CHAPTER 6

Process-Flow Analysis

LEARNING OBJECTIVES

After reading this chapter, you should be able to:

- **LO6.1** Describe process thinking and system boundaries.
- **LO6.2** Explain how the process view of business includes various functions.
- **LO6.3** Construct a process flowchart for a given process.
- **LO6.4** Analyze a process by asking a wide variety of questions informed by the process flowchart.
- **LO6.5** Determine process capabilities from analysis.
- **LO6.6** Explain the principles of process redesign.

A customer walks into a home improvement store, selects a paint color from the multitude of sample options, and gives the selection to the store employee. The employee enters information about the selection into a machine that automatically dispenses the appropriate set and quantities of pigments into a can of white paint. Another machine is used to shake the can, resulting in consistent color throughout the can. The customer walks away with a virtually customized product in a matter of minutes. The simple process used to create the customized paint combines the customer's preference, employee skills, and automated technology.

This chapter is about understanding processes and how they are used to produce and deliver products and services. It is also about determining what a process is capable of producing.

Process-flow analysis is about viewing and analyzing the transformation process as a sequence of steps connecting inputs to outputs. It is used to discover better methods or procedures for producing and delivering a product or a service deemed to be of value to customers.

Measuring process flows is essential to process-flow analysis and to improving transformation processes. We describe several process measures, including processing time, throughput time, flow rate, inventory, and capacity. We also define bottlenecks and provide methods for calculating these measures.

methods for calculating these measures.

The flowchart (often referred to as a process map) is an essential tool to facilitate process-flow analysis. Flowcharts should consider not only process flows but customers, suppliers, and employee inputs in designing better processes. A flowchart for a high-contact service process, such as surgery often reflects the customer's perspective, mapping the activities performed on the patient. In manufacturing, a flowchart often shows the activities performed on inventory as it moves through the production system.

To truly understand process-flow analysis, we begin this chapter with process thinking. This is a very powerful idea in business education and in practice.

6.1 PROCESS THINKING

LO6.1 Describe process thinking and system boundaries.

Process thinking is the point of view that all work can be seen as a process. It begins by describing the process of interest as a system. A system is defined by its boundaries, inputs, outputs, suppliers, customers, and system flows. System definition is needed before detailed measurement and process flowcharting can begin.

A **system** is a collection of interrelated elements whose whole is greater than the sum of its parts. The human body, for example, is a system. The heart, lungs, brain, and muscles cannot function without one another. They are interrelated, and the function of one part affects the others. The whole of the body is greater than any of its individual parts or components.

A business organization can also be viewed as a system. Its parts are the functions of marketing, operations, finance, accounting, human resources, and information systems. Each of these functions accomplishes nothing by itself. A business cannot sell what it cannot produce, and it does no good to produce a product or service that cannot be sold. The functions in an organization are highly interactive and have value as a system that they do not have separately.

Within operations, the transformation or conversion system is made up of workers, equipment, customers (for services), and the activities that carry out the transformation. The transformation system can be analyzed by first specifying the **system boundaries.** The boundaries delineate the resources and activities in the system being analyzed from those that are outside of the analysis and decision area. Identification of the system boundaries is always difficult and somewhat arbitrary, but it must be done to separate the system being analyzed from the larger system or to separate the system being analyzed from the larger system or organization in which it operates. In this sense, the boundaries of a firm separate the firm from the larger supply chain in which it resides.

To illustrate these concepts, consider the case of a bank that is installing a new information system. The new system will replace the current one, with larger capacity, new hardware, and new software. Training will be required to operate the new system, and so human resources can be considered part of the system. Operations will be affected by the new software and must be included within the system boundaries. Each part of the organization that is affected by the new information system should be included within the system boundaries, and functions that are not affected can be excluded as being outside the system boundaries. In this way, the appropriate system boundaries can be identified for purposes of analysis.

A *cross-functional team* should be formed, consisting of the functions that are affected by the conversion to the new information system. This team will be responsible for overseeing the conversion from each of their functional perspectives and should handle the interactions between functions. If this is done by a cross-functional team rather than workers from a single function, a systems view of the project will be taken. This sort of process thinking considers all the interacting functions within the system boundaries when making the conversion.

6.2 THE PROCESS VIEW OF BUSINESS

LO6.2 Explain how the process view of business includes various functions.

One of the most important contributions of process thinking is that a business can be viewed as a system that consists of a collection of interconnected processes. The **process view of a business** is horizontal in nature; the functional view is vertical. This is shown graphically in [Figure 6.1](#).

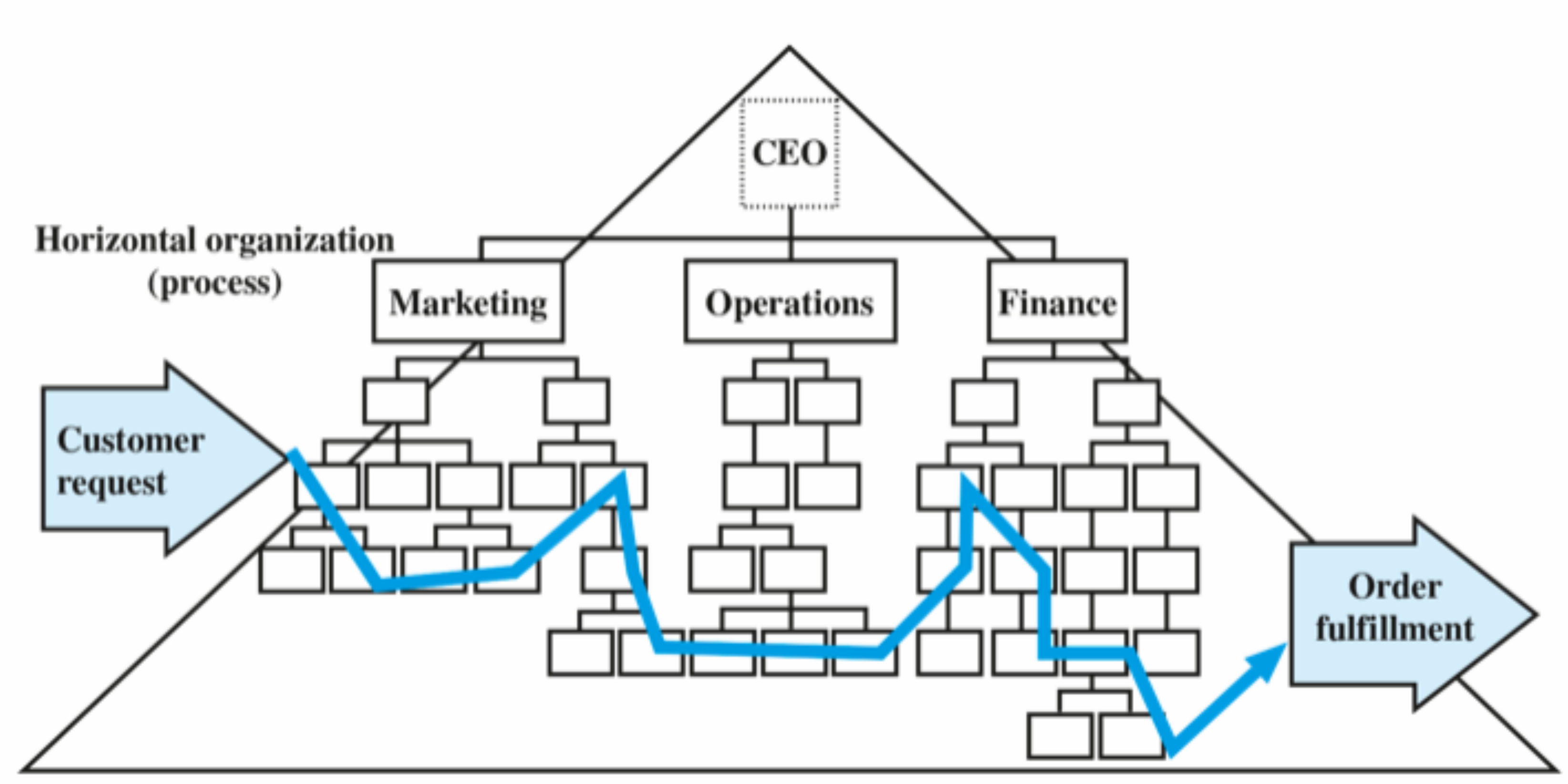

Figure 6.1 The process view of business.

Source: V. Grover and M. K. Malhorta, “Business Process Reengineering: A Tutorial on Concept, Evolution, Method, As an illustration of interconnected processes in a business, consider a scenario. A sales team has a process for creating the customer order, while at the same time interacting with operations to ensure adequate capacity is available to fill the order. Other marketing personnel use a process for pricing the customer order. Once operations receives the order, the necessary processes are used to produce enough output to fill the order. The shipping area has a process for securing the order for delivery, and transportation is scheduled to deliver the order to the customer. Finance uses its own processes to bill and receive payment from the customer, while relying on pricing information from marketing and order size and delivery confirmation from operations.

Viewing a business as a collection of processes emphasizes the cross-functional nature of decision making. It illustrates that functions must make handoffs to one another in executing a process. As a result, time and information can be lost between processes. In some cases, the number of steps in a process is so large that the system cannot function in an efficient and effective manner. See the example in the Operations Leader box of the complex and time-consuming process of setting up clinical trials to test newly developed cancer treatment drugs.

Another example comes from an MRI (magnetic resonance imaging) facility, where a backlog of patients had developed. The backlog was difficult to solve because the MRI facility did not control its own schedule. An outside service provider was contracted to schedule patients, and their scheduling caused several problems. The scan indicated on the schedule did not always match with the actual scan that the patient needed, and sometimes not enough scan time was scheduled for certain patients. Further, there was a need to hire an additional technician to conduct scans, and such technicians were in relatively short supply in the local labor market. Dealing with the backlog of patients waiting for scans is an operations problem, but processes outside of operations interact with processes within operations to cause the problem. Solutions to the backlog problem need to account for the larger system of activities within and outside of operations.

This example illustrates how operations is a part of a larger organization that includes many other functions. Nearly all operations decisions are related to at least one other function in the organization. The process view of business provides a vehicle for understanding the interactions between various organizational functions, and sometimes extending beyond organizational boundaries. These interactions can be streamlined and improved by process flowcharting, as is described next.

Operations Leader

Process Analysis to Improve Clinical Drug Trials

Vanderbilt-Ingram Cancer Center (VICC) wanted to improve the complex process of starting a clinical trial. A clinical trial is the research study used to conduct a controlled test of a new drug on humans. Patients volunteer to participate in such studies, and the results are used to determine whether the new drug will be approved for use in the marketplace.

VICC assembled a team of experts to map the process. The team included an oncologist, research nurse, administrator, oncology fellow, and three experts in process analysis. The team began by mapping process flows for major activities including initial preparation, approval processes, budgeting, and final preparation. The maps were then verified by the people involved in the daily operation of the studied processes.

Next, the mapping team used archival data from 218 previous trials to calculate the times to complete each process step. They separated the time taken into value-added and non-value added activities.

Investigation of activities included in the process maps revealed some surprises. For example, only 32–54 percent of mapped activities were deemed value added. The team's next step is to use what they have uncovered to speed up the opening of future clinical trials and to enhance patient treatment by providing more trials of more investigational drugs. This can be done by revising the process to eliminate non-value added activities.

Source: Adapted from David M. Dilts and Alan B. Sandler, "Invisible Barriers to Clinical Trials," *Journal of Clinical Oncology*, October 1, 2006.

6.3 PROCESS FLOWCHARTING

LO6.3 Construct a process flowchart for a given process.

Process flowcharting is a tool for beginning to understand and improve processes. This is a very commonly used tool in a wide variety of industries. It can be useful for almost any type of process, to gain understanding of the activities that must occur for the process to successfully produce a product or service.

Process flowcharting refers to the creation of a visual diagram to describe a transformation process. Flowcharting is known by several names: **process mapping, flow-process charting,** and in a service operations context as **service blueprinting.** Value stream mapping is yet another approach to process flowcharting popularized by firms that implement lean systems and lean thinking. Creating a visual diagram can be invaluable in documenting what happens within a transformation process. This pictorial documentation, when it includes process measurements, can help to identify how the transformation process can be improved by changing some or all of the following elements:

1. Raw materials
2. Product or service design
3. Job design
4. Processing steps or activities used
5. Management control information
6. Equipment or tools
7. Suppliers

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The visual diagram that is created from process flowcharting is known in generic terms as a flowchart (or process map, flow-process chart, service blueprint, or value stream map). There are many different specific forms of the flowchart in use, but the most common is the **systems flowchart.** An example of a systems flowchart for the "selecting a supplier" process is shown in **Figure 6.2**. In this example, the systems flowchart is drawn from the perspective of the buyer within an organization and shows the discrete steps, along with decision points and flow sequences, in selecting a supplier.

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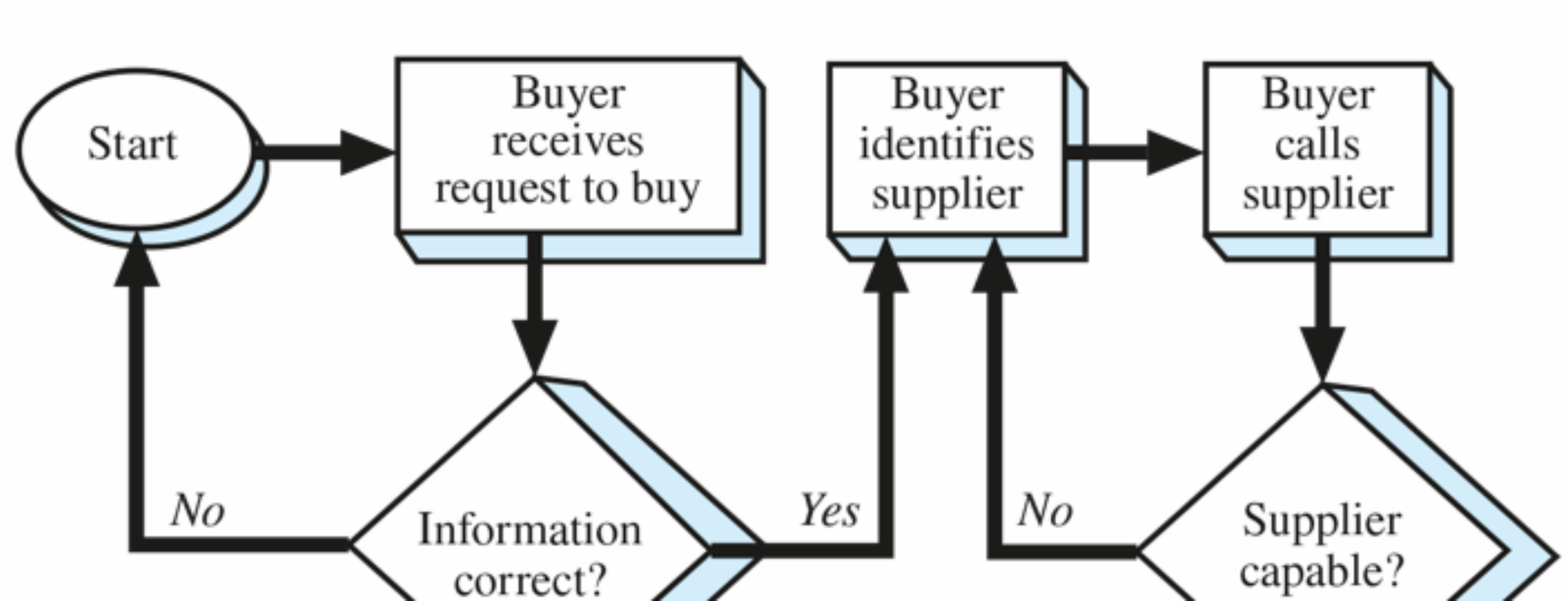


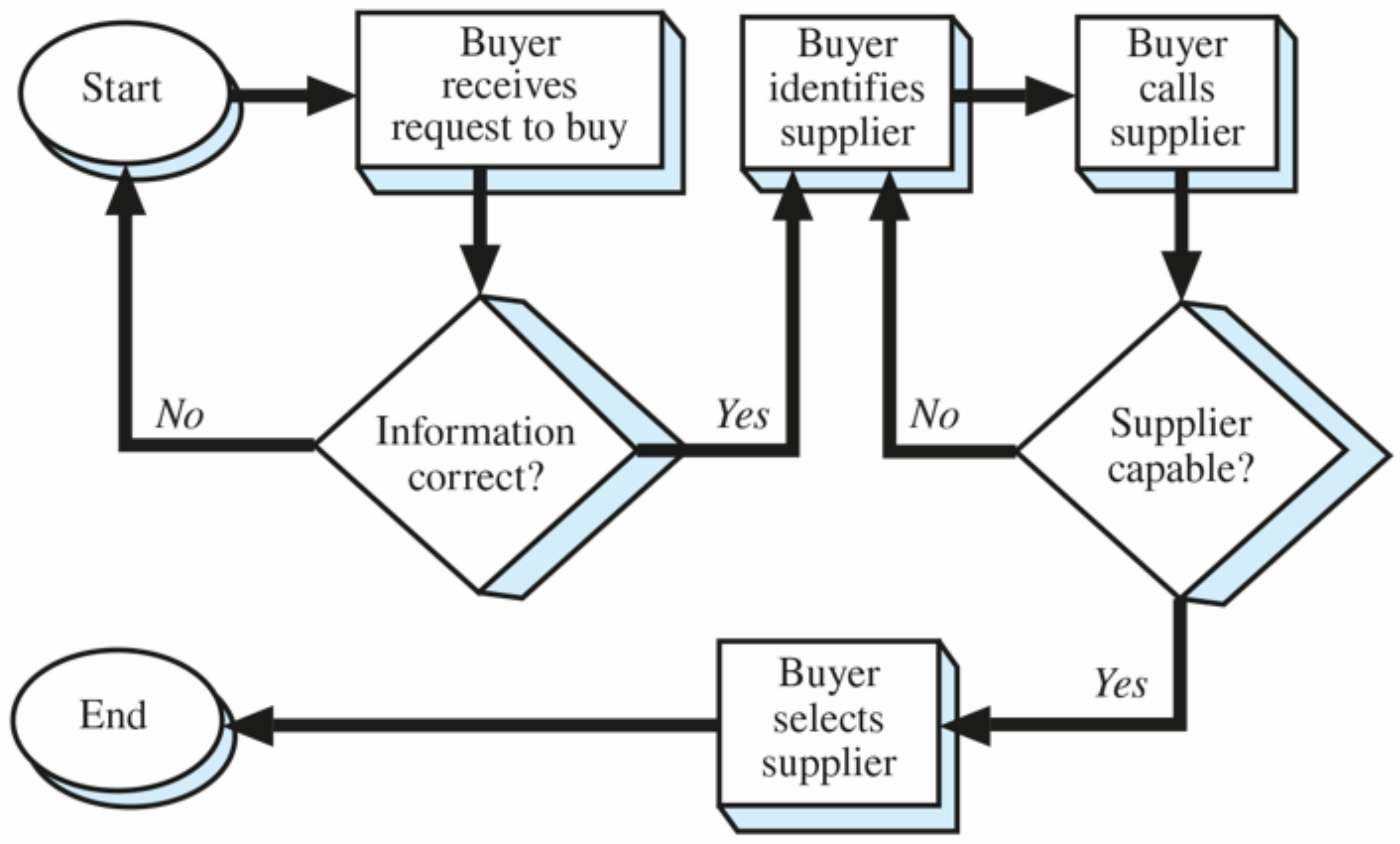
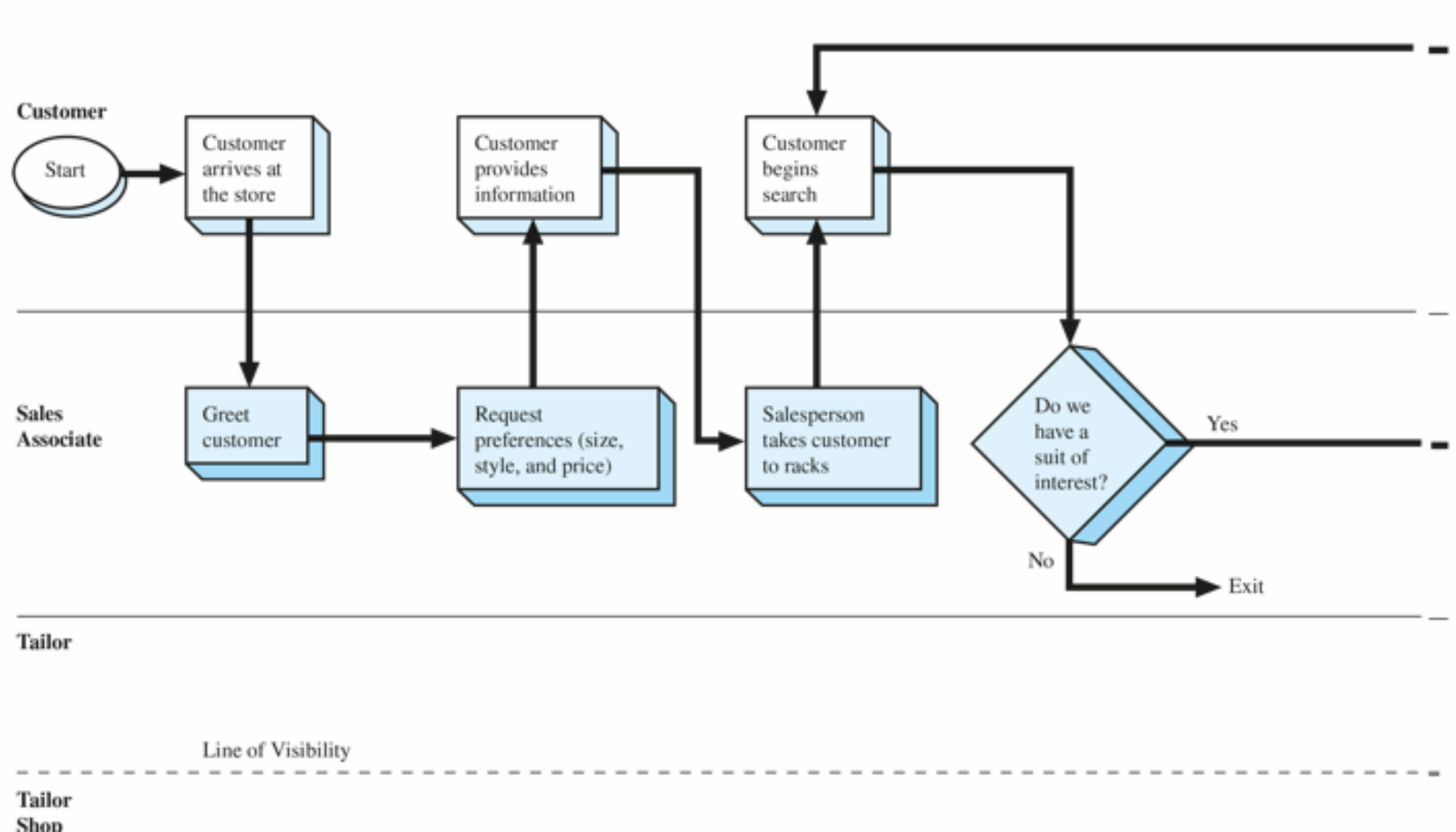
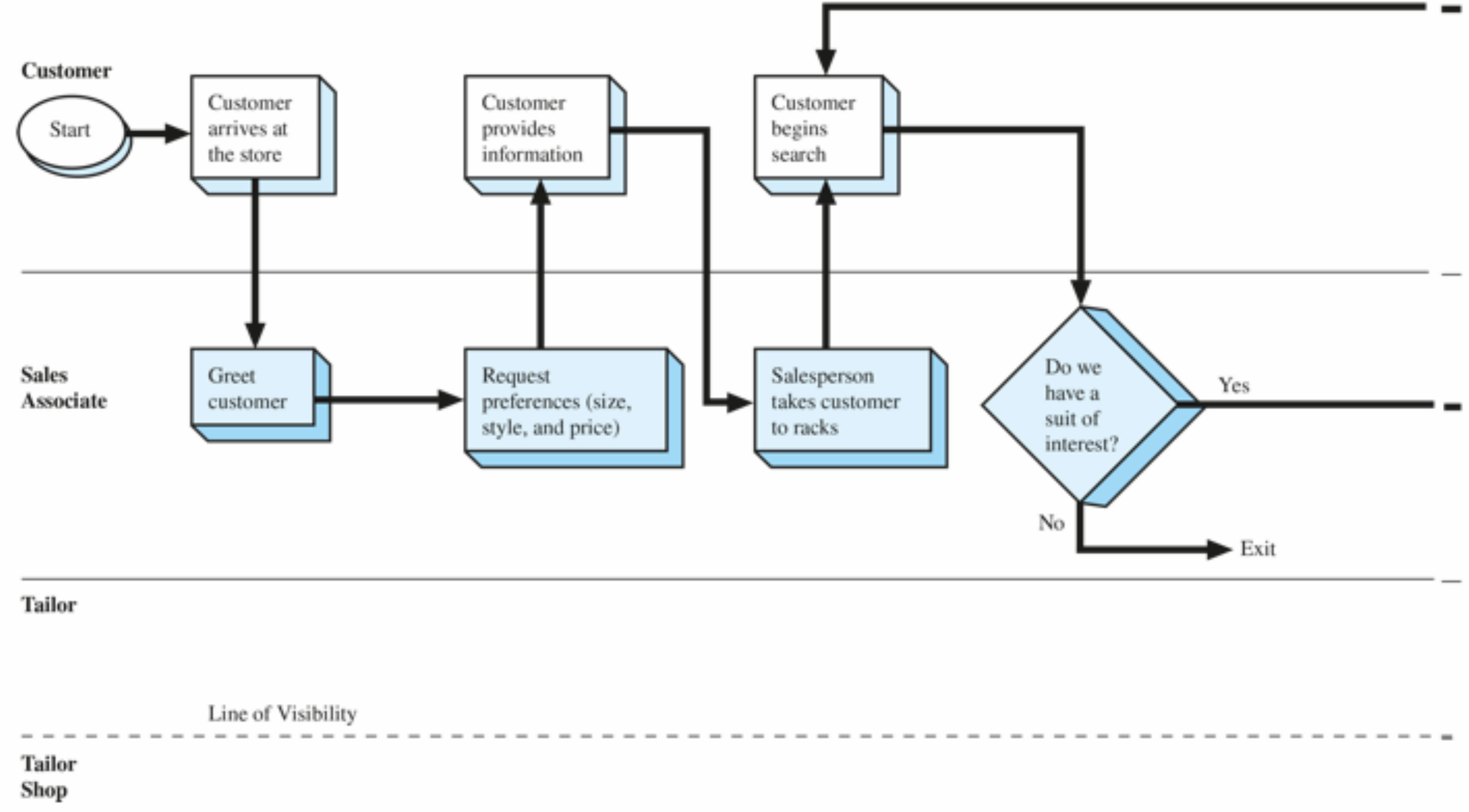


Figure 6.2 A flowchart for selecting a supplier.

The tailor makes alterations on the suit as part of the service blueprint.

Another example appears in [Figure 6.3](#), which shows the service provided to help a customer select and have altered a suit from a retail store. This systems flowchart depicts a service context with the customer being in the system and interacting with the service provider and is, as such, also called a service blueprint. Moreover, because the service blueprint captures the perspectives of different people—customer, sales associate, and tailor—it is also known generally as a *swim lane flowchart*. A swim lane flowchart is used to show the responsibilities of groups or individuals in either horizontal or vertical columns. It shows who or what is performing each step in the flowchart in the form of "swim lanes" in a pool. In [Figure 6.3](#), horizontal swim lanes are drawn to demarcate the various participants involved in the process of buying a suit from a retail store.





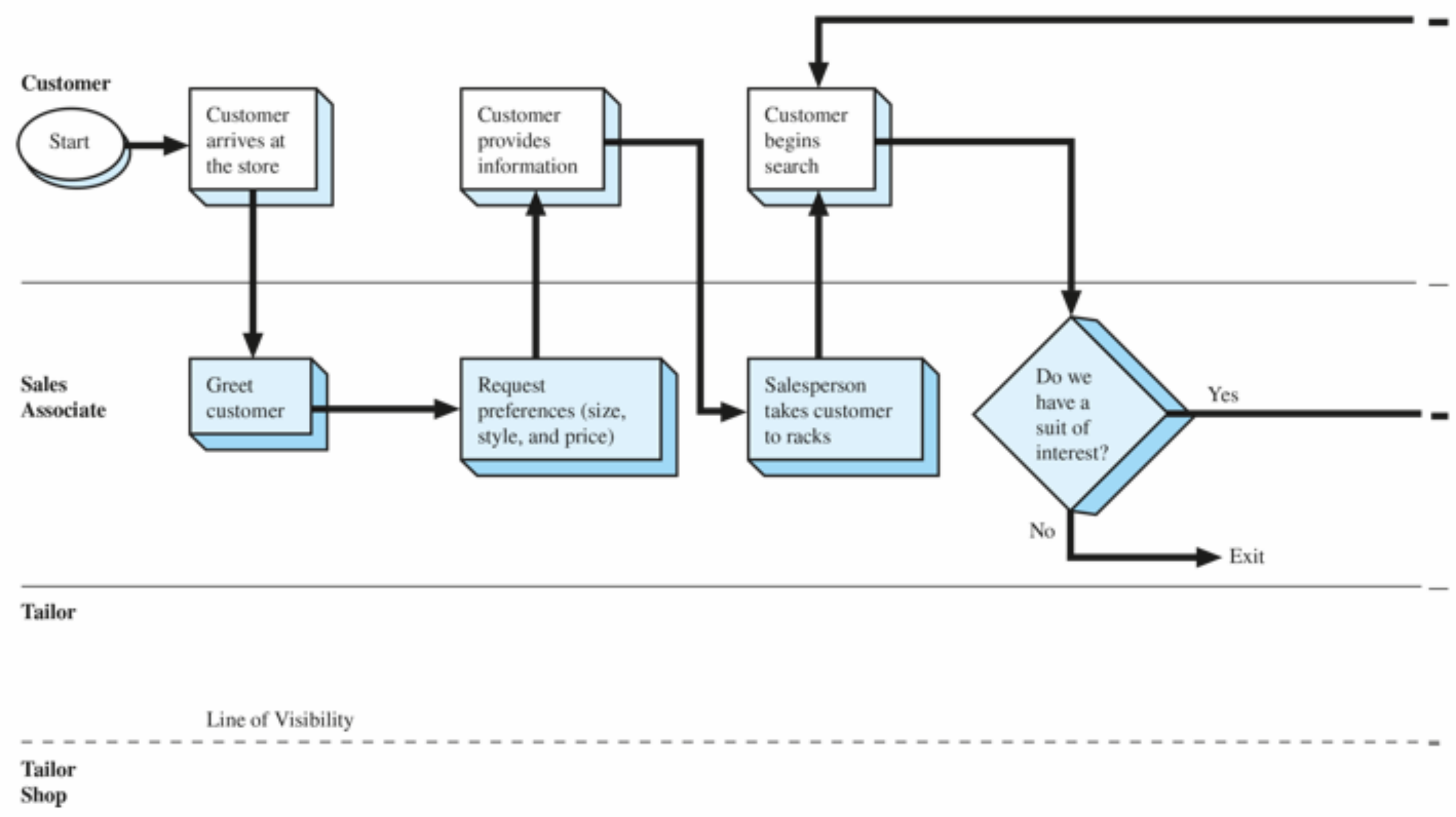


Figure 6.3 Service to select and have altered a suit from a retail store.

For any type of flowchart a number of principles should be followed to create a flowchart that is easy for individuals unfamiliar with the transformation process to understand and that facilitates process-flow analysis. These principles are consistent with process thinking, which views the transformation process as a system with inputs, outputs, customers, suppliers, boundaries, and processing steps and flows. The principles are as follows:

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1. **Identify and select a relevant transformation process (or system) to study.** This can be the entire supply chain for a product or a service, the entire firm, or a part of the firm, for example, the shipping department. Ideally, the selected transformation process is thought to affect performance.

2. **Identify an individual or a team of individuals to be responsible for developing the flowchart and for subsequent analyses.** This individual or team should have some familiarity with the transformation process and should have **process ownership,** that is, authority for initiating and/or implementing changes to the process. When a selected transformation process cuts across different functions, a cross-functional team should be involved. When a selected transformation process cuts across the supply chain, interfirm collaboration becomes critical.

3. **Specify the boundaries of the transformation process.** The boundaries denote where the selected transformation process begins and ends, identify the customer(s) and the supplier(s) of the transformation

ends, identify the customer(s) and the supplier(s) of the transformation process, and determine how many processing steps or activities are to be evaluated. In some cases, a function or department within an organization is the customer or supplier; in other cases, another firm is the customer or supplier.

4. **Identify and sequence the operational steps or the activities necessary to complete the output for the customer(s).** It is important in process flowcharting to depict what is actually happening and not what one thinks is happening. Once the "as it is" flowchart has been created and the transformation process has been analyzed, creating a "to be" flowchart may help show what the transformation process should look like when improvement changes have been implemented.

5. **Identify the performance metrics for the operational steps or the activities within the selected transformation process.** These metrics should be tied to the performance of the overall transformation process. For example, if delivery performance is of interest, it may be useful to track the processing times for each operational step or activity. Alternatively, if quality performance is of interest, it may be useful to track the defect rate for each operational step or activity.

6. **Draw the flowchart, defining and using symbols in a consistent manner.** Figure 6.4 shows the common symbols in Microsoft Visio for creating a systems flowchart. These symbols were used in Figures 6.2 and 6.3 and are also consistent with ISO 9000 standards for flowcharting.

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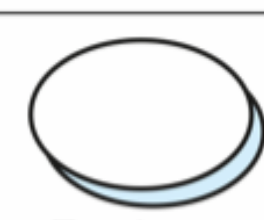
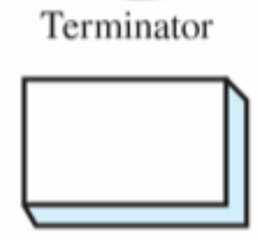
Symbol	Meaning
 Terminator	This symbol shows the "start" and the "end" of the flowchart, thereby specifying the boundaries of the transformation process to study. The words "START" and "END" should be written inside the symbol for clarity.
 Process	This symbol denotes an operational step or an activity to be performed. A short description of the operational step or the activity should be written inside the symbol for clarity.
 Decision/Evaluation	This symbol represents a decision, an evaluation, or an "IF-THEN" condition that has multiple potential outcomes (i.e., branches of arrows). The decision, evaluation, or condition should be properly described in writing inside the symbol for clarity. Each branch of arrow should be properly labeled to denote the meaning of the outcome from the decision, evaluation, or condition.
 Flow	This symbol denotes the direction of flow within the flowchart; the flow could be that of materials, information, or person (e.g., customer).

FIGURE 6.4 Common flowcharting symbols.

When other specific forms of flowcharts are created, the individual or team responsible may choose to use other symbols. This is allowed as long as the symbols are used consistently and, more importantly, a symbol key is provided to help interpret the flowchart that is drawn. Figure 6.5, for example, is a flow-process chart of the picking operations at a distribution center that provides produce, dairy, and meat items to grocery stores. In this case, the interest is in tracking the flow of

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to grocery stores. In this case, the interest is in tracking the flow of "materials" inside the distribution center. The flow-process chart depicts every step in the process from initial input of the customer order to picking groceries in various aisles, to consolidation, inspection, and shipment of the order. An information processing flowchart can also be drawn to depict the same picking operation, but here the interest is in tracking the flow of "information" for the purpose of management and control of the distribution center.

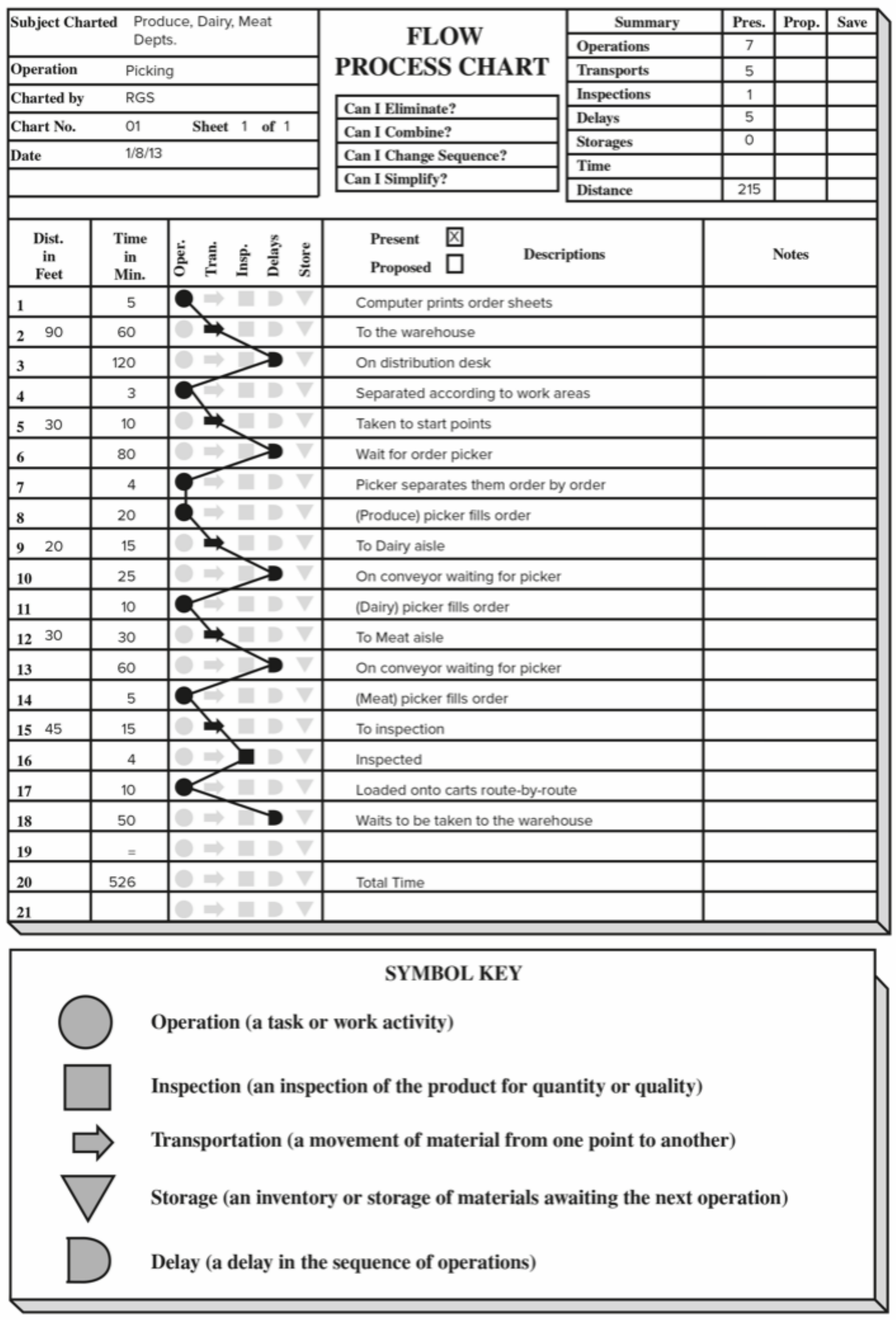

FIGURE 6.5 Flow-process chart for the picking operations.

6.4 PROCESS-FLOW ANALYSIS AS ASKING QUESTIONS

LO6.4 Analyze a process by asking a wide variety of questions informed by the process flowchart.

Creating a flowchart of a transformation process is an important first step in process-flow analysis. Once created, the flowchart can be analyzed to yield insights into how the transformation process can be improved, given a specific improvement goal. The improvement goal, for example, can be to increase efficiency, reduce throughput time, improve quality, or even boost increase efficiency, reduce throughput time, improve quality, or even boost worker morale.

A systematic approach should be followed to analyze the created flowchart and the underlying transformation process. This approach is epitomized by asking questions about the flowchart and, by extension, the underlying transformation process. **Table 6.1** shows typical questions about the performance of a system regarding flow, time, quality, quantity, and cost.

TABLE 6.1 Process-flow questions about performance

Question Category	Examples
1. Flow	• Is the transformation process balanced or unbalanced? • Where is the bottleneck in the transformation process? • Are all operational steps or activities necessary? • How jumbled is the flow within the transformation process?
2. Time	• How long does it take to produce/deliver one unit of output? • Can the length of this time be reduced? • What is the time between successive units of output? • Where is there excessive setup time? • Where is there excessive waiting time?
3. Quantity	• How many units theoretically can be produced/delivered in a given period (e.g., a week)? • How easy is it to change this quantity? • How many units are actually produced/delivered in a specified period (e.g., a week)?
4. Quality	• What is the historical defect rate? • Which operational step or activity contributes to the defect rate? • Where do errors occur?
5. Cost	• How much does it cost to produce/deliver one unit of output? • What are the cost buckets that make up the cost to produce/deliver one unit of output? • Can some cost buckets be reduced/eliminated?

When these questions are asked, opportunities to improve the underlying transformation process can be identified. For example, looking at the flow-process chart in Figure 6.5 and asking questions about the underlying transformation process can be identified. For example, looking at the flow-process chart in **Figure 6.5** and asking questions about the picking operations at the grocery distribution center led to the realization that many activities (transportation, inspection, delays, and storage) do not add value to the service provided and should be reduced or eliminated. Groceries in fact spent a considerable amount of time waiting for the next operation or in transit and very little time in value-added operations (only 57 minutes out of 526 minutes). As a result of asking questions, a number of changes were implemented, including relocating aisles (i.e., a process layout change), revising picking methods to reduce bottlenecks and labor time (i.e., changes to work methods and jobs), and designing special carts to make the loading of delivery vans easier and faster (i.e., an equipment change).

Similarly, looking at the service blueprint for the service of helping a customer purchase a suit from a retail store and asking questions might lead to suggestions for improvement such as the following:

- If sales associates can be trained to listen better to customer requests, will customers be more likely to find a suit of interest?
- Can customers call ahead and ask to have some suggested suits waiting for examination, reducing their search time?
- Is the tailor available while the customer is trying on the suit to provide suggestions on how the suit can be tailored to fit better?
- Does the layout of the retail store make it easy for customers to search and find what they want?

In summary, process-flow analysis begins with a good flowchart of the transformation process used to convert inputs into outputs. This can be facilitated by creating a flowchart that shows materials flows, information flows, or service flows. Once a flowchart is created, appropriate questions should be asked to highlight improvement opportunities in flow, time, quantity, quality, and cost.

6.5 MEASURING PROCESS FLOWS

LO6.5 Determine process capabilities from analysis.

Once a process flowchart aimed at improving a transformation process has been created, some basic measures of a transformation process can be described. These measures yield insights into the structure and performance of a transformation process.

Let's study the airport security process during check-in at a major airport. There is a line of passengers waiting to clear security and a number airport. There is a line of passengers waiting to clear security and a number of security scanners for examining passengers and their carry-on luggage. We can measure the total time it takes from entering the security line until passengers are cleared to catch their flights. It turns out that these three observations are related: the average number of passengers in the line, the average rate at which security can process passengers, and the average time it takes passengers to get through the line. This relationship is called **Little's Law,** named after the operations researcher who discovered it.

Average waiting time in line at airport security follows Little's Law.

© Philippe Merle/AFP/Getty Images

Little's Law shows that the average number of items in a system (I) is the product of the average arrival rate to the system (R) and the average time an item stays in the system (T). This average time in the system is **throughput time,** the time from when the processing begins until the product or service is completely finished. It includes both active processing time and any waiting time that occurs during processing. In mathematical terms Little's Law is stated as follows:

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$$I = T \times R$$

where I = average number of things in the system (or "inventory")
T = average throughput time (processing time + waiting time)
R = average flow rate in the process

In the case of airport security, if the security screeners can process an average of five passengers per minute ($R = 5$) and it takes an average of 20 minutes to get through the security line ($T = 20$), the average number of passengers in line will be 100 ($R \times T = 100$). An assumption is that the process is in a steady state in which the average output rate equals the average input rate to the process.

Little's Law is very powerful and is widely used in practice. It applies to manufacturing and service transformation processes. Little's Law can be used in a variety of settings and situations.

Example

Suppose a factory can produce an average of 100 units of product per day. The throughput time, including all processing and waiting time for the product, is an average of 10 days.

T = 10 days
R = 100 units per day

Then the average inventory (partly finished product) in the factory will be

$$I = 10 \times 100 = 1000 \text{ units}$$

For another example, the amount of money in accounts receivable can be considered as inventory, or the stock of money. Using Little's Law, if there is $2 million in accounts receivable (I) and $20,000 per day is added to and subtracted from (flows through) accounts receivable (R), the throughput time is

$$100 \text{ days } (T = I/R = 2{,}000{,}000/20{,}000)$$

Therefore, accounts receivable has 100 days of outstanding receivables.

Little's Law applies to any steady-state transformation process including manufacturing, people waiting in lines, invoice processing, transactions in a legal office, and even accounts receivable processing. Little's Law is useful when any two of the three variables in the formula are known, then the third can be calculated. The examples above show how this is done to calculate I and T. We can also calculate R if we know I and T ($R = I/T$).

Next, we extend process measurements to include capacity, supply, and demand. **Capacity** is the maximum rate of output from a transformation process or the maximum flow rate that can be sustained over a period of time. In the airport security example, the average flow rate was five passengers per minute, but the capacity of the security checkpoint may have been greater, say, eight passengers per minute. With random arrivals (such as passengers arriving to enter the line) it is necessary to have capacity that exceeds the average arrival rate. If the arrival rate is greater than the capacity, the line will build up to an infinite length. This occurs because there are periods when the arrivals are less than the average and the full capacity cannot be used during those times. Queuing (or waiting line) theory, which is covered in a technical chapter explains these phenomena in detail.

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Most processes are composed of several activities that require certain resources. In the airport screening example resources include the workers who check each passenger's identification and boarding pass, operators who run the scanning equipment, and the boarding pass, operators who run the scanning equipment, and the equipment itself. In general, if there are n resources that process each transaction, then

$$\text{Capacity} = \text{Minimum (capacity of resource}_1, \ldots, \text{capacity of resource}_n)$$

Note that the capacity of the entire process cannot be greater than the capacity of the most constraining (the smallest capacity) resource, which is called the **bottleneck.**

The amount of output a transformation process actually produces will depend on its capacity as well as the supply and demand of the process. The **flow rate** is as follows:

$$\text{Flow rate} = \text{Minimum (supply, demand, capacity)}$$

In the factory example above, assume that capacity is 200 units per day, demand is 75 units per day, and supply is 100 units per day. The flow rate would be 75 units per day (the minimum of the three variables) assuming they can produce only what is demanded. If they were able to increase demand to 150 units per day, the flow rate would be only 100 units per day unless supply could also be increased.

6.6 MEASURING PROCESS FLOWS AT PIZZA U.S.A.

To cement our understanding of the concepts of process measurement, let us look at a Pizza U.S.A. example. Suppose that one of the pizza stores produces fresh pizza with seven different topping choices, including the most popular "everything dump" pizza. The store is staffed by two employees: a pizza chef and an assistant. It has an oven that can bake up to four pizzas at a time. The transformation process (sequence of steps) followed at the store is as follows:

	Minutes	Who
Take the order	1	Assistant
Make the crust	3	Chef
Prepare and add ingredients	2	Chef
Bake the pizza	24	Oven
Cut pizza and box the order	1	Assistant
Take payment	1	Assistant

1. *What is the capacity of this process?*

1. *What is the capacity of this process?*

   Looking at the three resources, we have:

   - The assistant takes 3 minutes per order (1 + 1 + 1) and thus can process 20 orders per hour.
   - The chef takes 5 minutes per order (3 + 2) and can process 12 orders per hour.
   - The oven takes an average of 6 minutes per order (24 ÷ 4, because the oven holds 4 pizzas at a time), or 10 orders per hour.

For simplicity, we assume that each order is for one pizza and that pizzas can be added to the oven any time during the cooking cycle. The minimum of the three resource capacities is 10 orders per hour, and so the system can produce 10 orders per hour.

2. *What is the bottleneck in this process?*

The bottleneck in this case is the oven. The assistant is busy only half the time, and the chef has 1 minute of idle capacity out of every 6 minutes of average baking time. Reallocating jobs between the chef and the assistant to balance the workload may make the chef happy but will not increase the flow rate of the process. If Pizza U.S.A. wants to make more pizzas, something must be done to accelerate the flow of pizzas through the oven, or another oven must be added. The lesson here is that the process cannot produce more than the bottleneck can process.

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The oven is one of the resources that determines the process capacity.

3. *What is the throughput time?*

If we assume there is no waiting time in this system, we simply add the times of all the steps to fill an order:

$$1 + 3 + 2 + 24 + 1 + 1 = 32 \text{ minutes}$$

It takes 32 minutes to complete all the steps and make one pizza. Note that

It takes 32 minutes to complete all the steps and make one pizza. Note that adding an oven will increase the capacity and move the bottleneck to the chef, but it will not change the throughput time. Changes would have to be made in the actual process of cooking, preparation, or other flow times to reduce throughput time.

4. *What is the flow rate?*

Assuming that demand and supply exceed capacity, the flow rate is determined by the bottleneck capacity of 10 orders per hour. However, this is the maximum flow rate; the actual flow rate could be much less. If either demand or supply is less than capacity, then the smaller of the two will determine the flow rate. In the following question, we assume demand is only 60 percent of capacity, for a flow rate of six pizzas per hour.

5. *What does it cost to make a pizza if the average demand is 60 percent of capacity?*

Assume the chef gets paid \$15 per hour, the assistant gets paid \$11 per hour, and overhead cost is 50 percent of direct labor cost. At 60 percent of capacity, the average flow rate is six pizzas per hour. The cost per hour of operations is \$15 + \$11 = \$26 for labor plus 50 percent added for overhead = \$39 per hour, or \$39 ÷ 6 = \$6.50 per pizza. Assume the cost of ingredients is \$2.00 per pizza. Therefore, the total cost is \$6.50 + \$2.00 = \$8.50 per pizza.

6. *How can the unit cost of pizzas be reduced?*

Three possibilities are:

- Increase demand through pricing, advertising, or other means.
- If demand increases to exceed capacity, increase the flow rate of the entire transformation process by means of automation or process improvements.
- Reduce the unit cost of labor, materials, or overhead.

As you can see, these three approaches are interconnected because increasing demand will also require an increase in capacity at some point, and increasing the flow rate does no good unless demand is increased to sell the additional product.

6.7 PROCESS REDESIGN

LO6.6 Explain the principles of process redesign.

Process redesign usually starts with identifying critical processes required to meet the customers' needs. Then the critical processes, many of required to meet the customers' needs. Then the critical processes, many of which cut across organization boundaries, are analyzed in detail using the methods described in this chapter. Changes are often made to these processes as a result of the insight from process-flow analysis. These changes might include eliminating some steps and combining others, or could be as extreme as a complete reconfiguration of process steps. As a result, business processes are redesigned and integrated to better serve the customer. The term **business process reengineering** (BPR) has also been used to label extensive process redesign activities. See the Operations Leader box titled "Crédit Suisse: A Successful Process Redesign" for an example of how BPR is being deployed to aid in improving processes.

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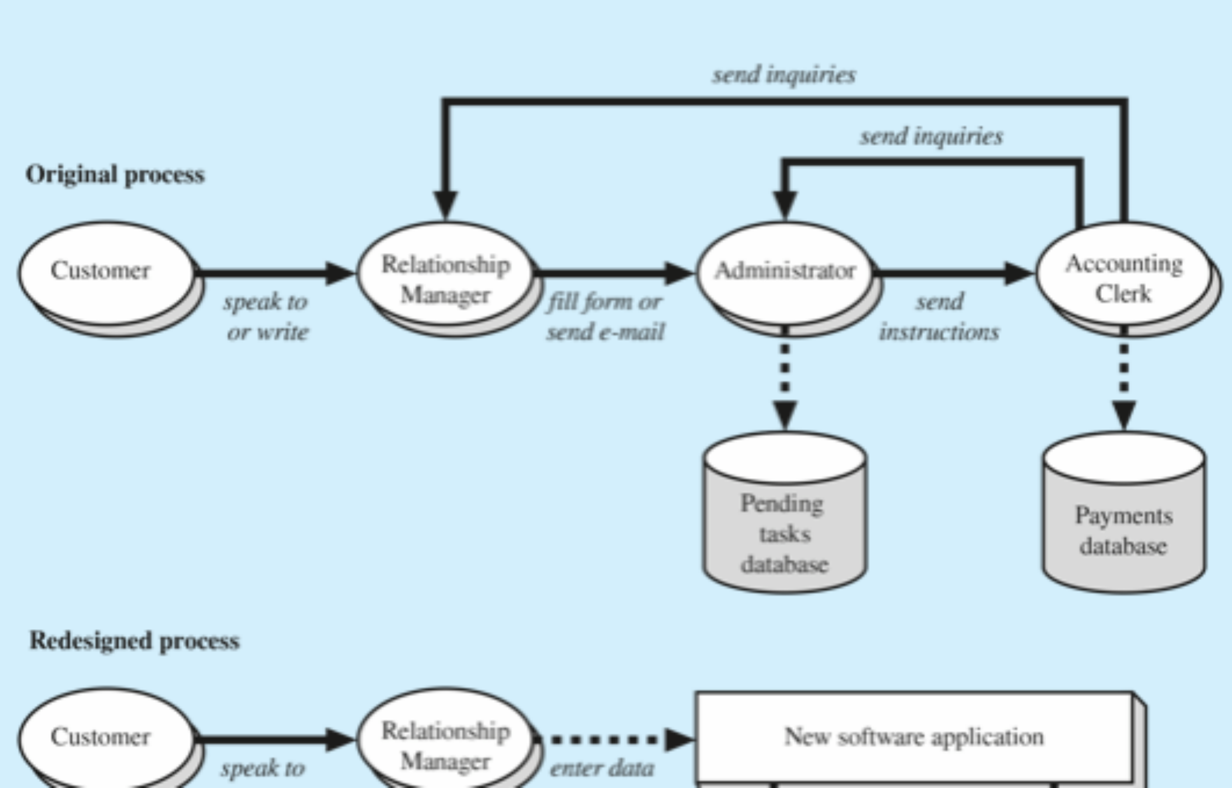
Operations Leader

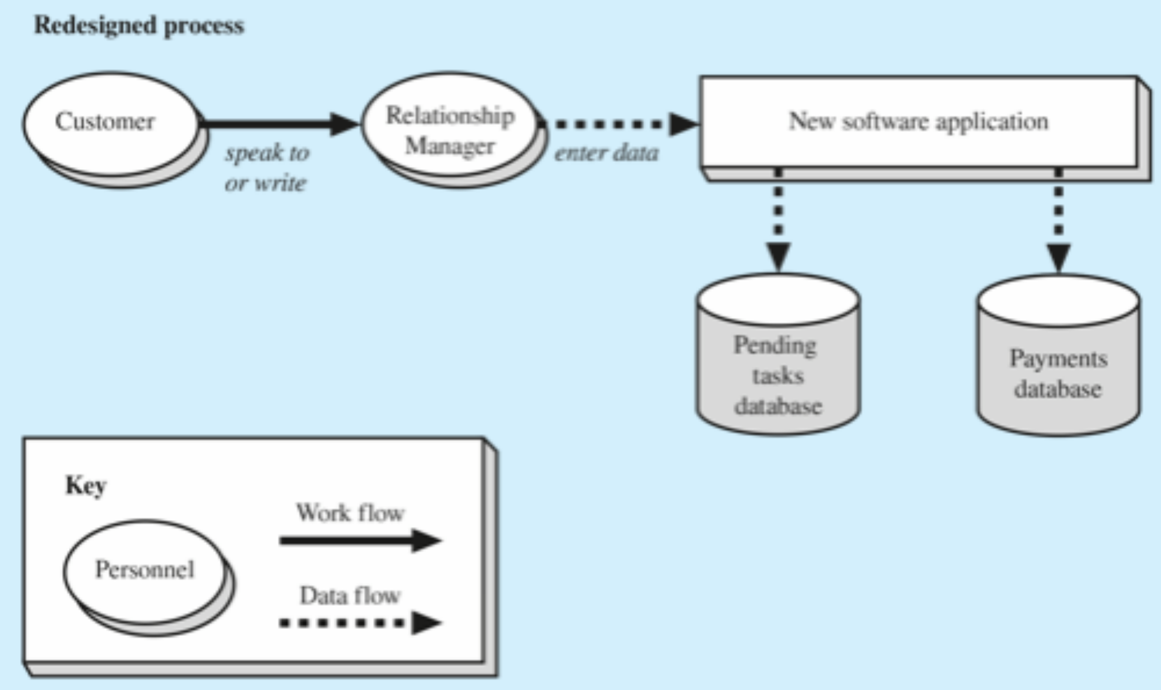
Crédit Suisse: A Successful Process Redesign

Headquartered in Zurich, Switzerland, Crédit Suisse is a global financial services institution with more than two million customers in 50 countries and a global workforce of more than 50,000 employees. Process redesign has been applied to many of its major service processes. The "accounts closing" process is described here.

Customers' rising expectations for faster service, along with increasing regulations, created a need for a faster and less error-prone process. Daily, hundreds of accounts are closed by retail and corporate banking customers. In the past, the steps of closing a customer account involved many manual steps and a variety of banking personnel. The original accounts closing process, shown here, was prone to errors, slow to respond, and not very efficient.

After the process was analyzed, an important insight came to light. Most requests for account closing could be handled in a standardized manner and therefore could be automated. A new software application was developed to allow the relationship manager to initiate all the activities that would close a customer account. Other bank personnel did not need to be involved, except in a small number of unusual cases. As a result, the time to close an account was reduced by 50 percent and the error rate was reduced to just 0.01 percent.





Source: Peter Küng and Claus Hagen, "The Fruits of Business Process Management: An Experience Report from a Swiss Bank," *Business Process Management Journal* 13, no. 4 (2007), pp. 477–87; www.credit-suisse.com, 2016.

In their famous book *Reengineering the Corporation* (2006), Hammer and Champy argue that most business processes are antiquated and need to be completely redesigned. Many existing processes have been designed within the confines of individual functions, such as marketing, operations, and finance and also do not make use of complete information systems. As a result, these processes take far too long to provide customer service and are inefficient and wasteful.

Consider a major insurance company that had just this problem. When the customer called about an insurance problem, the call was taken by the call center. The problem was entered into a computer and passed electronically to one of several departments: underwriting, policy service, accounting, or another department. The problem then waited in the queue, often for several days, until a worker had time to investigate it. In some cases, the customer's problem had been routed to the wrong department and had to be routed to another department, again spending several days in the queue. If the problem required more than one department to answer the question, the process of waiting was repeated. Finally, someone in customer service would get back to the customer after several weeks. In many cases, the original question was not answered completely or was answered incorrectly.

This process was redesigned by completely reorganizing the entire insurance operation around customer service representatives who would attempt to handle customer requests on the phone, if possible, using detailed protocols and standard scripts. If additional work was required, the customer service representative checked with other specialists and got back to the customer with an answer. The customer service representatives had been cross-trained in all the various disciplines required and were supported by the other departments. Although this required more training of customer service representatives, it greatly improved the speed and accuracy of the service while saving many millions of dollars. It also accuracy of the service while saving many millions of dollars. It also provided a single point of contact and less hassle for the customer.

Process redesign is **radical redesign** when processes simply cannot be improved in small steps and require a complete rethinking and rearrangement of process activities to improve them in a major way, as was the case for the insurance company described above. Often radical redesign is supported by new technology, in the form of either production technology or information technology.

To pursue a successful radical redesign requires four principles:

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1. **Organize around outcomes, not tasks.** The insurance company was originally organized according to tasks, using the classic division of labor. When the company reorganized around the outcome, which was customer service, dramatic improvements were made. A customer service representative handled all activities associated with the desired outcome. Although it is not always possible to have one person do everything, jobs can be broadened and handoffs between departments can be minimized.

2. **Have the people who do the work process their own information.** When bedside or portable information system access is available, nurses can update patient electronic medical records as they are dispensing medications to the patient. By doing so, nurses avoid delaying the record update and also do not "hand off" the information for input by someone else, thus reducing the likelihood of inadvertent errors. This principle can be applied in many situations in which information is passed from one department
to another.

3. **Put the decision point where the work is performed, and build control into the process.** It is better to push decision making to the lowest possible level. This will eliminate layers of bureaucracy and speed up the decision-making process. In the insurance example, the customer service representative had greater latitude to make decisions directly for the customer rather than referring decisions to other departments. To accomplish this, however, information and controls must be built into the process itself.

4. **Eliminate unnecessary steps in the process.** Simplifying the processes frequently means that unnecessary steps and paperwork are eliminated. Every step is examined by using the flowcharting techniques discussed earlier, and only those that add value for the customer should be retained. Process redesign can be used to streamline and implify work flows.

Process redesign is just one of many methods that can be used to improve operations. It uses a process view of the organization as a way of improving process flows. As a result of process redesign, processes will be improving process flows. As a result of process redesign, processes will be simplified, process flows improved, and non-value-added work eliminated.

6.8 KEY POINTS AND TERMS

This chapter has emphasized process-flow analysis by building on the ideas of systems, measurement, flowcharting, and process redesign. The key points are as follows:

- A prerequisite to process-flow analysis is definition of the system to be analyzed. Systems definition requires isolation of the system of interest from its environment by defining a boundary, customers, outputs, inputs, suppliers, and process flows.
- The process view is the idea that a business is a set of horizontal processes that are interconnected with the objective of meeting customer needs.
- Process flowcharting creates a pictorial description of a transformation process. The aim is to create flowcharts, or visual diagrams of a transformation process, that are easy to understand by people who may not be familiar with the underlying transformation process.
- Process flowcharting can be applied to materials flow, information flow, and customer flow. In manufacturing, a flow-process chart is created to show materials flow. In services, a service blueprint is created to show how customers interact with service providers.
- Process-flow analysis takes the flowchart and the measurements of a transformation process and seeks answers to relevant questions. These questions help highlight opportunities that can be implemented to improve the transformation process.

- Measurement is essential to process improvement. Some key measurements of a process are throughput time, flow rate, inventory, and capacity. The bottleneck resource determines the capacity of the entire process.
- Process redesign is used for changing how a process is carried out. It is often cross-functional in nature and may require a complete overhaul of work methods, flows, and information systems.

Key Terms

Process-flow analysis 92
Process thinking 93
System 93
System boundaries 93

STUDENT INTERNET EXERCISES

1. Examples of Process Maps
   www.smartdraw.com

Click on "Templates" and "Flowchart" and study a variety of the maps. What are some of the clearest and most informative flowchart characteristics? Are there some flowcharts that are confusing or not clear?

2. Q-Skills
   www.q-skills.com/flowchrt.html

Read the summary of flowcharting and write a short report on some of the challenges of using flowcharts.

3. Little's Law
   en.wikipedia.org/wiki/Little's_law

Read this short article on Little's Law for more background information.

SOLVED PROBLEMS

SOLVED PROBLEMS

Problem

1. A ticket line for a Minnesota Vikings football game has an average of 100 fans waiting to buy tickets and an average flow rate of 5 fans per minute. What is the average time that a ticket buyer can expect to wait in line?

Solution

Using Little's Law $I = T \times R$, solve for T:

$$T = I \div R = 100 \div 5 = 20$$

A ticket buyer can expect to spend an average of 20 minutes in line.

Problem

2. Joe's commercial laundry has contracts to wash bedsheets for hotels. Joe intakes each batch of sheets, which takes 1 minute, and then the sheets are washed, taking 20 minutes, and dried, taking 30 minutes. The batch of sheets is ironed, taking 10 minutes for one employee to complete each batch, and there are two employees ironing sheets. Finally, Joe packages the sheets and bills the customer, taking 2 minutes. Joe has five washing machines and seven dryers that can process one batch of sheets each.

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   a. What is the capacity of the laundry system, and what is the bottleneck?
   b. What is the average throughput time of a batch of sheets?
   c. If the flow rate is 10 batches per hour, what is the average number of batches of sheets in the system (inventory)?

Solution

a. The capacity of each resource is as follows:

   - Joe takes 3 minutes for each batch and can thus handle 20 batches per hour.
   - Ironing takes 10 minutes, and so each employee can handle 6 batches per hour and the total capacity for two employees is 12 batches per hour.
   - Washing machines take 20 minutes per batch or three loads per hour for each machine, and there are five machines, for a total capacity of 15 batches per hour.
   - Dryers take 30 minutes per batch or two loads per hour from each

- Dryers take 30 minutes per batch or two loads per hour from each machine × seven machines for a capacity of 14 batches per hour.

The most constraining (minimum capacity) resource is the ironing, and so the system capacity is 12 batches per hour and ironing is the bottleneck.

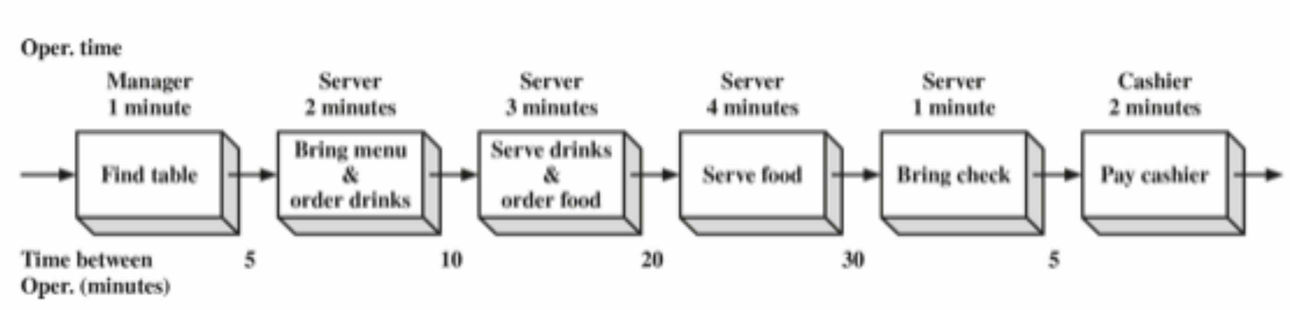
b. The average throughput time (assuming no waiting time) of the system for each batch of sheets is:

$$T = 1 + 20 + 30 + 10 + 2 = 63 \text{ minutes}$$

c. $I = T \times R = (63 \div 60) \times 10 = 10.5$ batches (note, that the 63 minutes must be converted to hours using 60 minutes in an hour).

Problem

3. A restaurant has 30 tables. When the guests arrive, the manager seats them, servers serve them, and the cashier assists them when they pay the bill. The process is shown with processing times above the process steps and waiting times that occur between operations below the steps. One manager, one cashier, and four servers are available.



a. What is the capacity of the system and the bottleneck resource?
b. What is the throughput time for each customer?
c. If there are 20 arrivals per hour, what is the average number of tables filled?

Solution

a. The capacity of each resource is as follows:

- The manager takes 1 minute each and can handle 60 customers (or tables) per hour.
- The cashier takes 2 minutes each and can handle 30 customers per hour.
- Each server takes 10 minutes per table and can handle 6 tables per hour. There are four servers, and so the total capacity for servers is 24 tables per hour.
- There are 30 tables available.

The resource with the minimum capacity is the servers, and so the system capacity is 24 tables per hour and the bottleneck is the servers.

b. The throughput time (including both processing time and waiting time) of the system for each customer is

$$1 + 2 + 3 + 4 + 1 + 2 + 5 + 10 + 20 + 30 + 5 = 83 \text{ minutes}$$

c. If there are 20 arrivals per hour, there will be an average of

$$I = T \times R = (83 \div 60) \times 20 = 27.7 \text{ tables being used}$$

Discussion Questions

1. In the following operations, isolate a system for analysis and define customers, services produced, suppliers, and the primary process flows.
    a. A college
    b. A fast-food restaurant
    c. A library
2. Explain how the process view of an organization is likely to uncover the need for greater cross-functional cooperation.
3. Explain Little's Law in your own words. How can it be used, and what are its limitations?
4. Provide a definition of a bottleneck. Why is it important to find the bottleneck?
5. Explain the differences between capacity, flow rate, and demand.
6. What kinds of problems are presented by the redesign of existing processes that are not encountered in the design of a new process?
7. Why is it important to define the system of interest before embarking on improvement? Give three reasons.
8. Find examples of flowcharts and study their details. Describe how the flowcharts might be used to make improvements.
9. Describe service blueprinting in your own words, including examples of when it should be used.

Problems

1. In a company that processes insurance claims, the average flow rate is 10 claims per hour and the average throughput time is six hours.
    a. How many claims are in the system on average?
    b. If the demand for claims to be processed is seven per hour and the capacity is eight per hour, what is the flow rate?
    c. What assumptions have you made in your answers?
2. Suppose a bank clears checks drawn on customers' checking accounts by using the following process:

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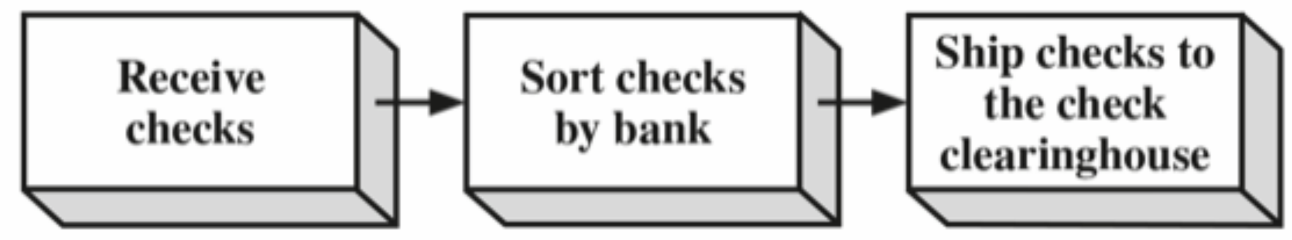


   a. If the capacity for receiving checks is 1000 checks per hour, for sorting checks is 800 checks per hour, and for shipping checks is 1200 per hour, what is the capacity of the system to process checks?
   b. If the flow rate is an average of 600 checks per hour and there are an average of 200 checks in the system, what is the average throughput time of checks?
   c. What could be done to decrease the throughput time?

3. The Stylish Hair Salon has three stylists who provide services to women. After checking in with the receptionist, which takes an average of 1 minute, the customer's hair is washed, dried, and styled, taking an average of 25 minutes. The payment takes 3 minutes and is also performed by the receptionist.

   a. What is the capacity of the process, and what is the bottleneck?
   b. What is the average throughput time? If the average flow rate is five customers per hour, what is the average number of customers in the system?
   c. If the input to the system is random, what will happen as the flow rate approaches the capacity of the system?

4. Judy's Cake Shop makes fresh cakes to customer orders. After receiving the order by Judy's assistant, which takes 2 minutes, Judy then takes 8 minutes to mix the ingredients for the cake and loads a cake pan for baking. Then the cake is put into the oven for 30 minutes. The oven can hold three cakes at one time. When the cake is taken out of the oven, it is cooled for 1 hour. The assistant then takes 2 minutes to pack the cake for pickup and bills the customer, which takes 3 minutes.

   a. What is the capacity of the process, and what is the bottleneck?
   b. What is the throughput time for a typical cake?
   c. If on average five orders are taken per hour, how many cakes are there in the process (on average)?

5. The Swanky Hotel provides room service for its guests. The process for room service begins with a room service manager who takes orders by phone at an average of 2 minutes per order. The manager then sends the order to the kitchen, where it takes a cook an average of 16 minutes

the order to the kitchen, where it takes a cook an average of 16 minutes to prepare the food for each order. There are four cooks in the kitchen. If the customer orders a beverage, the room service manager sends the order to the bar at the same time the order is sent to the kitchen. It takes 3 minutes for a bartender to fill the order, and 80 percent of the orders require a beverage. When the kitchen and bar orders are both ready, a waiter takes them to the room and bills the guest. There are six waiters to provide the service, and each order takes 20 minutes for the waiter to complete.

a. What is the capacity of the process, and what is the bottleneck?
b. What is the throughput time of a typical order?
c. Assume that on Friday evenings an average of 10 room-service orders per hour are placed. How many orders are in the system on average on Friday nights?
d. Assume the following pay rates for the employees. Waiters are paid $9 per hour (not including tips), cooks are paid $15 per hour, the bartender is paid $10 per hour, and the room service manager is paid $18 per hour. Also, assume that 60 percent overhead is added to direct labor and that the cost of food and beverages averages $6 per order.
    - What is the average cost of an order when operating at 10 orders per hour?
    - What is the minimum cost per order that the system can achieve?
e. What assumptions have you made in these calculations that may not be reasonable?

6. A furniture factory makes two types of wooden tables, large and small. See the flowchart below.

	Setup Time, Minutes	Run Time per Piece, Minutes	Capacity, Pieces per Hour
Wood cutting	30	5	15
Make four legs	60	10	10
Make tops	60	12	8
Finish the wood	20	8	12
Assemble and ship	20	17	14

Small tables are made in batches of 100, and large tables are made in batches of 50. A batch includes a fixed setup time for the entire batch at each process step and a run time for each piece in the batch. Both large and small tables have the same processing times. The capacities of each process step are given, and apply to production of either type of table, as shown in the flowchart.

a. What is the capacity of the system, and what is the bottleneck?

b. What are the throughput times for batches of large and small tables?

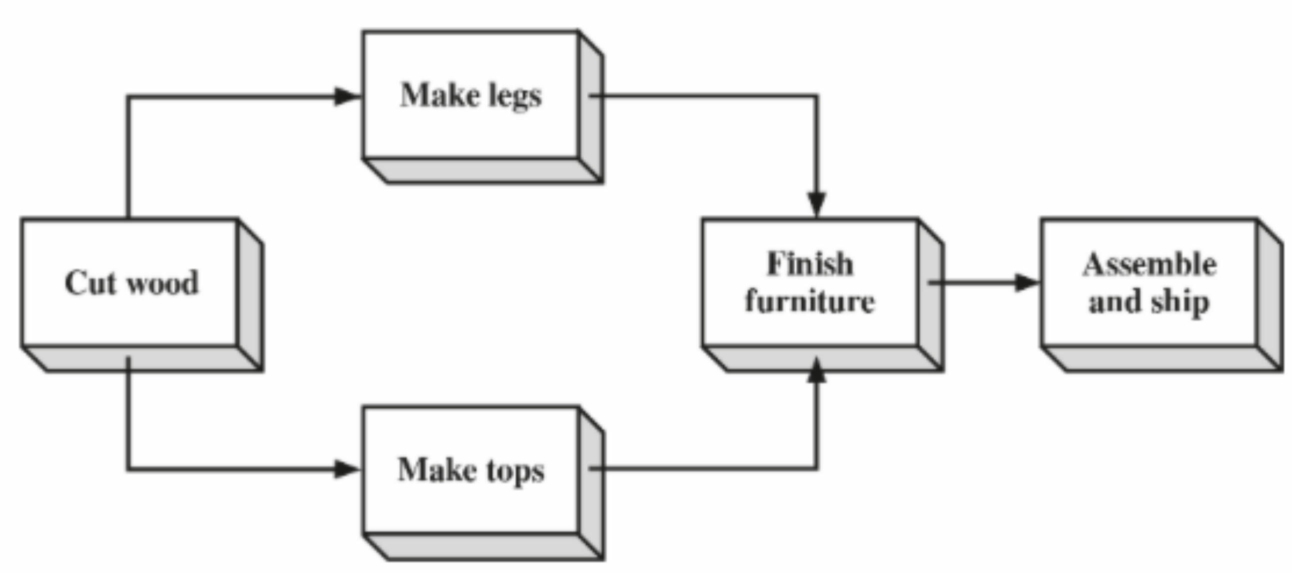
c. When producing at a rate of six small tables per hour on average, how many tables will be in the system?

7. Draw a flowchart of the following processes:

a. The procedure used to pay your bills

b. College registration

c. Checking out a book from the library



8. Review your answers in problem 7 to be sure that you are correctly using the flowchart symbols described in this chapter.

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9. Use the key questions of what, who, where, when, and how for problem 7 to suggest improvements in the processes.

10. Using the correct symbols, draw a flowchart of the following processes:

a. Preparing yourself for a job interview

b. Going to the library to study and returning to your room

11. Use the what, who, where, when, and how questions to make improvements in problem 10.

12. Draw a service blueprint for the following:

a. Pizza delivery

b. Automobile repair

13. Analyze the service blueprints in problem 12 for possible improvements. Use the flow, time, quantity, quality, and cost questions.