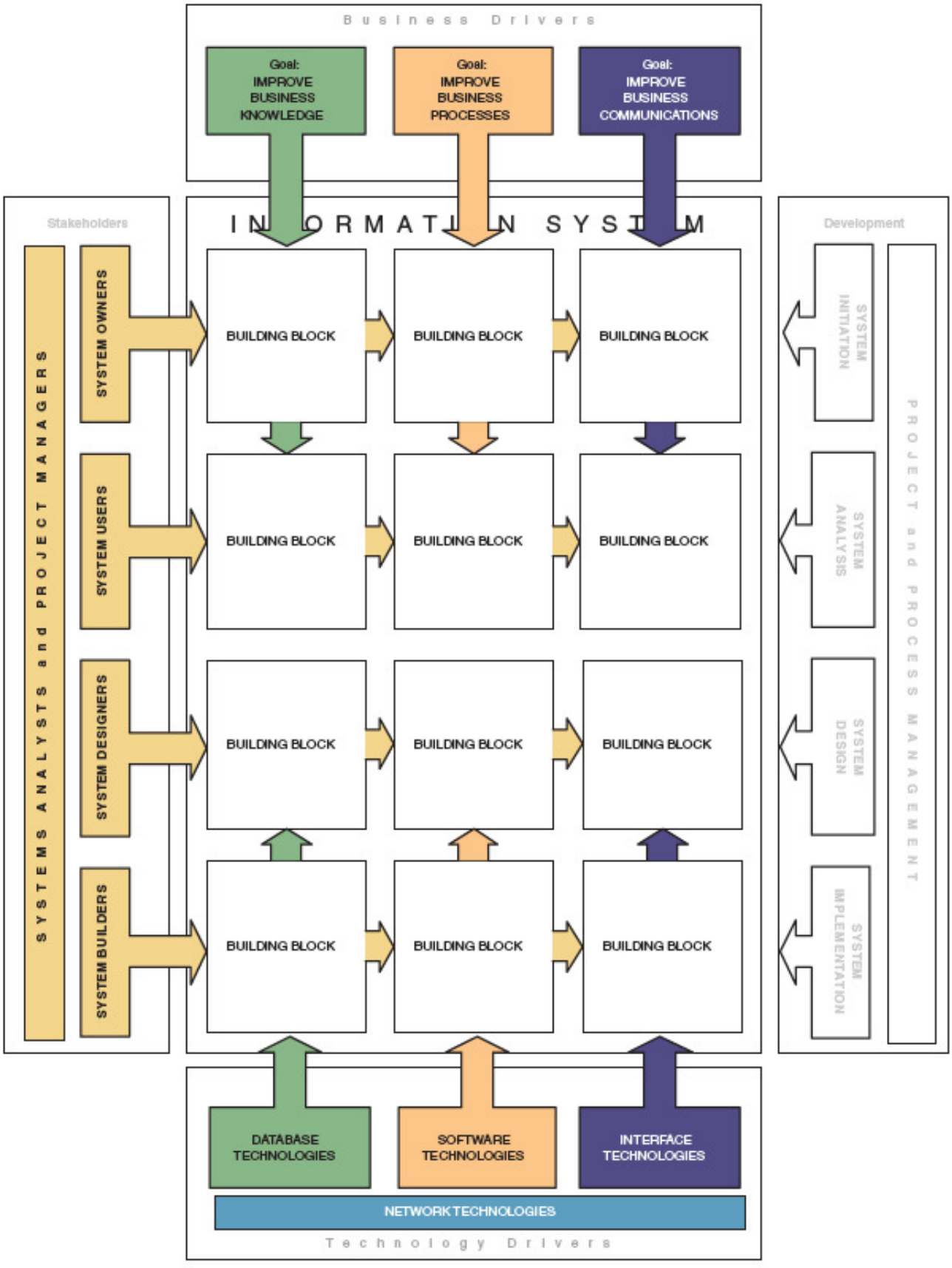


FIGURE 2-3 Information System Perspectives and Focuses

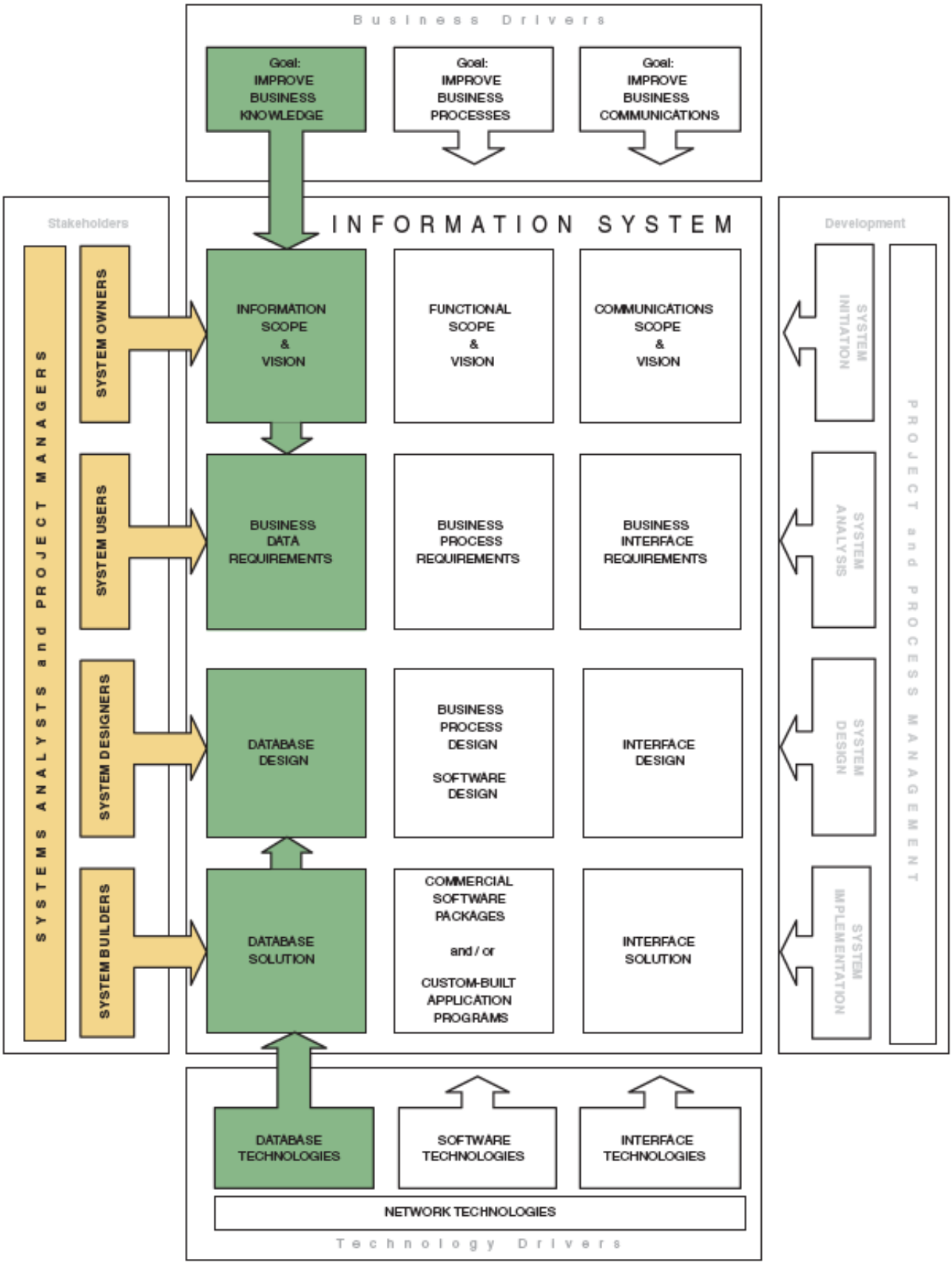


FIGURE 2-4 A BUSINESS KNOWLEDGE Perspective of Information Systems

intelligent decisions that support the organization's mission, goals, objectives, and competitive edge.

Business knowledge may initially take the form of a simple list of business entities and business rules. Examples of business entities might include CUSTOMERS, PRODUCTS, EQUIPMENT, BUILDINGS, ORDERS, and PAYMENTS. What do business entities have to do with knowledge? Information is produced from raw data that describe these business entities. Therefore, it makes sense that we should quickly identify relevant business entities about which we need to capture and store data.

It is also useful to understand simple business associations or rules that describe how the business entities interact. Examples of useful business rules for a sales system might include the following:

- A CUSTOMER can place ORDERS—an ORDER must be placed by a CUSTOMER.
- An ORDER sells PRODUCTS—a PRODUCT may be sold on an ORDER.

Intuitively, a system's database needs to track these business entities and rules in order to produce useful information (for example, "Has CUSTOMER 2846 placed any unfilled ORDERS?").

System owners are concerned with the big picture. They are generally not interested in details (such as what fields describe a CUSTOMER or an ORDER). The primary role of system owners in a systems development project should be to define the scope and vision for the project. For KNOWLEDGE, scope can be defined in simple terms such as the aforementioned business entities and rules. System owners define project vision and expectations in terms of their insight into problems, opportunities, and constraints as they relate to the business entities and rules.

System Users' View of KNOWLEDGE Information system users are knowledgeable about the data that describe the business. As information workers, they capture, store, process, edit, and use that data every day. They frequently see the data only in terms of how data are currently stored or how they think data should be stored. To them, the data are recorded on forms, stored in file cabinets, recorded in books and binders, organized into spreadsheets, or stored in computer files and databases. The challenge in systems development is to correctly identify and verify users' business data requirements. **Data requirements** are an extension of the business entities and rules that were initially identified by the system owners. System users may identify additional entities and rules because of their greater familiarity with the data. More importantly, system users must specify the exact data attributes to be stored and the precise business rules for maintaining that data. Consider the following example:

data requirement a representation of users' data in terms of entities, attributes, relationships, and rules.

> A system owner may identify the need to store data about a business entity called CUSTOMER. System users might tell us that we need to differentiate between PROSPECTIVE CUSTOMERS, ACTIVE CUSTOMERS, and INACTIVE CUSTOMERS because they know that slightly different types of data describe each type of customer. System users can also tell us precisely what data must be stored about each type of customer. For example, an ACTIVE CUSTOMER might require such data attributes as CUSTOMER NUMBER, NAME, BILLING ADDRESS, CREDIT RATING, and CURRENT BALANCE. Finally, system users are also knowledgeable about the precise rules that govern entities and relationships. For example, they might tell us that the credit rating for an ACTIVE CUSTOMER must be PREFERRED, NORMAL, or PROBATIONARY and that the default for a new customer is NORMAL. They might also specify that only an ACTIVE CUSTOMER can place an ORDER, but an ACTIVE CUSTOMER might not necessarily have any current ORDERS at any given time.

Notice from the above example that the system user's data requirements can be identified independently of the DATABASE TECHNOLOGY that can or will be used to store the data. System users tend to focus on the "business" issues as they pertain to

the data. It is important that the system users provide data requirements that are consistent with and complementary to the information scope and vision provided by the system owners.

System Designers' View of KNOWLEDGE The system designer's KNOWLEDGE perspective differs significantly from the perspectives of system owners and system users. The system designer is more concerned with the DATABASE TECHNOLOGY that will be used by the information system to support business knowledge. System designers translate the system users' business data requirements into database designs that will subsequently be used by system builders to develop computer databases that will be made available via the information system. The system designers' view of data is constrained by the limitations of whatever database management system (DBMS) is chosen. Often, the choice has already been made and the developers must use that technology. For example, many businesses have standardized on an enterprise DBMS (such as *Oracle, DB2,* or *SQL Server*) and a work group DBMS (such as *Access*).

In any case, the system designer's view of KNOWLEDGE consists of data structures, database schemas, fields, indexes, and other technology-dependent components. Most of these technical specifications are too complex to be reasonably understood by system users. The systems analyst and/or database specialists design and document these technical views of the data. This book will teach tools and techniques for transforming business data requirements into database schemas.

System Builders' View of KNOWLEDGE The final view of KNOWLEDGE is relevant to the system builders. In the KNOWLEDGE column of Figure 2-4, system builders are closest to the actual database management system technology. They must represent data in very precise and unforgiving languages. The most commonly encountered database language is *SQL (Structured Query Language).* Alternatively, many database management systems, such as *Access* and *Visual FoxPro* include proprietary languages or facilities for constructing a new database.

Not all information systems use database technology to store their business data. Many older legacy systems were built with *flat-file* technologies such as VSAM. These flat-file data structures were constructed directly within the programming language used to write the programs that use those files. For example, in a *COBOL* program the flat-file data structures are expressed as PICTURE clauses in a DATA DIVISION. It is not the intent of this book to teach either database or flat-file construction languages, but only to place them in the context of the KNOWLEDGE building block of information systems.

> PROCESS Building Blocks

Improving business and services processes is another fundamental goal of an information system. Processes deliver the desired functionality of an information system. Processes represent the *work* in a system. People may perform some processes, while computers and machines perform others.

The PROCESS building blocks of information systems are illustrated in Figure 2-5. Notice at the bottom of the PROCESS column that SOFTWARE TECHNOLOGIES will be used to automate selected processes. As you look down the PROCESS column, each of our different stakeholders has different perspectives of the information system. Let's examine those views and discuss their relevance to the PROCESS column.

System Owners' View of PROCESSES As usual, system owners are generally interested in the big picture. They tend to focus not so much on work flow and procedures as on high-level **business functions,** such as those listed in the margin of page 53. Organizations are often organized around these business fuctions with a vice president

business function a group of related processes that support the business. Functions can be decomposed into other subfunctions and eventually into processes that do specific tasks.

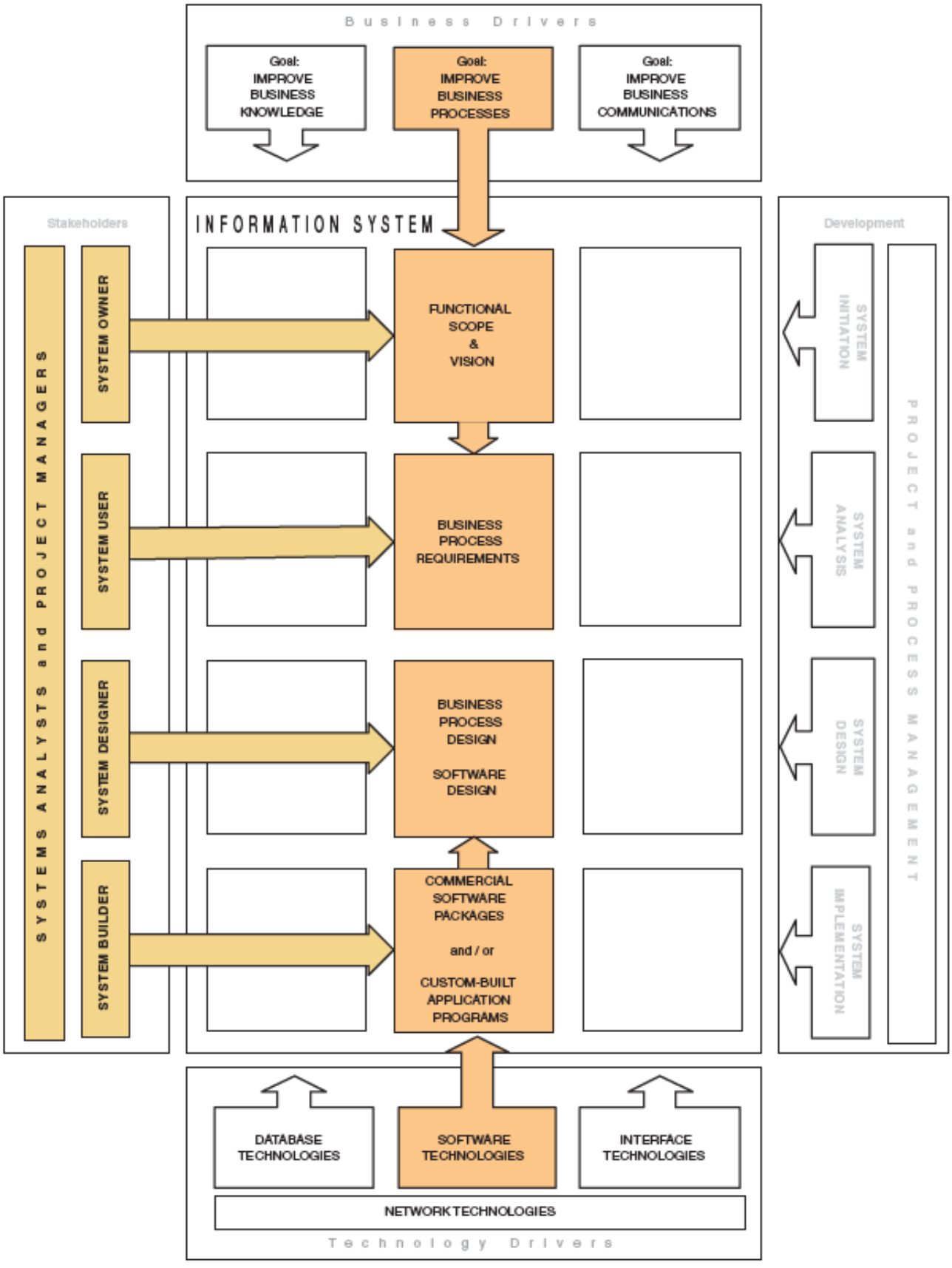


FIGURE 2-5 A BUSINESS PROCESS Perspective of Information Systems

overseeing each function. Unlike business events (such as CUSTOMER SUBMITS ORDER) that have a definite beginning and end, a business function has no starting time or stopping time.

Historically, most information systems were (or are) *function-centered.* That means the system supported one business function. An example would be a SALES INFORMATION SYSTEM that supports only the initial processing of customer orders. Today, many of these single-function information systems are being redesigned as **cross-functional information systems** that support several business functions. As a contemporary alternative to the traditional SALES INFORMATION SYSTEM, a cross-functional ORDER FULFILLMENT INFORMATION SYSTEM would also support all relevant processes subsequent to the processing of the customer order. This would include filling the order in the warehouse, shipping the products to the customer, billing the customer, and providing any necessary follow-up service to the customer—in other words, all business processes required to ensure a complete and satisfactory response to the customer order, regardless of which departments are involved.

TYPICAL BUSINESS FUNCTIONS

Sales
Service
Manufacturing
Shipping
Receiving
Accounting

cross-functional information system a system that supports relevant business processes from several business functions without regard to traditional organizational boundaries such as divisions, departments, centers, and offices.

As shown in Figure 2-5, the system owners view a system's business PROCESSES with respect to the functional scope being supported by the systems and to a vision or expectation for improvements. The system's business functions are frequently documented by systems analysts in terms of simple lists of business events and responses to those events. Some examples of business events and responses are as follows:

- Event: CUSTOMER SUBMITS ORDER
  Response: CUSTOMER RECEIVES ORDERED PRODUCTS
- Event: EMPLOYEE SUBMITS PURCHASE REQUISITION FOR SUPPLIES
  Response: EMPLOYEE RECEIVES REQUESTED SUPPLIES
- Event: END OF MONTH
  Response: INVOICE CUSTOMERS AGAINST ACCOUNTS

With respect to each event and response identified, system owners would identify perceived problems, opportunities, goals, objectives, and constraints. The costs and benefits of developing information systems to support business functions would also be discussed. As was the case with KNOWLEDGE, system owners are not concerned with PROCESS details. That level of detail is identified and documented as part of the system users' view of processes.

System owners also frequently identify services and levels of service that they seek to provide to customers, suppliers, and employees. A popular example is customer, supplier, or employee *self*-service. Human resource systems, for example, increasingly provide employees with the ability to enter their own transactions such as change of address, medical claims, and training requests. System owners also identify needs for information systems to improve service by reducing errors and improving service.

This book will teach you how to identify and document project scope in terms of relevant business functions, business events, and responses.

process requirements a user's expectation of the processing requirements for a business process and its information systems.

System Users' View of PROCESSES Returning again to Figure 2-5, we are ready to examine the system users' view of processes. Users are concerned with the business processes, or "work," that must be performed in order to provide the appropriate responses to business events. System users specify the business process in terms of **process requirements** for a new system. Process requirements are often documented in terms of activities, data flows, or work flow.

policy a set of rules that govern a business process.

These process requirements must be precisely specified, especially if they are to be automated or supported by software technology. Business process requirements are frequently defined in terms of **policies** and **procedures.** Policies are explicit rules that must be adhered to when completing a business process. Procedures are the precise steps to be followed in completing the business process. Consider the following example:

procedure step-by-step set of instructions and logic for accomplishing a business process.

CREDIT APPROVAL is a policy. It establishes a set of rules for determining whether or not to extend credit to a customer. That credit approval policy is usually applied within the context of a specific CREDIT CHECK procedure that established the correct steps for checking credit against the credit policy.

work flow the flow of transactions through business processes to ensure appropriate checks and approvals are implemented.

Process requirements are also frequently specified in terms of **work flow.** Most businesses are very dependent on checks and balances to implement work flow. For example, a purchase requisition may be initiated by any employee. But that requisition follows a specific work flow of approvals and checks before it becomes a purchase order transaction that is entered into an information processing system. Of course, these checks and balances can become cumbersome and bureaucratic. Systems analysts and users seek an approproriate balance between checks and balances and service and performance.

Once again, the challenge in systems development is to identify, express, and analyze business process requirements exclusively in business terms that can be understood by system users. Tools and techniques for process modeling and documentation of policies and procedures are taught extensively in this book.

System Designers' View of PROCESSES As was the case with the KNOWLEDGE building block, the system designer's view of business processes is constrained by the limitations of specific application development technologies such as *Java, Visual Basic.NET, C++*, and *C#*. Sometimes the analyst is able to choose the software technology; however, often the choices are limited by software architecture standards that specify which software and hardware technologies must be used. In either case, the designer's view of processes is technical.

Given the business processes from the system users' view, the designer must first determine which processes to automate and how to best automate those processes. Models are drawn to document and communicate how selected business processes are, or will be, implemented using the software and hardware.

Today, many businesses purchase commercial off-the-shelf (COTS) software instead of building that software in-house. In fact, many businesses prescribe that software that can be purchased should never be built—or that only software that provides true competitive advantage should be built. In the case of purchasing software, business processes must usually be changed or adapted to work with the software. Hence, in this scenario the business process design specifications must document how the software package will be integrated into the enterprise.

software specifications the technical design of business processes to be automated or supported by computer programs to be written by system builders.

Alternatively, in the case of building software in-house, business processes are usually designed first. And the business process specifications must then be supplemented with **software specifications** that document the technical design of computer programs to be written. You may have encountered some of these software specifications in a programming course. As was the case with KNOWLEDGE, some of these technical views of PROCESSES can be understood by users but most cannot. The designers' intent is to prepare software specifications that (1) fulfill the business process requirements of system users and (2) provide sufficient detail and consistency for communicating the software design to system builders. The systems design chapters in this book teach tools and techniques for transforming business process requirements into both business process design and software design specifications.

System Builders' View of PROCESSES System builders represent PROCESSES using precise computer programming languages or application development environments (ADEs) that describe inputs, outputs, logic, and control. Examples include *C++, Visual Basic .NET, C#* (part of the Microsoft *Visual Studio .NET* ADE), and *Java* (available in ADEs such as IBM *WebSphere* and BEA *WebLogic*). Additionally, some applications and database management systems provide their own internal languages for programming. Examples include *Visual Basic for Applications* (in *Access*) and

PL-SQL (in *Oracle*). All these languages are used to write custom-built **application programs** that automate business processes.

This book does not teach application programming. We will, however, demonstrate how some of these languages provide an excellent environment for rapidly developing a system using prototyping software. **Prototyping** has become the design technique of choice for many system designers and builders. Prototypes typically evolve into the final version of the system or application.

As mentioned earlier, sometimes decisions may involve purchasing a commercial software package as a system solution. In this scenario, the system builder may need to focus on customization that must be done to the software package. The system builder may also be expected to develop application programs that must be integrated with the commercial package to extend the package's functional capabilities. Finally, the system builder must also focus on program utilities that must be written to help with the conversion and integration of the commercial program and existing systems.

application program a language-based, machine-readable representation of what a software process is supposed to do or how a software process is supposed to accomplish its task.

prototyping a technique for quickly building a functioning but incomplete model of the information system using rapid application development tools.

> COMMUNICATIONS Building Blocks

Let's examine our final building block—COMMUNICATIONS. A common goal of most organizations is to improve business communications and collaboration between employees and other constituents. Communication improvements in information systems are typically directed toward two critical interface goals for an information system:

- Information systems must provide effective and efficient communication interfaces to the system's users. These interfaces should promote teamwork and coordination of activities.
- Information systems must interface effectively and efficiently with *other* information systems—both with those within the business and increasingly with other businesses' information systems.

The COMMUNICATIONS building blocks of information systems are illustrated in our framework in Figure 2-6. Notice at the bottom of the COMMUNICATION column that it utilizes INTERFACE TECHNOLOGIES to implement the communication interfaces. And once again, as you look down the COMMUNICATION column, each of our different stakeholders has different views of the system. Let's examine those views and discuss their relevance to systems development.

System Owners' View of COMMUNICATION The system owners' view of COMMUNICATION is relatively simple. Early in a systems development project, system owners need to specify:

- With which business units, employees, customers, and external businesses must the new system interface?
- Where are these business units, employees, customers, and external businesses located?
- Will the system have to interface with any other information, computer, or automated systems?

Answers to these questions help to define the communications scope of an information systems development project. Minimally, a suitable system owners' view of information system communication scope and vision might be expressed as a simple list of business locations or systems with which the information system must interface. Again, relevant problems, opportunities, or constraints may be identified and analyzed.

System Users' View of COMMUNICATION System users' view of COMMUNICATION is more in terms of the information system's inputs and outputs. Those inputs and outputs can take many forms; however, the business interface requirements are more

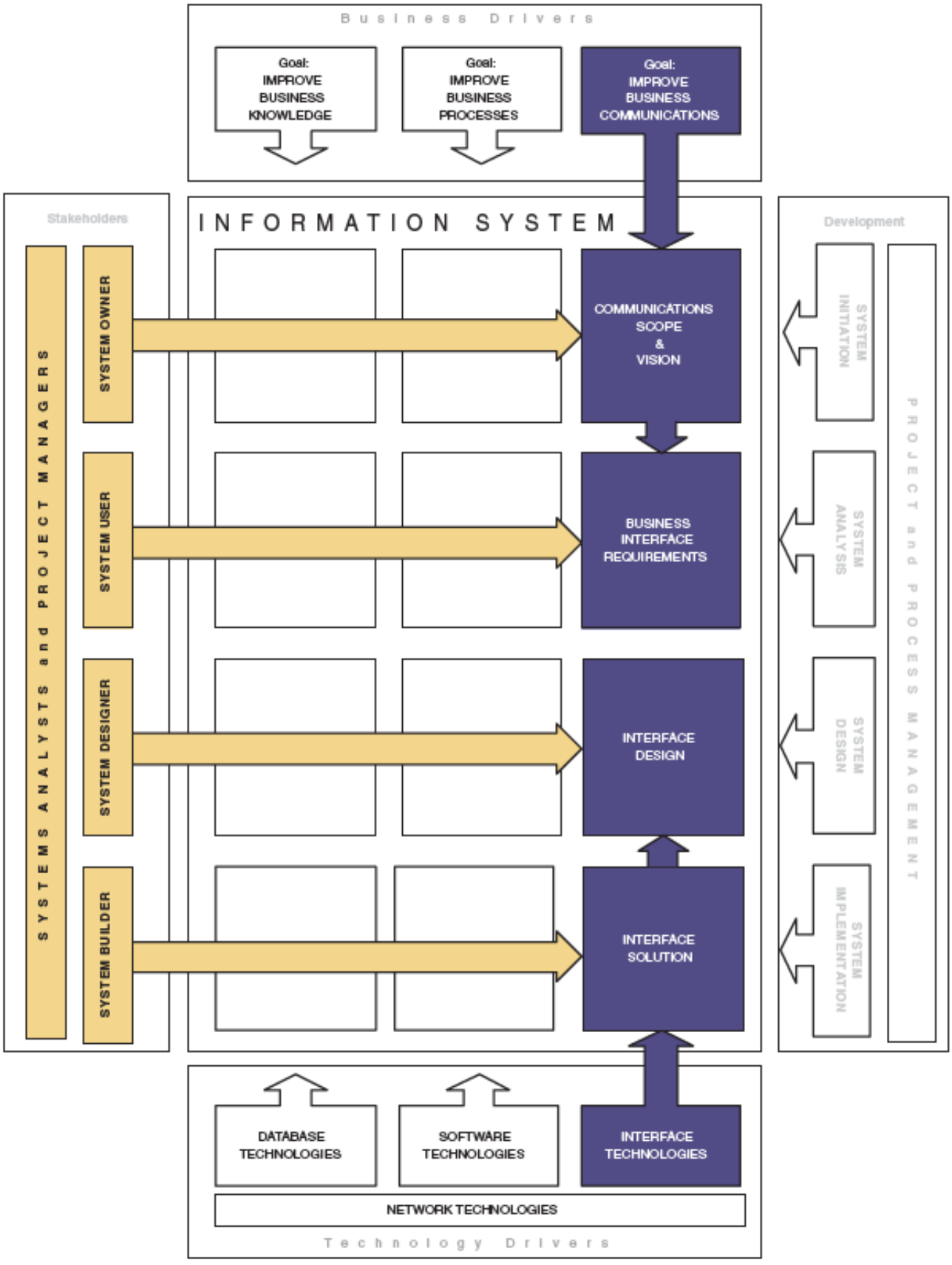


FIGURE 2-6 A BUSINESS COMMUNICATIONS Perspective of Information Systems

important than the technical format. The inputs and outputs represent how the proposed system would interact with users, employees, business units, customers, and other businesses.

The details of those inputs and outputs are important. System users might specify the details in the form of a list of fields (and their values) that make up the inputs or outputs. Alternatively, and because system users have become comfortable with the graphical user interface (e.g., *Windows* or Web browsers) for the system, the details might be specified in the form of prototypes. System users are increasingly demanding that their custom-built information system applications have the same "look and feel" as their favorite PC tools such as word processors and spreadsheets. This common graphical user interface makes each new application easier to learn and use.

Both list and prototype approaches to documenting the system users' view of COMMUNICATION will be addressed in various chapters of this book.

System Designers' View of COMMUNICATION System designers must be concerned with the technical design of both the user and the system-to-system communication interfaces. We call these **interface specifications.** Let's begin with the user interface.

interface specifications technical designs that document how system users are to interact with a system and how a system interacts with other systems.

Users and designers can be involved in interface design. But whereas system users are interested in requirements and format, system designers have other interests such as consistency, compatibility, completeness, and user dialogues. The **user dialogue** (sometimes called *interface navigation*) specifies how the user will navigate through an application to perform useful work.

user dialogue a specification of how the user moves from window to window or page to page, interacting with the application programs to perform useful work.

The trend toward graphical user interfaces (GUIs) such as *Windows* and Web browsers has simplified life for system users but complicated the design process for system designers. In a typical *Windows* application, there are many different things users can do at any given time—type something, click the left mouse button on a menu item or toolbar icon, press the F1 key for help, maximize the current window, minimize the current window, switch to a different program, and many others. Accordingly, the system designer views the interface in terms of various system states, events that change the system from one state to another, and responses to those events. Today, there are many more design decisions and considerations the system designer must address to document the dialogue of a graphical user interface solution. Tools used to document user dialogues will be discussed in the design unit of this book.

Web interfaces have further complicated the designer's activities. Society has come to expect more glitz in Web interfaces. For that reason, it is not at all uncommon for the design team to include graphical design specialists and human–computer interface specialists to ensure that the interface for a Web server is both compelling and easy to use.

Although not depicted in Figure 2-6, modern system designers may also design *keyless interfaces* such as bar coding, optical character recognition, pen, and voice or handwriting recognition. These alternatives reduce errors by eliminating the keyboard as a source of human error. However, these interfaces, like graphical user interfaces, must be carefully designed to both exploit the underlying technology and maximize the return on what can be a sizable investment.

Finally, and as suggested earlier, system designers are also concerned with system-to-system interfaces. Increasingly, system interfaces are the most difficult to design and implement. For instance, consider a procurement information system that is used to initiate and purchase everything from supplies to equipment. A procurement system must interface with other information systems such as human resources (to determine authority to purchase and approve orders), accounting (to determine if funds are available against an account), receiving (to determine if ordered goods were received, and accounts payable (to initiate payment). These interfacing systems may use very different software and databases. This can greatly complicate system interface design. System interfaces become even more complex when the interface is between information systems in different businesses. For example, in the aforementioned system, we might want to enable our procurement system to directly interface with a supplier's order fulfillment system.

Legacy information systems in most businesses were each built with the technologies and techniques that represented the best practices at the time when they were developed. Some systems were built in-house. Others were purchased from software vendors or developed with consultants. As a result, the integration of these heterogeneous systems can be difficult. Consequently, the need for different systems to interoperate is pervasive. Accordingly, the time system designers spend on system-to-system integration is frequently as much as or more than the time they spend on system development. The system designer's mission is to find or build interfaces between these systems that (1) do not create maintenance projects for the legacy systems, (2) do not compromise the superior technologies and design of the new systems, and (3) are ideally transparent to the system users.

System Builders' View of COMMUNICATION System builders construct, install, test, and implement both user and system-to-system interface solutions using INTERFACE TECHNOLOGY (see Figure 2-6). For user interfaces, the interface technology is frequently embedded into the *application development environment (ADE)* used to construct software for the system. For example, ADEs such as those for *Visual Studio .NET,* and *Powerbuilder* include all the interface technology required to construct a *Windows* graphical user interface (GUI). ADEs such as those for *Java* and *Cold Fusion* provide similar functionality for Web interfaces. Alternatively, the user interface could be constructed with a stand-alone interface technology that supports *xHTML* (e.g., Macromedia's *Dreamweaver*).

System-to-system interfaces are considerably more complex than user interfaces to construct or implement. One system-to-system interfacing technology that is currently popular is middleware. **Middleware** is a layer of utility software that sits in between application software and systems software to transparently integrate differing technologies so that they can interoperate.

middleware utility software that allows application software and systems software that utilize differing technologies to interoperate.

One common example of middleware is the open database connectivity (ODBC) tools that allow application programs to work with different database management systems without having to be rewritten to take into consideration the nuances and differences of those database management systems. Programs written with ODBC commands can, for the most part, work with any ODBC-compliant database (which includes dozens of different database management systems). Similar middleware products exist for each of the columns in our information system framework. System designers help to select and apply these products to integrate systems.

At the time of this writing, *XML* (*eXtensible Markup Language*) has emerged as an evolving standard for system-to-system communication. *XML* is unique in its ability to share data between systems through data streams that not only include the data but also include the meaning and structural definitions for that data. *XML* capabilities are the new frontier for software that implements electronic data exchange over the Web.

Once again, this book is not about system construction; however, we present the system builder's view because the other COMMUNICATION views lead to the construction of the actual communication interfaces.

Network Technologies and the IS Building Blocks

In this chapter, we unveiled a framework for information systems architecture that was initially inspired by the work of John Zachman.[1] The Zachman "Framework for Information Systems Architecture" achieved international recognition and use. The Zachman framework is a matrix (similar to the chapter map at the beginning of this chapter). The rows correspond to what Zachman calls *perspectives* of different

[1]John A. Zachman, "A Framework for Information Systems Architecture," *IBM Systems Journal* 26, no. 3 (1987), pp. 276–292.

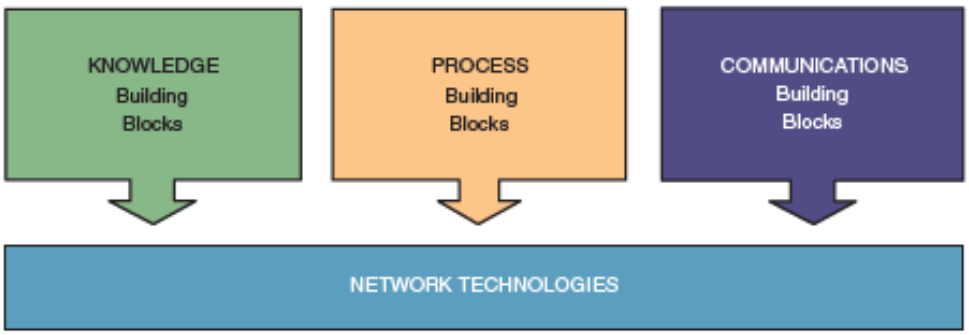


FIGURE 2-7
The Role of the Network in Information Systems

people involved in systems development and use. The columns correspond to *focuses* on different aspects of the information system. Zachman's architecture includes a separate column that closely equates to what our framework recognizes as NETWORK TECHNOLOGIES. (We have chosen to omit that column because network frameworks are more typically covered in data communications and networking textbooks—and those textbooks tend to focus on the Open Systems Interconnect (OSI) framework as opposed to Zachman's.)

But unquestionably, today's information systems are built on networks. Figure 2-7 shows a modern high-level information systems framework that demonstrates the contemporary layering of an information system's KNOWLEDGE, PROCESSES, and COMMUNICATIONS building blocks on NETWORK TECHNOLOGIES. Today's best-designed information systems tend to separate these layers and force them to communicate across the network. This *clean-layering* approach allows any one building block to be replaced with another while having little or no impact on the other building blocks. For example, the DATABASE TECHNOLOGY, SOFTWARE TECHNOLOGY, or INTERFACE TECHNOLOGY could be changed without impacting the other building blocks.

It is not the intent of this book to teach network technology. Most information systems and technology programs offer courses that can expand your understanding of network technology.

Learning Roadmap

So where are we now? If you have already read Chapter 1, you learned about information systems development projects with a focus on the stakeholders, the process, and the business and technical drivers that influence the need for new systems. If you haven't already done so, you should at least skim Chapter 1 to learn about the *context of systems analysis and design methods.*

In Chapter 2, you learned about the product itself—information systems—in terms of basic building blocks. This architectural perspective focused on the different information system views of the various stakeholders. You learned that system owners and users view information systems from the standpoint of achieving goals—improving business knowledge, processes, and communications—whereas system designers and builders view information systems in terms of technology that supports the achievement of goals.

Most readers should proceed directly to Chapter 3, which introduces you to the process of information system development. You'll learn about information systems problem solving, methodologies, and development technology as you expand your education in the fundamentals for systems analysis and design methods.

Summary

1. Organizations are served by a federation of information systems that support various business functions. Businesses have front-office information systems that support business functions that extend out to their customers and back-office information systems that support internal business operations and interact with suppliers.
2. The many classes of information system applications overlap and interoperate to complement and supplement one another.
3. Information systems architecture provides a unifying framework into which various stakeholders with different perspectives can organize and view the fundamental building blocks of information systems:
   a. System owners and system users tend to focus on three common business goals of any information system—improvements in business knowledge, business processes, and business communications.
   b. System designers and builders tend to focus on technologies used by the information system in order to achieve the business goals. They focus on the database technologies that support business knowledge, software technologies that support business processes, and interface technologies that support business communications.
4. The three views represented in the model are:
   a. KNOWLEDGE—the business knowledge that helps managers make intelligent decisions.
   b. PROCESSES—the activities (including management) that carry out the mission of the business.
   c. COMMUNICATIONS—how the system interfaces with its users and other information systems.
5. Improving business knowledge is a fundamental goal of an information system:
   a. The system owner is interested in information that adds new business knowledge.
   b. Information system users are knowledgeable about the data that describes the business. This data is used to create information and subsequent business knowledge.
   c. System designers are concerned with the database technology that will be used by the information system to support business knowledge.
   d. System builders focus on the actual database management system technology used to store the business data that will support business knowledge.
6. Improving business processes is a fundamental goal of an information system:
   a. System owners are interested in the business functions the groups of related processes, that support a business.
   b. System users specify the business process in terms of process requirements for a new system. Business process requirements are frequently defined in terms of policies and procedures. Policies are explicit rules that must be adhered to when completing business processes. Procedures are the precise steps to be followed in completing business processes.
   c. System designers view business processes in terms of the application development environment and the software technology used to develop the system. Many businesses purchase commercial off-the-shelf software solutions instead of building the software in-house.
   d. System builders focus on custom-built applications programs that automate business processes.
7. A common goal of most organizations is to improve business communications:
   a. System owners define the communications scope of an information system development project.
   b. System users view communications in terms of the information system's inputs and outputs.
   c. System designers are concerned with the technical design of both user and system-to-system communication interfaces.
   d. System builders are concerned with the interface technology they use to implement user and system-to-system communication interfaces.
8. Today's information systems are built on networks. Network technology allows properly designed information systems to separate the KNOWLEDGE, PROCESS, and COMMUNICATION building blocks and force them to communicate across the network.

Review Questions

1. What is the difference between front-office information systems and back-office information systems?
2. How do transaction processing systems (TPSs), management information systems (MISs), and decision support systems (DSSs) interact with each other?
3. Why do we need to identify the information system architecture?
4. What are the three business goal–oriented perspectives or views of an information system that systems owners and system users tend to focus on? What are the three technological perspectives that system designers and builders tend to focus on?
5. How are the business perspectives and the technology perspectives of an information system related?
6. In any given building blocks of an information system, the views of four groups of stakeholders need to be taken into account during the development of the system. What are these four stakeholder groups?
7. Briefly describe how system designers and system builders tend to view KNOWLEDGE in a system.
8. Understanding business functions is essential in the process building block of an information system. What are six high-level business functions typical of many companies?
9. If you were the system owner of an online CD store, list two business functions of your online store in terms of business events and responses to those events.
10. Give an example of a policy and the procedures needed to implement the policy.
11. What is prototyping? Why do we need such a technique?
12. What are the two most critical goals in the communication building blocks?
13. What is user dialogue?
14. Why has the increasing use of graphical user interfaces (GUI) complicated the design process for system designers?
15. What role does network technology play in developing an information system?

Problems and Exercises

1. Companies generally need to use more than one information system to support all their different business functions. These functions are frequently referred to as either front-office information systems or back-office systems. Define each of these two types of systems and identify some of the typical business functions supported by them.
2. As a systems analyst, designer, or builder, you will frequently be involved with your organization's information systems architecture. What is an information systems architecture, and what is its purpose?
3. Although system owners and system users generally have different perspectives of their organization's information system, both groups tend to focus on three business goals that are common to any information system. What are these goal-oriented perspectives, and what is their importance?
4. In an information system, the process building blocks represent the work that occurs in a system, which may be performed by people or by computers and machinery. Stakeholders tend to have different views or perspectives of these building blocks. What are these different stakeholder perspectives regarding processes, and how they differ from each other?
5. Assume you are a systems designer and your organization is building a new inventory management system. In reviewing the requirements documentation, it appears that an error was made and some additional data elements were left out that are needed to meet the business or technical objectives of the inventory management system. What should you **not** do at this point?
6. Assume you are designing a retail point-of-sale (POS) system for your company. What are the typical system interfaces of a point-of-sale system that need to be taken into account in designing the POS system?
7. As business technology becomes more powerful and sophisticated, many businesses are redesigning

their single-function information systems, such as sales, into cross-functional information systems that provide integrated support for separate, but related, business functions. Assume that you are designing an order management system that will integrate all business functions triggered by the submission of a sales order. What typical business functions would be included in a cross-functional information system?

8. Middleware is frequently used in systems integration projects when different information systems are tied together to exchange data via system-to-system interfaces. Briefly define middleware, explain its benefits, and provide an example.
9. In identifying and documenting business requirements, systems analysts need to be able to distinguish between laws, policies, and procedures. Why is this important?
10. It is common for system owners and system users to have very different views of the same business processes used in an information system. Why do you think this is? Consider an airline that is developing a customer self-check-in system at airports. What do you think the perspective of the system owners is? What about the system users? Give examples of how the business processes for an airline check-in system will be viewed by the system owners and system users.
11. System designers and system builders also tend to have very different views of system building blocks. Explain the different ways that designers and builders might view the communication building blocks using the customer self check-in system scenario described in the last question.
12. System designers frequently have a number of technical design options to choose from when designing interfaces between different systems and applications. What should designers always keep in mind when designing these interfaces?
13. The framework for information systems architecture used in this textbook is derived from the pioneering framework developed by John Zachman. What is one of the advantages of designing systems based upon this or similar frameworks?
14. At times, an organization may choose to purchase a commercial off-the-shelf (COTS) software package. What do you think are the pros and cons of using off-the-shelf applications compared to custom-built applications?
15. If an organization chose a COTS package as their solution, would the view of the system builder be the same as for a custom-built application? If not, how would it be different?

Projects and Research

1. Select a medium to large organization. The organization can be in the public or private sector, and it can be one with which you are personally familiar or one for which information is readily available.

   a. Describe the organization you have selected (type of organization, mission, products or services, size, annual sales or revenues, etc.).
   b. Select one of the major information systems the organization uses and/or is developing, and describe it.
   c. In the organization you selected, who would typically be the owner of this system?
   d. Describe, from the viewpoint of the owner, the information produced by this system.
   e. If the organization initiated a project to replace or modify this system, how might the system owner define the scope and vision of the project within the context of the organization you selected
   f. Who are the typical users of this system?
   g. Describe, from the perspective of the users, the information produced by this system.
   h. What is an essential difference in how system owners and users view the information produced by the system?

2. Contact and interview two or three systems analysts, in different organizations if possible, regarding this chapter's subtopic on communication building blocks.

   a. Describe the nature of each analyst's company or organization, its mission, and current business issues or needs.
   b. How important does each of the system analysts consider communications with system users versus system builders; that is, which is more important and why?
   c. Do they find it more difficult to communicate with the system users or with the system builders? Why?

d. If they were CIOs for a day, what would each of them change about the way their designers communicate with system users and builders?
e. Which viewpoints do you agree with, or do you have a totally different one than the people you interviewed? Justify your answer.

3. Select an information system used by a medium to large organization. It can be one with which you are personally familiar or one whose organizational structure and information system you have researched.

a. What is the nature of the organization you have selected, its mission, and the high-level purpose of their information system?
b. Who is the owner of the system?
c. If you were the owner of the system, describe how you would see the system processes from that viewpoint.
d. Who are the users of the system?
e. If you were one of the system users, describe how you would see the system processes from that viewpoint.
f. If you were the system designer, describe the system processes from that viewpoint.
g. What are the essential differences in viewpoints?

4. Imagine that you are the owner of a small business and are searching on the Web for a company that can supply the products or services needed by your business. Find several business-to-business (B2B) Web sites that offer the products or services for which your business is looking. Familiarize yourself with their Web sites from the viewpoint of a typical business customer who is visiting these sites for the first time.

a. What is the nature of your organization, and for what type of goods or services are you looking?
b. Which B2B sites did you find on the Web?
c. Compare the different sites. If all other things were equal (price, availability, brands offered, etc.), would you be more likely to purchase goods or services from one than the other(s), solely because of differences in their Web sites? Why or why not?
d. From the viewpoint of a business customer, do you think design or usability is more important for a Web site? Explain your answer.
e. From the viewpoint of a consumer, would your answer be the same as in the preceding question? Explain.

5. Research several articles published in the last few years in your library and/or on the Web that discuss ethical issues related to systems design.

a. What articles were you able to find?
b. Describe some of the situations and ethical issues that might arise from time to time in systems design.
c. Pick one of the situations described in (b) and describe what you believe to be the system designer's ethical obligation, if any.
d. (Extra credit) Do you think that requiring IT professionals, that is, systems analysts, designers, and builders, to be licensed or certified would increase professionalism and/or reduce unethical behavior? Why or why not?

6. The textbook uses a framework for describing information systems architecture that is based upon John Zachman's "Framework for Information Systems Architecture" model. Using the Web or your school library, research other frameworks for describing IS architectures, and select one, such as Open Systems Interconnect (OSI).

a. Which frameworks did you find, and which did you select?
b. Describe its approach to communicating systems architecture. Include a diagram if applicable.
c. What are its similarities to the framework used in the textbook?
d. What are its differences?
e. If you were a systems owner, which one would you find easier to understand?
f. If you were a systems analyst, which one would you find easier to understand?

Minicases

1. An IT manager requests an amount of funds to upgrade the e-mail server. Without the necessary upgrade, the server will be burdened by the sheer amount of e-mail and will run the risk of crashing. The business manager denies the request, citing the past reliability of the server, and expresses concern at the recent large IT expenditures. The business manager leaves the conversation wondering what IT investments are really necessary, and if the IT manager is just creating "job security."

The IT manager, likewise, leaves the meeting frustrated at not having the tools he/she needs to do the job properly. The IT manager knows that when the server crashes, it will be his/her responsibility to fix.

a. Do you think this happens often in business?
b. What perspectives do you think each are taking on the problem?
c. How could each have communicated those perspectives and business needs better?

2. Interview at least one person in marketing, customer service, and accounting/payroll in the same company. What types of information do they handle? Do they share information across departments? Do you notice overlap in information or in data entry?
3. Government service departments are deeply burdened by the amount of data that they hold and process. Interview someone from a service department and draft a short essay. Service departments that must sift through vast amounts of data are those that deal with, for example, missing persons, child protective services, DMV, and tracking of persons on probation following a crime. You should include, but are not limited to, topics such as:
   - What is the department's (or person's) job?
   - What kind of data do they collect and analyze?
   - What kind of analyses do they do on the data?
   - How much information do they collect, from whom, and what programs do they use?
4. Your neighborhood grocery store, Wow Grocery, always seems to be running out of your favorite ice cream. In frustration, you ask the store manager why they always seem to be out. The store manager, Bob, tells you that the small store cannot afford an inventory management system, so inventory is updated manually. This means that oftentimes the store must either stock extra quantities of well-liked items or risk running out. Unfortunately, Wow Grocery does not have a large enough freezer to store additional stocks of ice cream. As a result, the store runs out of the ice cream quite frequently.
5. What can Wow Grocery do to automate or manage its inventory system without spending much money? Draft your solution into a short paper.

Team and Individual Exercises

1. How do you solve a seemingly insolvable problem? As a team, develop a methodology for solving the following question: How many homes are there in the United States that are painted yellow?
2. Try something you have not done before (legal, not dangerous, and rated G). Share with the class what you did, and why you did it. Why is it important to try and experience new things?
3. Share (with your team) an unethical incident that you have observed. How did that incident affect you directly? What indirect impact did it have on others?

Suggested Readings

Galitz, Wilbert O. *The Essential Guide to User Interface Design: An Introduction to GUI Design Principles and Techniques,* 2nd ed. New York: John Wiley & Sons, 2002.

Goldman, James E.; Phillip T. Rawles; and Julie R. Mariga. *Client/Server Information Systems: A Business-Oriented Approach.* New York: John Wiley & Sons, 1999. For students who are looking for a student-oriented introduction to information technology architecture and data communications, we recommend our colleagues' book because it was written for business and information systems majors to provide a comprehensive survey of the technology that supports today's information systems.

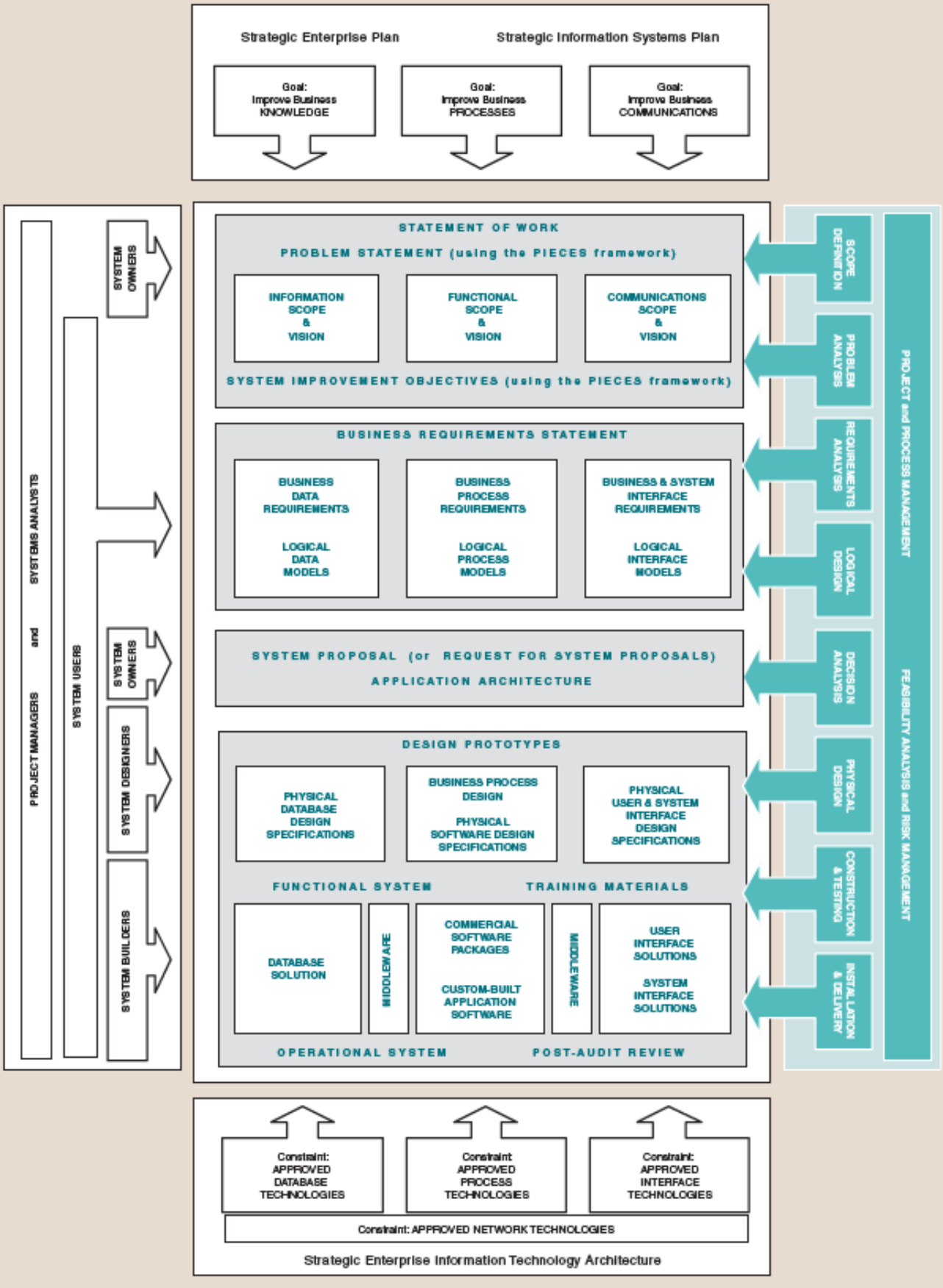
Inmon, W. H. *Building the Data Warehouse,* 3rd ed. New York: John Wiley & Sons, 2002.

Sethi, Vikram, and William R. King. *Organizational Transformation through Business Process Reengineering.* Upper Saddle River, NJ: Prentice Hall, 1998.

Taylor, David, and Alyse D. Terhune. *Doing E-Business: Strategies for Thriving in an Electronic Marketplace.* New York: John Wiley & Sons, 2000.

Zachman, John A. "A Framework for Information System Architecture." *IBM Systems Journal* 26, no. 3 (1987). We adapted the matrix model for information system building blocks from Mr. Zachman's conceptual framework. We first encountered John Zachman on the lecture circuit, where he delivers a remarkably informative and entertaining talk

on the same subject as this article. Mr. Zachman's framework has drawn professional acclaim and inspired at least one conference on his model. His framework is based on the concept that architecture means different things to different people. His framework suggests that information systems consist of three distinct "product-oriented" views—data, processes, and technology (which we renamed *communications*)—to which we added a fourth view, "interface." The Zachman framework offers six different audience-specific views—for each of those product views—the ballpark and owner's views (which we renamed as *owner's* and *user's views,* respectively), the designer's and builder's views (which we combined into our *designer's view*), and an out-of-context view (which we called the *builder's view*).


Strategic Enterprise Plan
Strategic Information Systems Plan
Goal: Improve Business KNOWLEDGE
Goal: Improve Business PROCESSES
Goal: Improve Business COMMUNICATIONS
PROJECT MANAGERS and SYSTEMS ANALYSTS
SYSTEM USERS
SYSTEM OWNERS
SYSTEM OWNERS
SYSTEM DESIGNERS
SYSTEM BUILDERS
STATEMENT OF WORK
PROBLEM STATEMENT (using the PIECES framework)
INFORMATION SCOPE & VISION
FUNCTIONAL SCOPE & VISION
COMMUNICATIONS SCOPE & VISION
SYSTEM IMPROVEMENT OBJECTIVES (using the PIECES framework)
BUSINESS REQUIREMENTS STATEMENT
BUSINESS DATA REQUIREMENTS
LOGICAL DATA MODELS
BUSINESS PROCESS REQUIREMENTS
LOGICAL PROCESS MODELS
BUSINESS & SYSTEM INTERFACE REQUIREMENTS
LOGICAL INTERFACE MODELS
SYSTEM PROPOSAL (or REQUEST FOR SYSTEM PROPOSALS)
APPLICATION ARCHITECTURE
DESIGN PROTOTYPES
PHYSICAL DATABASE DESIGN SPECIFICATIONS
BUSINESS PROCESS DESIGN
PHYSICAL SOFTWARE DESIGN SPECIFICATIONS
PHYSICAL USER & SYSTEM INTERFACE DESIGN SPECIFICATIONS
FUNCTIONAL SYSTEM
TRAINING MATERIALS
DATABASE SOLUTION
MIDDLEWARE
COMMERCIAL SOFTWARE PACKAGES
CUSTOM-BUILT APPLICATION SOFTWARE
MIDDLEWARE
USER INTERFACE SOLUTIONS
SYSTEM INTERFACE SOLUTIONS
OPERATIONAL SYSTEM
POST-AUDIT REVIEW
SCOPE DEFINITION
PROBLEM ANALYSIS
REQUIREMENTS ANALYSIS
LOGICAL DESIGN
DECISION ANALYSIS
PHYSICAL DESIGN
CONSTRUCTION & TESTING
INSTALLATION & DELIVERY
PROJECT and PROCESS MANAGEMENT
FEASIBILITY ANALYSIS and RISK MANAGEMENT
Constraint: APPROVED DATABASE TECHNOLOGIES
Constraint: APPROVED PROCESS TECHNOLOGIES
Constraint: APPROVED INTERFACE TECHNOLOGIES
Constraint: APPROVED NETWORK TECHNOLOGIES
Strategic Enterprise Information Technology Architecture