Progress in IS

Nadja Damij
Talib Damij

Process Management

A Multi-disciplinary Guide to Theory, Modeling, and Methodology

Springer

Progress in IS

For further volumes:
http://www.springer.com/series/10440

Nadja Damij • Talib Damij

Process Management

A Multi-disciplinary Guide to Theory, Modeling, and Methodology

Springer

Nadja Damij
Faculty of Information Studies
Novo Mesto
Slovenia

Talib Damij
Faculty of Economics
University of Ljubljana
Ljubljana
Slovenia

ISSN 2196-8705 ISSN 2196-8713 (electronic)
ISBN 978-3-642-36638-3 ISBN 978-3-642-36639-0 (eBook)
DOI 10.1007/978-3-642-36639-0
Springer Heidelberg New York Dordrecht London

Printed on acid-free paper

Springer is part of Springer Science+Business Media (www.springer.com)

Foreword 1

With great pleasure I read this book, which deals with the very important and complex problem of process management, something that affects all organizations and consequently everyone of us. It affects the customer who wishes to acquire a high-quality product or who applies for a certain approval or necessary document, the manager who is responsible for ensuring that a certain job is done in the best possible way, the patient who needs a medical examination as soon as possible, or the doctor whose concern is that the medical procedures are performed efficiently.

Exploring process management is an important basis for understanding how the processes within an organization are organized and carried out and also how they should be organized and performed in order to make the organization a better and competitive one.

The current book elucidates the multidisciplinary nature of process management by explaining the theoretical foundations related to it in the first part; these are business, business process, process modeling, process performance analysis, knowledge management, and simulation. In addition, it provides an efficient methodology that ensures process management implementation in real life in the second part.

As an important contribution toward full comprehension of process management, the book shows the necessity of implementing process performance measures and knowledge management concepts in order to optimize functioning of the business process.

In the second part, the book describes an easily understandable and efficient methodology that is very useful for carrying out process management in different kinds of organizations.

I sincerely believe that this book provides an efficient solution to the problem of process management. I think it will be widely read and therefore deserves the highest consideration for publication by a major publishing firm. I endorse the manuscript without reservations and look forward to seeing it in print soon.

Professor Janez Grad, Ph.D.

Foreword 2

In the book at hand, the authors thoroughly present and examine the field of process management that literally reaches into all aspects of human activities. In times like ours when we keep referring to crises and the need for sustainable approaches, it is becoming apparent that existing business processes are no longer suitable. New processes are needed, and the question which arises is how to obtain them. The answer lies in a critical analysis of existing processes and innovative development of new altered and improved processes. In this exact sense, the book represents an important source of both theoretical and practical knowledge.

The second part of the book links introductory underlying theory to a concrete methodology – Tabular Application Development (TAD). This is a practical approach of five phases for implementing process management. The methodology is further illustrated with helpful examples from health care, where today most important process improvements and IS (information systems) developments are taking place.

The book can be used as a textbook as well as a guide to the methodology. It will be helpful to students as well as experts from the fields of process management and information system. It can also serve as an encouragement to every person who is aware that changes in models, processes, and information systems are needed but does not have the answer on how to proceed.

Professor Vladoslav Rajkovič, Ph.D.

Preface

The title of this book indicates that its main purpose is to discuss an efficient way of comprehending and conducting process management in companies and organizations. The problem of process management has become part of our lives and affects everyone on a daily basis because we are all related to it in one way or another, for example, when we wish to order a product from a company, place an application in a governmental organization, or enter a hospital.

For this reason, understanding what process management is and how processes within organizations should be organized effectively is very important for students of business and management information systems as well as for managers who deal with leadership functions and practitioners who carry out process management in real life. Therefore, this book sets out to provide students and practitioners with a better understanding of the meaning of this important topic in order to help organizations to do business and carry out services for different kinds of customers more efficiently.

This book is also aimed at academics who teach courses in the field of process management or related fields and at researchers who conduct studies and projects in different aspects of this complex and multidisciplinary subject.

The main reason for writing such a book is that in spite of the availability of a number of good texts on the market that discuss the subject of process management, we found it very difficult to obtain a book that adequately covers the multidisciplinary nature of the problem. Thus, on one hand, this book tries to explain the theoretical foundations related to the process management approach, which play an important role in carrying it out properly, while on the other, it tries to connect the theory discussed with actual practice in order to translate it into reality. This is achieved by developing an efficient methodology able to support the work of process management teams and providing the possibility of implementing the knowledge gained efficiently.

The second reason that led us to write this book was our desire to write a book about process management from a different point of view, one based on our years of experience in teaching different courses related to it and conducting several successfully published research studies in this field. These results and experience were used in the process of development of a methodology that enables a process management team to carry out process identification, modeling, improvement, and supportive information systems development.

The real world of any organization whose functioning we intend to improve and make as successful and competitive as possible is a complex system consisting of a number of core, usually large, business processes and other supportive processes. Each of these processes comprises a set of smaller processes called work processes that are formed from groups of activities. The complexity of such a system is difficult to grasp and supervise without using an efficient methodology able to lead the process management teams through the process management approach.

The book is written mainly to discuss the problem of process management in companies, governmental organizations, healthcare organizations, etc. Processes in these organizations may over time accumulate problems and obstacles, which cause them to become ineffective and inefficient. In order to stop the organization from losing its customers and becoming an unsuccessful one, immediate actions for ensuring process improvement should be taken.

The book is divided into two parts. The first part covers concisely the theoretical foundation of the field of process management. In addition, this part also discusses theory from other related fields, a knowledge of which is necessary to create a complete understanding of the problem as a whole in order to carry it out properly. The second part introduces a methodology called TAD (Tabular Application Development) that was developed with the specific purpose of carrying out the implementation of process management in the real world using the theoretical foundations explained in the first part.

The Authors

Acknowledgments

We would like to express our special appreciation to Prof. Janez Grad, Faculty of Economics, University of Ljubljana, Slovenia, for reviewing this book and for his constructive comments and valuable advice.

We would like also to show our gratitude to Prof. Vladoslav Rajkovič, Faculty of Organizational Sciences, University of Maribor, Slovenia, for reviewing this book and for his remarks and important suggestions.

We also owe a lot of thanks to Dr. Anthony Byrne, Jozef Stefan Institute, Slovenia, for patiently performing the proofreading.

The Authors

Contents

Part II TAD Methodology

Introduction 1

Part I of this book discusses theoretical foundation related to business process management that should be understood, particularly by students, as well as by managers and practitioners, from different point of views.

Thus Part I consists of seven chapters, which discuss important theoretical themes that represent a solid foundation for carrying out process management, such as: the Business Process, Business Process Modeling, Business Process Approaches, Process Analysis, Knowledge Management, Simulation, and Data Modeling.

The first chapter introduces the layout of the book chapter by chapter. The second chapter explains how a company or an organization makes business and therefore is divided into three sections, namely: Business, Functional Areas, and Business Process. The first section defines what a business is and describes different types of companies on the basis of ownership and functioning. The second section introduces how a company or an organization is structured into connected organizational units called functional units, defines what a functional area is, introduces different types of functional areas, and lists some of the disadvantages of functional organization. The third section deals with a process-oriented organization as an alternative to a functional organization and in this sense the meaning of a business process and the advantages of understanding the organization from a process point of view.

The third chapter tackles the problem of process modeling. This chapter is divided into two sections: Process Modeling and Process Modeling Techniques. The first section discusses a process model and the necessity of developing a process model in order to carry out testing, improvement, or innovation of the real process. This section shows that the purpose of process modeling is to develop a process model that truly reflects the behavior of the original process. The second section briefly introduces a number of well-known modeling techniques, such as: the Data Flow Diagram, Unified Modeling Language, and Business Process Management Notations.

The fourth chapter discusses three popular approaches needed to analyze and improve the performance and quality of the processes in an organization. These

N. Damij and T. Damij, *Process Management*, Progress in IS,
DOI 10.1007/978-3-642-36639-0_1, © Springer-Verlag Berlin Heidelberg 2014

approaches are Business Process Reengineering, Business Process Improvement, and Business Process Management. The first section of this chapter presents business process reengineering as a radical approach that is based on creation of a new efficient process that is not overloaded with problems and obstacles from the history of the organization's functioning. The second section introduces business process improvement as an alternative approach focused on making the functioning of existing business processes more efficient by looking for ways and solutions to increase their performance, quality, and lower their costs. The last section shows that business process management is an approach that combines the possibilities of optimization of processes with the use of contemporary information technology in order to create better and more effective processes, and consequently successful and competitive organizations.

The fifth chapter deals with the very important topic of process analysis and is divided into three sections. The first section deals with analyzing process performance by calculating three process flow measures, namely cycle time, flow rate, and inventory, and the relationship between them established by Little's law. The second section introduces the possibility of computing the process total cycle time, which means the time spent by a flow unit from the moment of entering the process until the moment of leaving it. This section includes important tools to analyze the process cycle time, such theoretical cycle time and critical path. The third section tackles the problem of process capacity by representing the essential role that is played by process resources and their availability, which may have a great effect on the process capacity.

The sixth chapter discusses the very interesting topic of knowledge management, whose purpose is to identify, capture and apply the knowledge accumulated by the experienced employees of an organization. This chapter consists of three sections. The first one introduces knowledge management concepts and the meaning of developing a system that helps the organization in identifying, eliciting, and storing knowledge. The second section focuses on knowledge management models, particularly Nonaka and Tekeuch's knowledge model, called the spiral model, which is based on four types of knowledge conversions. The last section discusses the knowledge management cycle as an approach that describes a way of knowledge realization from its identification from the minds of experienced people to its implementation in the reality of the organization.

The seventh chapter gives a brief introduction to the simulation technique and its importance for improving systems functioning by experimenting with different ideas for changing the behavior of systems. In this sense, queues, which become part of our daily life, are discussed in the first section in which the problem of queues and the basic queuing process is presented. The second section introduces simulation as a technique that enables us to imitate the behavior of a real system over time without disturbing its functioning. In addition to this, we may create various scenarios of systems behavior by generating a number of what-if questions. The third section explores what a system is, the components of which it consists, and the kinds of systems that exist. The last section shows a group of steps, which could be used to carry out the simulation of a certain system.

The eighth chapter introduces the development of a data model of the system. For this purpose, different approaches and techniques are presented. From the theory of relational data modeling, we may recall the normalization technique is an efficient approach that can be used to develop a systems data model. Such a data model is then transformed into an object class model by defining operations within its classes, as it is discussed in Chap. 12.

Part II of this book is focused on presenting the TAD methodology, which is used to carry out business process management. The methodology consists of the five phases Process Identification, Process Modeling, Process Improvement and Innovation, System Development, and System Maintenance. Thus, this part is divided into five chapters.

Chapter 9 discusses the first phase of TAD methodology, which deals with the problem of identifying an organization's business processes, starting with a set of core processes that are essential for the functioning of the organization. This phase, Process Identification, consists of two steps. The first step identifies the business processes of the organization, which is done by organizing interviews with the management at the strategic and business levels and analyzing the organization's documents. The purpose of the interviews with the top level of management is to understand what role the organization plays and where it is heading. The second step deals with defining the flow of each of the identified business processes through various functional areas of the organization. This means that for each listed business process, a group of work processes is identified that are performed within different departments of the organization.

Chapter 10 explains the second phase of TAD methodology, called Process Modeling. This second phase deals with developing a process model for the business processes identified in the previous phase. For this purpose, a special modeling technique called the Activity Table is used. The main characteristic of this modeling technique is its lower flexibility which endeavors to create order in identifying and following the process's activities. This is a very important element in transferring the reality of the process into a process model. The Activity Table developed during this phase consists of two parts. The first part shows a graphical representation of the process model, while the second part describes the process in detail. For this reason, Chap. 9 consists of two sections, each of which deals with developing a certain part of the Activity Table. To carry out process model creation properly, further interviews need to be organized with management at operational level and with the employees who are involved in performing these activities on a daily basis.

Chapter 11 introduces the third phase of TAD methodology. This is the most important phase in process management, which is necessary to ensure implementation of changes, improvements and innovative ideas into the business process functioning and structure in order to optimize it. The task of business process improvement and innovation needs to involve the use of knowledge from other related scientific disciplines, such as knowledge management, simulation, and others. Therefore, the current phase consists of four subphases, which are "as-is" process model analysis, "to-be" process model creation, "to-be" process model analysis, and process simulation. The first subphase performs an analysis of the process performance of the "as-is" process model and calculates process performance parameters, such as process flow, cycle time efficiency and process capacity, with the purpose of gaining essential information about what kind of a process we are dealing with. The calculated process performance enables management to make a decision about the necessity for process improvement or innovation. The second subphase uses concepts of the knowledge management cycle and ideas gained from process performance analysis to create a "to-be" process model. This subphase consists of two steps: ideas identification and ideas implementation. The third subphase analyzes the "to-be" process model by calculating the process performance parameters in order to identify the improvement made in comparison with the performance of the "as-is" model. The fourth subphase uses the simulation technique to imitate the functioning of the "to-be" process model in order to study the reality of the process behavior and the possibility of making further improvements.

Chapter 12 represents the fourth phase of TAD methodology, which deals with the development of a process management system that implements the "to-be" process model created in the previous phase. This phase first develops a class model and the design of the system, continues with developing a software system, and finishes by deploying the system in the organizational real environment. The fourth phase thus consists of three subphases: class model development, systems design and systems implementation. The first subphase builds a class model of the system using a simple approach. The second subphase deals with creating the system design according to the structure of the Activity Table – Part 1. In the third subphase, the class model and design of the system are implemented by developing a software application system that is deployed and installed in the organization as so to execute the functionality of the business process discussed.

Chapter 13 discusses the final and fifth phase of TAD methodology, which deals with controlling the functioning of the improved business process and the process management system. Therefore, this phase consists of two steps: system maintenance and process maintenance. The first step uses the monitoring function in order to uncover problems and deficiencies in the process management system. This monitoring function is done by analyzing a log file that registers all the events that happen to each business process instance. In addition, the process management system should provide the possibility of visualizing the current state of any process instance that flows through the business process.

The final Chap. 14 implements the use of the methodology in a practical and concentrated way, as a step by step algorithm, using a case study of interest.

The Appendix gives a simple short guide that describes the possibility of using MS Excel to create the Activity Table in an easy manner.

Part I

Foundation

2 Business Process

Goals. In this Chapter the following questions and themes are explored:
- The meaning of business
- Type of businesses
- Functional organization of a company
- Functional areas and their roles within an organization
- What is a business function
- Understanding a process-oriented view of an organization
- The meaning of a business process
- Structure of a business process
- The role of a business in the functioning of an organization
- What is a work process
- What is an activity and a task
- Understanding the functioning of the company as a whole

2.1 Business

It is important to begin this Chapter by introducing in a brief way how a company works in order to make business, and how the company or organization is structured into connected organizational units that operate as a whole to form the organization or enterprise.

The purpose of this introduction is to enable readers, particularly students, to understand what business is, how to look at a company or organization from a business process point of view, and what role the business process plays within the company or other kinds of organization.

The term business is understood by many authors as the performance of some kind of work that brings profit to its owners. It is also accepted that by the term business we usually understand a company, firm, or enterprise.

Business covers all activities within an organization, such as planning, organizing, and producing marketable products or services at a required level of

N. Damij and T. Damij, *Process Management*, Progress in IS,
DOI 10.1007/978-3-642-36639-0_2, © Springer-Verlag Berlin Heidelberg 2014

quality, and selling at competitive prices. All these factors contribute a great deal to creating a better climate and possibilities for bringing profit to the company. Since the reason for doing business is normally earning a profit, which is essential for the owners to extend their working area, improve their existing products, and increase their wealth.

Business is defined by Burlton (2001) as: “A business is any organization whose aim is to create results of value for someone who cares about those results”. The author explains that the purpose of any business entity is to act as a transformation mechanism. When an appropriate event and conditions trigger action, customer requirements and consumable resources – such as raw materials, money and information are transformed into goods, services, and business outcomes for the customers’ benefit. These results can have a physical component, such as a tangible product, as well as an informational or knowledge-based one, such as a report, book, or expertise provided.

Therefore, from Burlton’s definition, we may conclude that the term business covers the work carried out by the company including the work performed within the framework of the company to produce the desired product or service, as well as the work of the company that is aimed at building good relationships with customers and suppliers.

In addition to companies, there are also other organizations that provide important services, such as governmental or civil organizations, which organize business as non-profitable work to perform different administrative processes and procedures in order to serve people’s requirements. Such organizations run different kinds of necessary administrative functions that are essential for people’s daily needs in society.

Laguna and Marklund (2005) define business as: “An organizational entity that deploys resources to provide customers with desired products or services”. This definition actually covers both kinds of organizations; i.e. both companies that tend to maximize their profit, i.e. profit-maximizing type of companies, and non-profit making civil and governmental organizations.

Understanding the term business could be generalized as creating an organization that develops a needed and marketable product or service that satisfies customers, creates a certain profit for its owners, and provides earnings to it employers.

Business ownership can take a number of different kinds or forms depending on the type of the company. Thus, ownership could be a sole proprietorship, a partnership or a corporation. These types are introduced very shortly, as follows:

- A sole (single) proprietorship means that the business is owned by one person, who is responsible for the business and also has to carry a personal liability for the debts which may be created by the business;
- A partnership means that the business is owned by a group of people who carry responsibility for the business and also have personal liability for any debts that may be created by the business;

- A corporation means that the business is owned by a number of shareholders and controlled by a board of directors that hires a staff of managers to lead the corporation; and
- There are businesses, which are owned by their employees, such as the co-operative organizations, or e.g. in the UK, the John Lewis Partnership.

We may differentiate between different types of companies depending on their mission and the kind of business that they are established for. These types include manufacturing, information, financial, real estate, retail-trade, service companies, and others:

- A manufacturing company purchases the needed components or raw materials from suppliers; the components are then used and manufactured to produce predetermined and planned products, which are delivered to the market through the company's network or other retail-trade companies.
- An information company usually develops various administrative, business software packages, or technical software products whose purpose is to support the functioning of different processes or procedures within companies or organizations. An information company also deals with marketing and selling software packages of other specialized information companies, or establishes an educational center that offers and teaches different IT courses.
- A financial company deals with the fields of financial management and financial risk management. Such a company carries out different kinds of financial operations such as funds, investment, etc.
- A real estate company carries out its business by selling or renting houses and other buildings for private or business purposes.
- A retail-trade company purchases products from manufacturers and other suppliers and sells them on the market.
- A service company is usually specialized in offering particular specialized service(s) and charges customers for the work done.

A company must establish very good relationships with its partners which tend toward achieving the satisfaction of all parties. Creating such relationships is essential for planning, organizing, and preparing a needed working environment, and providing everything necessary for the business to operate properly in order to produce and deliver its outputs.

The company works in a prescribed manner by starting with purchasing essential inputs, such as raw materials, components, and other inputs from suppliers. The purchased inputs then go through different processing or manufacturing procedures in order to transform them into the desired outputs that in the end are offered as products or services on the market to customers.

As was mentioned before, the purpose of businesses is obvious; this is to sell their products or services and to create the profit needed to continue their work, improve the quality of their outputs, increase and extend their work, and increase their wealth. All operations in a company are planned, organized, lead, and controlled by the management of the company.

The company is led by management at different levels; these are the strategic, business, and operational levels. A strong and appropriate linkage should be established between the different levels of management in order to ensure that the organization is functioning as one body in which each part accomplishes its specialized kind of work. Such a linkage or relationship is essential to put into reality the implementation of the organization's goals and objectives.

At the strategic level, top management focuses on determining the organization's values, such as defining its vision and mission, determining strategic goals and objectives, and developing a strategic plan. The role of top management is also to ensure that strategic goals and objectives are transferred into reality and implemented at lower levels of the company.

The responsibility of the management at the business level of the organization is to carefully analyze the market environment and investigate real possibilities of transferring the strategic goals and objectives defined by the management at the strategic level into realistic business plan, goals and objectives that can be transformed into reality.

The role of business management is to determine the target market and customers to enable the company to achieve the accomplishment of its business plan, goals and objectives. This level of management is also responsible for meeting customer's needs, requirements and expectations, and for developing appropriate relationships with business partners, such as customers, suppliers, and others.

The management at operational level of the organization is responsible for translating the business goals and objective into operational or action plans. The role of this level of management is to define operational goals and objectives in accordance with the business goals and objectives and develop necessary action plans, such as the working process, budget, resources procurement, quality control, and other plans. These plans enable the company to anticipate, lead, and control the accomplishment of its operational goals within the time scheduled, the budget estimated, and the expected level of quality of the outputs produced.

In addition to this, the operational management is responsible for determining, recruiting and purchasing the resources needed for performing the work organized within different departments in accordance with the operational plans. Furthermore, the role of this level of the management is to ensure that the work is done in accordance with the planned and expected performance and at a defined level of quality.

2.2 Functional Areas

Organizations for the most part today are structured into functions and hierarchies and most people have been brought up with the belief not only that this is the most natural and efficient way of organizing, but that it is the only way of organizing. This has been the case ever since organizations began to be studied in a coherent way in the late nineteenth century (Robson and Ullah 1996).

Almost every company is organized into a group of departments or units, which are called functional areas. Each functional area is specialized in accomplishing a particular and specialized kind of work that is usually connected to the work performed within the framework of other functional areas. Some of these functional areas are the following: Marketing and Sales, Production and Material Management, Research and Development, Human Resources, Finance and Accounts, Customer Service, and Administration/IT Support.

To understand the functioning of a company and how it makes a business or other organization and how it conducts work, we have to understand how it is organized into a number of units or functional areas.

A functional area represents a certain organizational unit or department within the company or organization, where a set of tightly connected business functions and activities are carried out in order to accomplish a particular kind of work in accordance with the specialization of the functional area.

In the framework of each of these functional areas are a number of business functions and activities that perform a specific kind of work in which the functional area is specialized. The work performed within the functional area is usually carried out by a group of specifically educated, specialized, and experienced employees.

The work accomplished within the framework of a determined functional area is usually tightly related to and needed by work performed within one or more other functional areas. Therefore, the work started within a certain functional area is usually continued and completed by performing a set of tasks within other functional areas.

In the literature, it is possible to find different classifications of functional areas for various categories of companies. In the following, typical functional areas of a production company are briefly presented.

Marketing and Sales. This functional area is usually divided into Marketing and Sales branches. The responsibility of the Marketing branch is to carry out marketing analysis that enables the people in the branch to develop a good promotional plan for the products and service of the company, which is created on the basis of a realistic analysis of the market. Marketing is also involved in calculating and suggesting the best possible prices of the company's products and services in comparison with the prices of other competitive products.

The main role of the Sales branch is receiving customer orders, archiving and forwarding them to other functional areas, and ensuring that they are processed properly. This branch may receive customer orders in different ways; for example customers usually send them via ordinary mail to this functional area, generate and place them via the web application of the company, fax them, or use other possible routs of communication.

Marketing and Sales is connected to other different functional areas, such as Production and Materials Management, Human Resources and so on. For example, a copy of the customer orders is sent to Production and Materials Management to produce the ordered products and deliver them. Marketing and Sales is related to Human Resources by sending requirements for recruiting specifically educated personnel, and also for organizing other operations for their employees, such as trainings and so on needed to improve their capabilities.

Marketing and Sales is connected with the company's information system, where it stores sales orders in the system's database in order to carry out sales analyses and reports, which are essential for the management staff to develop suitable marketing and sales plans. Such analyses may play an important role in carrying out necessary changes and improvements for developing better or new products and determining competitive product prices in comparison to similar products of other companies. There are many business functions and activities, which are performed within the framework of this functional area, such as:

– Performing marketing research,
– Carrying out marketing analysis,
– Developing a marketing plan,
– Calculating products prices,
– Developing a sales forecast,
– Processing sales orders, and
– Carrying out sales analysis.

Production and Material Management. The role of this functional area is to develop a product manufacturing plan based on information gained from the sales plan and other sales analyses prepared by Marketing and Sales, the material purchasing plan created on the basis of the production plan, and the quality plan that the ensures manufacturing of products of a high level of quality.

The Material Management branch supports the production process by purchasing appropriate quality raw materials and other components needed for manufacturing company's products in accordance with the purchasing plan. In addition to this, Material Management deals with determining faster and safer ways to deliver shipments of the products ordered to the customers.

The Production and Material Management functional area is connected to a number of other functional areas. From Marketing and Sales it gets sales plans, sales analyses, and sales orders. And in the opposite direction the Production and Material Management provides Marketing and Sales with information about product availability and sales order fulfillments.

This functional area provides Finance and Accounts with purchasing and manufacturing data based on purchasing orders and the products produced. Such data is needed in Finance and Accounts to register purchasing transactions and to calculate manufacturing expenses. This functional area is also connected to Human Resources concerning recruiting of needed professional employees.

Production and Material Management may play an important role in increasing customer satisfaction by manufacturing high-level quality products and providing production on time and prompt delivery of the products to customers.

There are a number of business functions and activities performed within this functional area, such as:

– Developing a production plan,
– Developing a purchasing plan,
– Developing a quality plan,
– Monitoring the production process,

- Planning and controlling the budget,
- Controlling quality,
- Purchasing raw materials and other components, and
- Determining effective shipment approaches.

Research and Development. The Research and Development functional area is responsible for researching possibilities and finding solutions for developing marketable and profitable quality products at reasonable prices. The role of this functional area is essential in leading the company toward being a competitive and successful organization.

The work in this is functional area depends on information obtained from the organization's environment as well as from other functional areas within the company, such as Marketing and Sales, Production and Material Management, Finance and Accounts, and Human Resources.

Development of a new product or making improvements to an existing product is done on the basis of information gained from Marketing and Sales, such as marketing analysis, sales analysis, and feedback information received from customers. Following new developments in the field of concern, in addition to the mentioned analyses enable the management and professional staffs in Research and Development to carry out comparative analyses with other competitive products and conduct experimental tests in order to develop a new product or improve their existing one. Taking into account new developments in the market and customer satisfaction as a priority, then using feedback information may contribute a great deal in achieving the desired success of the company.

Research and Development is linked to Production and Material Management by providing information about the development of new products or changing ideas for improvement of the existing ones. This functional area is also connected with Finance and Account by getting information about the budget planned for it. Human Resources hires needed professionals in accordance with requirements issued from this functional area.

Research and Development performs many functions and activities, including some of the following:

- Researching the possibility of new product development,
- Experimenting with ideas for new product development,
- Developing new products,
- Testing newly developed products,
- Experimenting with ideas for product improvement,
- Carrying out the improvement of existing products, and
- Testing improved products.

Human Resources. The Human Resources functional area hires people by following prescribed procedures for recruiting employees and experts with the required education and experience in accordance with the employment plan and corresponding to requirements gained from other functional areas.

This functional area takes care of organizing proper training of the recruited employees and that they are paid in accordance with the regulations of the company. It also plays an important role in implementing procedures for promotion of employees.

The Human Resources department is also responsible for storing and updating data in the company's database about employees, jobs, skills required for each job, and payment for every job.

In the framework of this functional area a number of business functions and activities are performed, some of which are:

– Taking care of recruitment,
– Organizing employee training,
– Providing health care insurance for employees,
– Carrying out retention, resignation, retirement and dismissal procedures,
– Following promotion procedures.

Finance and Accounts. Finance and Accounts plays the main role in connecting all the functional areas together by storing all business transactions in the company's database. These are financial transactions and events caused by the sale of the company's products or services, receiving payments from customers, getting tenders and invoices, and also sending payments to suppliers after purchasing raw materials and other components needed for the production function of the company.

This functional area prepares financial analyses and reports for management about the financial state of the company. Such analyses and reports are made on the basis of data stored in the database about the transactions registered.

As was mentioned before, the Finance and Accounts obtains data from other functional areas. Marketing and Sales provides data about sales orders, Production and Material Management provides data about product manufacturing, Human Resources gives information about employees, and Research and Development delivers information about the budget needed to accomplish their plan.

Finance and Accounts also carries out development of the financial plan of the organization and deals with finding capital and resources essential for expanding and improving the company's work.

In the framework of this functional area, a number of business functions and activities are carried out, including the following:

– Registering accounts receivable transactions,
– Registering accounts payable transactions,
– Preparing salaries,
– Preparing financial analyses and reports,
– Developing the financial plan of the organization, and
– Providing capital and resources.

Customer Service. The main goal of the Customer Service functional area is to establish good relationships between the company and its customers by defining effective ways to support them, searching for better solutions to existing problems, and providing them with the information and advice needed in order to fulfill their needs and expectations.

The main goal of Customer Service is to ensure customer satisfaction, which consequently is to make sure customers return and remain satisfied customers of the company's products or services.

Therefore, this functional area has the essential responsibility of how to achieving the goal of customer satisfaction, which represents a necessary factor for the success of the company in today's competitive and dynamic business climate.

Within Customer Service many activities and business functions are executed, including:

– Providing customers with information,
– Giving advice needed,
– Conducting customer support,
– Helping in solving customer claims, and
– Providing after-sales support.

Administration and IT Support. Administration is responsible for all administrative work throughout the company or organization, and which is done by the administration staff. It is also responsible for other tasks, such as cleaning, security, and maintenance, which are usually done by other contracted companies.

IT Support is usually represented by a separate department, whose main role is to integrate all the functional areas together by developing an integrated and effective information system, enabling employees and customers to perform electronic transactions using special web applications of the company.

This functional area comprises different business functions and activities, including the following:

– Preparing meetings and reports,
– Reception work,
– Organizing and recording mail,
– Providing software and hardware support,
– Developing and maintaining the company's information system, and
– Taking care of network communications.

2.3 Business Process

At the beginning of the current section, let us emphasize that the purpose of the present chapter is to explore what a business process is, the meaning of business processes for understanding the functioning of an organization as a whole, and the advantages of a process-oriented organization in comparison with a functional organization.

By a business process we mean the different processes conducted within various types of organizations whose purpose is creating outputs that are produced to serve customers' needs. Such processes are:

– Processes performed within companies that serve customers requirements;
– Administrative processes carried out by governmental organizations that serve the needs of people; and
– Healthcare processes executed in hospitals, clinics and infirmaries that serve patients' healthcare.

From the previous sections, we may conclude that an organization is usually structured vertically into a group of units called functional areas. Furthermore, there are a number of business functions and activities that are executed within the framework of each of the functional areas on a daily basis.

This means that different inputs enter a certain functional area from the organization's environment or other functional areas within the organization and cause the execution of its business functions and activities, which result in the creation of outputs that may enter other activities within the functional area as inputs. Such a process is continued following the process flow until the final outputs of the functional area are completed, which then may enter either another functional area as new inputs or leave the border of the functional area as the company's or organization's final products.

If the company is organized into functional areas, it is called a vertical or functional organization. This actually means that the company is divided into specialized organizational units in order to carry out specific kinds of work operations lead by differently educated groups of employees.

Consequently, such a kind of organization leads to the fact that the work conducted within the framework of a certain functional area (unit or department) is practically almost isolated from the work performed within other functional areas. So, a functional type of organization causes the creation of an artificial boundary around each functional area or department, which then becomes almost an independent organizational unit within the company with its particular rules and procedures.

Such a functional organization can be the reason for the creation of different problems and disadvantages, such as:

– Higher level managers are unable to follow the flow of work started by one of the functional areas, continued, and accomplished throughout some other areas;
– Functional managers become uninterested in the work performed in other functional areas and concentrate only on the work conducted within their own functional areas;
– Work isolated within department boundaries could increase the possibility for devising more complicated work procedures and bureaucracy because employees are unable to see the organization's work as a whole.

Robson and Ullah (1996) point out that a functional organization has a number of difficulties, such as:

– Different departments often take a very parochial view, and are uninterested in issues that do not appear to affect them directly;
– Destructive competition between departments seems often to be pursued more vigorously than the competition with outside competitors;

– Communications are also often slowed down by over-strict adherence to the bureaucratic requirement to pass messages to the head of the department before they can be passed to another department.

In recent years, the understanding of organizations has changed and looking at the organization from the business process point of view has become a more popular and acceptable way of organizing business compared to a functional organization. This is because of the problems caused by the functional type of organization, which induces functional managers and employees in a certain department to care only about the work accomplished within their own department and not to think broadly about the work done within other departments and the organization as a whole.

For example, many academics have witnessed even in schools and colleges cases of wasting time and energy by waiting for the approval of a simple application to be issued, because such an approval needs to be controlled and signed by the managers of different departments. For example, submitting an application for attending an international conference needs to go through at least three departments, whose managers need to control, approve, and sign it. What is amazing is that whenever enquiries are made about the application, the answer is that there is something that has not yet arrived from another department or the manager of a certain department is not available. Even this simple procedure, which could be solved by one person within one single day or even within an hour or two, is so complicated because of the division of the organization by artificial walls, where the administrative procedures are so rigid with very low performance, and the low level managers what to prove that they are the people in-charge.

It is very clear that such an organization needs more resources and time to function compared to a process-oriented organization and consequently we usually find in this kind of an organization a lot of bureaucracy and overstaffing with employees for different and mainly useless purposes.

The process view actually could be understood as looking at the functioning of the company from the customer's perspective, which requires following the flow of work procedures and their accomplishment throughout different functional areas of the company or organization.

This means that a process-oriented organization creates a linkage that connects different business functions executed within the framework of various functional areas in order for the company to function as a whole.

In addition to this, a process-oriented organization requires the creation of a special kind of manager, who are responsible for taking care of the process and following the work flow throughout different functional areas. Consequently, this means increasing the power of business managers or business process owners in order to create tight linkages between the various departments.

The process-oriented organization has a number of advantages compared with the functional one, such as:

– Determining the process owner for each business process; this is the process manager responsible for the business process;

– Making it possible for process managers to follow the work flow across different functional areas;
– Helping in removing the boundaries between departments totally or at least partially;
– Minimizing conflicts and misunderstandings between employees of different departments; and
– Encouraging cooperation between employees of various departments and teaching them to understand the work from the customer's perspective.

A process-oriented view may, however, cause coordination problems and conflicts of interest between the functional and process managers. This difficulty should be solved at the highest level of management by supporting and encouraging the new kind of organization, which in addition to improving work performance and quality, may in the end lead to achieving a number of necessary changes in the working culture of the organization.

However, each business process actually exists within determined boundaries, which play the role of drawing the process size and differentiating it from other business processes. Process boundaries are defined by its inputs and outputs. The inputs enter the process in different stages of its functioning, beginning with the one(s) that starts the process. The outputs leave the process in various stages of its functioning, ending with the one(s) that ends the process.

In any organization two types of processes exist; these are core and support processes. Robson and Ullah (1996) defined these processes as follow:

– The core processes are the operational processes of the business and result in the production of the outputs that are required by the external customer; and
– The support processes are those that enable the core processes to exist.

Ould (1995) identified three types of process: core, support, and management.

– Core processes concentrate on satisfying external customers;
– Support processes concentrate on satisfying internal customers; and
– Management processes concern themselves with managing the core processes or the support processes, or they concern themselves with planning at the business level.

There are many outstanding authors who made very important contributions to exploring the field of business processes and their meaning for improving the functioning of a company or organization. The ideas expressed by these authors about business processes are very valuable and worth our attention and understanding. And therefore, it is important to introduce some of them in what follows.

The business process is defined by Brady et al. (2001) as: "A business process is a collection of activities that takes one or more kinds of input and creates an output that is of value to the customer" (Fig. 2.1).

Robson and Ullah (1996) defined a business process as: "A flow of work passing from one person to the next, and for larger processes probably from one department to the next".

An important contribution was made by Harrington et. al. (1997), where interesting definitions were given for a process, major process, subprocess, activity, and task:

Fig. 2.1 A business process

– A process is a logical, related, sequential (connected) set of activities that takes an input from a supplier, adds value to it, and produces an output to a customer;
– A major process is one that usually involves more than one function within the organizational structure, and its operation has a significant impact on the way the organization functions;
– A subprocess is a portion of a major process that accomplishes a specific objective in support of the major process;
– Activities are things that go on within a process or subprocess; they are usually performed by units of one (one person or one department);
– Tasks are individual elements and/or subsets of an activity; tasks relate to how an item performs a specific assignment.

The definitions made by Harrington et al. (1997) are important because they determine an easy and practical specification for a major process by saying: "When a major process is too complex to be flowcharted at the activity level, it is often divided into subprocesses". Such a specification could be very useful as a rule or practical guide for practitioners and students. The authors go on to define a differentiation between an activity and a task by emphasizing that an activity is performed by units of one, which means that an activity includes a few tightly related tasks, whereas a task is an elementary work. We may imagine an activity is a group of instructions and a single instruction is a task. Figure 2.2 shows a business process hierarchy.

An interesting contribution was made by Burlton (2001) that explores business process from another point of view called the outside-in perspective: "A true process comprises all the things we do to provide someone who cares with what they expect to receive".

The author emphasizes that a true process starts with the first event that initiates a course of actions and isn't complete until the last aspect of the final outcome is satisfied from the point of view of the stakeholder, who initiated the first event or triggered it. The process is characterized by the following:

– Inputs of all types, such as raw materials, information, knowledge, commitments, and status are transformed into outputs and results;
– Transformation occurs according to process guidance, such as policies, standards, procedures, rules, and individual knowledge; and
– Reusable resources are employed to enable the change to happen, such as facilities, equipment, technologies, and people.

Laguna and Marklund (2005) present an interesting idea that characterizes processes into three types:

– Individual processes, which are carried out by separate individuals, such as: Order Receiving – an individual process within the Marketing and Sales department;

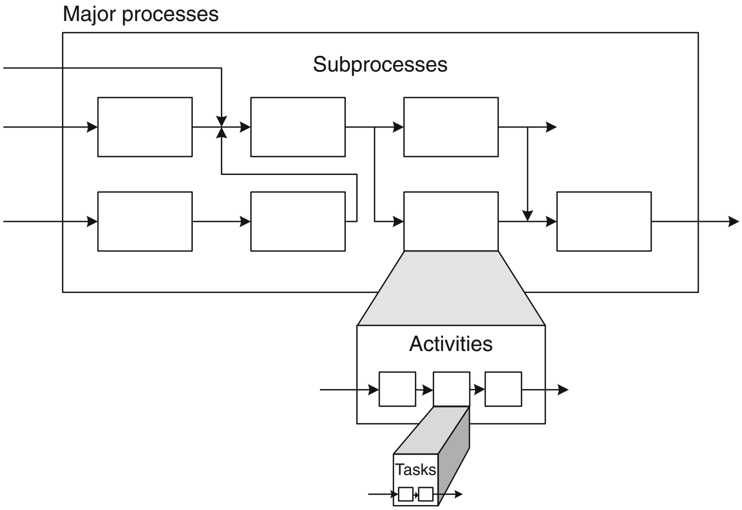


Fig. 2.2 A business process hierarchy (Source: Harrington et al. 1997)

– Vertical or functional processes, which are contained within a certain functional area or department, for example: Production Planning – a functional process within the Production Department; and
– Horizontal or cross-functional processes, which cut across several functional areas, for example: Order Fulfilled – a horizontal process, which goes through the departments Sales, Production, and Accounts.

The authors stated that between the three process types exists a hierarchy in the sense that a cross-functional process can be decomposed into a number of connected functional processes, which consist of a number of individual processes. Furthermore, any process can be broken down into one or more activities and an activity may comprise a number of tasks. For example, receiving an order is an activity, which comprises tasks, such as answering the phone, talking to the customer, and verifying necessary information. Assuming that the activity is performed by one employee, it is then an individual process.

The structure of the process was characterized by Laguna and Marklund (2005) in five components and elements: inputs and outputs, flow units, network of activities and buffers, resources, and information structure; see Fig. 2.3.

(a) Inputs and outputs

To understand a process, is important to identify its boundaries; this is its entry and exit point. Identifying the input is necessary for the process in order to produce the desired output. Inputs and outputs can be tangible (such as raw materials) or intangible (such as information).

(b) Flow units

A flow unit can be defined as a job or an entity that proceeds through various activities and finally exits the process as a accomplished output. The flow unit can be a unit of input (e.g., raw material), a unit of one or several intermediate

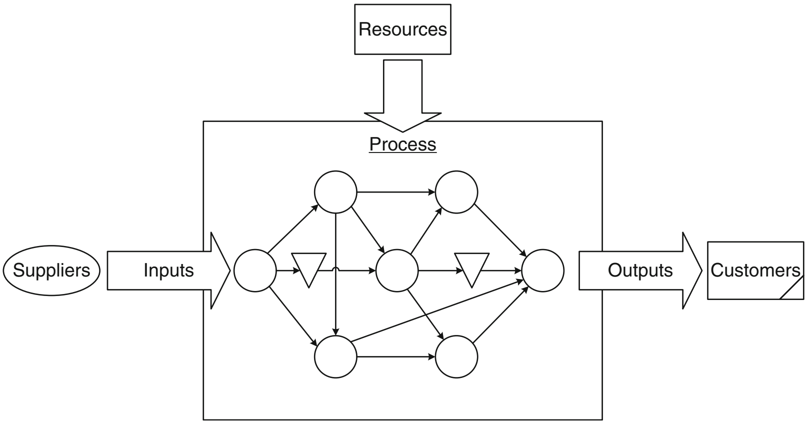


Fig. 2.3 A process structure (Source: Laguna and Marklund 2005)

products or components (e.g., the frame in a bicycle-assembly process), or a unit of output (e.g., a finished product).

(c) Network of activities and buffers
A process is composed of activities and buffers through which the flow units have to pass in order to be transformed from inputs into outputs. Buffers are also included in most processes between the activities. Real examples of buffers are waiting rooms in hospitals or the waiting that occurs between the end of a predecessor and the start of a successor activity.

(d) Resources
Resources are tangible assets that are necessary to perform activities within a process. Resources are often divided into two categories: capital assets (e.g., real estate, machinery, equipment, and computer systems) and labor (e.g., employees).

(e) Information structure
The information structure specifies which information is required and which is available in order to make the decisions necessary for performing activities in a process.

Based on the process hierarchies and process structure, Laguna and Marklund (2005) give a more comprehensive and complete definition of a business process: "A business process is a network of connected activities and buffers with well-defined boundaries and precedence relationships, which utilize resources to transform inputs into outputs for the purpose of satisfying customer requirements".

After introducing the above very interesting ideas developed by outstanding researchers, and after studying other views of well-known authors in the field of business process, who will be mentioned later in the following sections, it is time to introduce our own view and understanding of an organization's functioning. Such a view is based on looking at the organization from the process point of view or what is known as a process-oriented organization. And for this reason, let us temporarily

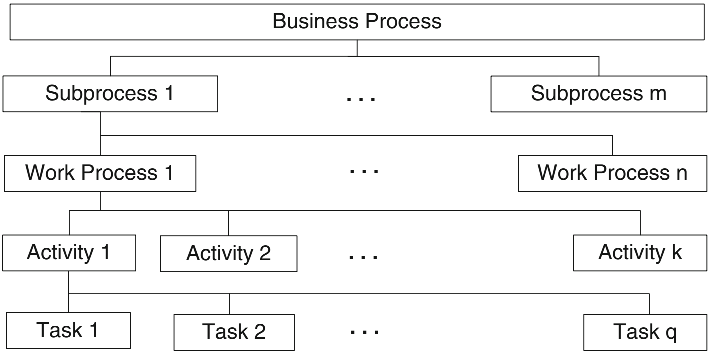


Fig. 2.4 Structure of a major business process

ignore the functional organization and functional areas into which the organization is structured.

In reality, the core functioning of an organization is actually carried out by different horizontal cross-functional processes rather than the functional areas into which the organization is partitioned. The purpose of a functional organization is to group employees with similar expertise together in order to perform similar kinds of work that concern a specific working area, where particular rules and regulations, related to this working area, are implemented.

Therefore, the role of each functional area is to perform a specific kind of work in which the area is specialized within the framework of wider business processes. In other words, the departments of an organization are responsible for performing various segments of cross-departmental business processes. Thus, the fact of looking at the organization from the process point of view is essential to obtain the whole picture about the organization's functioning from the starting inputs that enter the system to the delivering of final outputs to the customers.

Figure 2.4 shows the structure of a major cross-functional business process. In reality, such a process is usually complex. In such a case and in order to overcome its complexity, the process should be decomposed into a number of subprocesses. A business process or subprocess, depending on the process complexity, is partitioned further into a set of work processes. Furthermore, each work process contains a group of activities. Every activity may contain a number of tasks each of which represents an elementary work.

A process-oriented organization shows that every company consists of a set of business processes. A major business process represents a linkage that comprises a number of different work processes and activities. These terms are compatible with the terms of functional processes and individual processes used by Laguna and Marklund (2005).

Transforming the structure of the major business process shown in Fig. 2.4 into the reality of a functional organization in which most companies are organized is presented in Fig. 2.5. This is done by showing work processes, which are actually segments of bigger business processes, as rectangles that are placed in the frames of

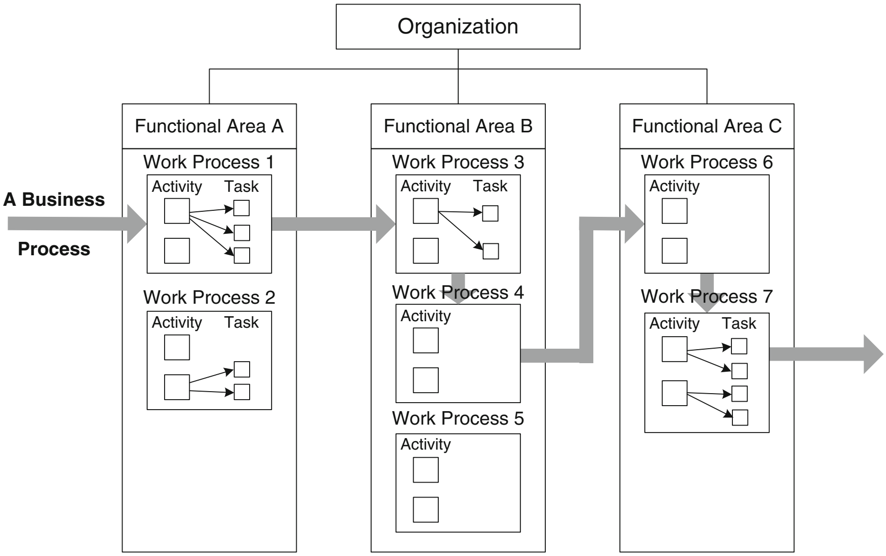


Fig. 2.5 The reality of a major business process

functional area boxes but are linked together within cross-functional business processes. Thus, to show the whole business process, a cross-functional arrow is drawn that links together a number of work processes within different functional areas of the organization in the determined sequence order in which they are performed.

Figure 2.5 introduces a business process view shown within the reality of the functional organization of the company. From this figure the following conclusions could be drawn:

– A business process is a horizontal process, which represents the linkage between a number of work processes performed within a number of the organization's functional areas. A business process starts with an input(s) that enters it from the environment of the organization and causes the execution of a set of groups of activities, which consist of different work processes, in a determined sequence order in order to develop a desired output(s) that leaves the process to the environment.
– A complex business process could be decomposed into different subprocesses in accordance with the partitioning of the process into specific parts that tackle specific kinds of problems.
– A work process represents a group of successive activities using a number of paths in order to carry out a specific joint work. This starts with an input(s) that enters the first activity of the process, continues in such a way that each predecessor activity creates an output that as an input enters its successor activity, and ends by an output(s) that leaves the last activity of the process.

– An activity is a simple microprocess that consists of one or more tasks and represents a well-defined work performed by one person, such as creating a document. An activity may also be understood as a simple algorithm that contains a few instructions. The activity starts with an input(s) or an event that triggers the execution of one or several successive elementary works, and ends by creating an output(s).
– A task could be understood as an elementary work within an activity or a part of an algorithm that represents the execution of an activity, for example printing a document or signing a document.

Each business process is owned by a person called the process owner. This person is responsible for taking every action necessary to keep the process as effective as expected concerning its performance, cost, and quality. The business process owner is responsible for following and controlling the work accomplished within the work processes that form the business process within the framework of different functional areas. To achieve this, the business process owner has to take action and discuss with operational managers any problems that appear in connection with those work processes that are executed within their departments, so as to ensure that proper action is taken to solve the problem(s) at the right time.

References

Brady, A. J., Monk, F. E., & Wagner, J. B. (2001). *Concepts in enterprise resource planning*. Boston: Course Technology Thomson Learning.

Burlton, T. R. (2001). *Business process management profiting from process*. Indianapolis: SAMS.

Harrington, H. J., Esseling, E., & van Nimwegen, H. (1997). *Business process improvement. Workbook*. New York: McGraw-Hill.

Laguna, M., & Marklund, J. (2005). *Business process modeling, simulation, and design*. Upper Saddle River: Pearson Prentice Hall.

Ould, A. M. (1995). *Business process modelling and analysis for re-engineering and improvement*. New York: Wiley.

Robson, M., & Ullah, P. (1996). *A practical guide to business process re-engineering*. Hampshire: Gower.

3 Business Process Modeling

Goals. In this chapter the following questions and themes are explored:
– Discussing what is a process model and process modeling
– Understanding what is an activity
– Explaining which parameters define an activity
– Introducing well-known process modeling techniques
– Process model development using DFD
– Using UML core modeling diagrams
– Describing BPMN, its categories, and its elements

3.1 Process Modeling

A model is an abstraction of the usually complex functioning of a real system that preserves all the characteristics of the system, ensuring that the model reflects the true behavior of the original system.

A process model is usually a diagram that depicts of a group of activities that are connected sequentially as predecessor(s) to successor(s) by their outputs and inputs, and organized in a number of paths in order to describe a certain functioning within an organization.

Weske (2007) gave the following interesting definition: "A business process model consists of a set of activity models and execution constraints between them. A business process instance represents a concrete case in the operational business of a company, consisting of activity instances. Each business process model acts as a blueprint for a set of business process instances, and each activity model acts as a blueprint for a set of activity instances".

The development of a business process model is necessary because it is difficult or impossible to conduct experimental testing of the original process. Such testing is necessary to identify problems and obstacles existing within the process in order to find solutions to improve it.

N. Damij and T. Damij, *Process Management*, Progress in IS,
DOI 10.1007/978-3-642-36639-0_3, © Springer-Verlag Berlin Heidelberg 2014

A process model should contain all the characteristics important to make the model as real a reflection of the original process as possible. This way of modeling enables the modeler to build a process model that behaves as the real business process does.

Transferring the original behavior into the process model is essential in order to carry out all the necessary experiments and testing of the business process without disturbing the functioning environment of the original process. Otherwise, there is a possible danger that modelers, groups, or companies which work in the field of business process modeling may develop pure business process models that overlook a number of important activities or characteristics of the real processes. In such cases, which unfortunately exist in reality, modelers or analysts create impoverished models that do not reflect the true behavior of the original processes. Of course such models are not suitable for carrying out experiments and tests instead of the real business processes.

Unfortunately, many such impoverished process models have been developed in the real world, and they represent a true problem and are the actual cause of the high percentage of failures of business process improvement projects.

Business process modeling is the approach of carefully identifying, understanding and analyzing the behavior of a certain business process, and then using a modeling technique(s) in order to develop a model that reflects the true behavior of the process discussed.

Therefore, developing a process model should start by identifying, studying and understanding the functionality of the business process. This is done first of all by creating a plan of interviews organized with the employees that are involved in doing particular work within the framework of the process. The purpose of these interviews is to identify the workflow, work processes and activities performed within the business process.

Each activity performed within the process should be defined more precisely by identifying a number of parameters that describe the activity and determine its characteristics, and which differentiate it from other activities.

3.1.1 Activity Parameters

Performing any activity is connected with a number of parameters or characteristics; these parameters determine the work performed within the activity, related conditions that should be satisfied, its time duration, input(s) that triggers its execution, and an output produced by the activity as a result of this execution.

Paul and Yeates (2008) listed a number of these parameters, such as inputs, events, business roles, resources, time, and outputs, which we introduce in the following briefly.

Inputs. An input enters the system from its environment and triggers the execution of a sequence of activities that forms a certain process in order to create a result as a response to the input entered. Examples of such an input are the customer's placement of an order or registering a patient in a hospital, etc.

When an input enters an activity, it triggers the performance of a certain work within the activity that produces an output(s), which leaves the activity and enters its successor activity as an input.

Therefore, following the inputs and outputs leads us to identify all the activities that form a certain process. Furthermore, carefully following and connecting the activities by their inputs and outputs enables us to develop a process model that is true to the original process.

Inputs may be external or internal. External inputs enter the system from the environment; this is the outside world that surrounds the company, such as a customer's order. Internal inputs are created inside the system; this is within other processes or other activities of the same process, such as receiving the Accounting Department a copy of a shipment document from the Production and Material Management Department.

Events. Triggering the execution of activities, in addition to inputs, is also done by different events. It is very important to differentiate between events and inputs. An event does not have a source, which means it cannot enter an activity from another predecessor activity.

An event is related to a certain factor such as time or something else that creates the event. A time event means that at a determined time an activity or a number of activities must be executed, for example, the activity "Conducting project team meeting" must be done every Friday at a certain hour. An event could be related to something else, such as a manager's decision to perform an activity in order to carry out a certain work.

Business Rules. A business rule describes the way in which an activity has to be performed and which conditions or constraints must be fulfilled in order for the execution of the activity to take place.

The description of the performance of a certain activity is actually an algorithm that describes in detail, step by step, a procedure that shows how the execution of the activity should be carried out.

Conditions or constraints are restrictions and limitations that should be considered and satisfied in order to perform the activity. So, conditions are imposed on the execution of an activity corresponding to the follow up activities, regulations defined within the company, or other regulations and laws.

Resources. Each activity needs a number of determined resources in order to be performed. Such needed resources may include raw materials, equipment and an enabler, who is responsible for execution of the work defined by the activity in accordance with the procedure that describes the mode of execution. The enabler usually represents one or more persons (employees) or a software system that carries out the execution of the activity.

Time. Time is an important parameter that is used to measure the performance of an activity. Usually in the business world, particularly in administrative processes, such a parameter is not accurately measured. Often it is not used in practice, even though it may exist in the company's documentation or could be approximately defined. It is, however an essential parameter, particularly in the case when the organization decides to improve its business processes.

Outputs. When a certain input enters an activity, it triggers the execution of the activity, which means performing a determined work or micro process that transforms the input entered into an output. Such an output could enter another activity as a needed input to trigger a successor activity, or leave the last activity within a process as a final output of the process.

Therefore, an output is a result of a transformation applied to an input that enters an activity by performing a certain work conducted within the activity.

3.2 Process Modeling Techniques

The purpose of business process modeling is to develop a model that reflects the organization and functionality of an existing or new business process after understanding its workflow in detail. The aim of developing a process model is usually to analyze it carefully in order to carry out necessary changes, or implementing new ideas that lead to improvement of its operation in relation to increasing performance, improving quality, and minimizing cost.

Business process modeling is usually carried out using a modeling technique. There are many modeling techniques which can be used in this field, such as the Data Flow Diagram, Unified Modeling Language, Business Process Management Notations, and others. In this section, the main elements of some well-known and widely used techniques are described shortly.

3.2.1 Data Flow Diagram

The Data Flow Diagram (DFD) has been widely used as a modeling technique within structured systems analysis and design methods. DFD is still in use as a modeling technique and therefore it is important to introduce it briefly.

DFD is a top-down process modeling technique that uses the concept of process decomposition. The decomposition technique enables the analyst to partition any process first into its subprocesses and then each subprocess into more understandable and less complex processes. The decomposition of processes is continued until an elementary level of processes is achieved in which each process is understood completely, described in detail, and represents a certain task that cannot be partitioned further.

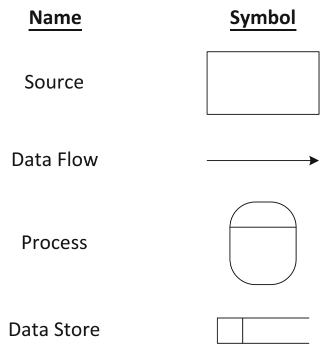


Fig. 3.1 Basic symbols of DFD

3.2.1.1 DFD Elements

DFD uses four basic elements to develop a logical process model; these simple elements are Source, Data Flow, Process, and Data Store, which are shown in Fig. 3.1. The following figures of DFDs at different levels are adapted from the figures given in Kendal and Kendal (2008).

Source. A source is introduced by a square with the name of the source written inside it. The source is used to show an external entity, which sends data to the system or receives information from the system, or more precisely, from a determined process within the framework of the DFD.

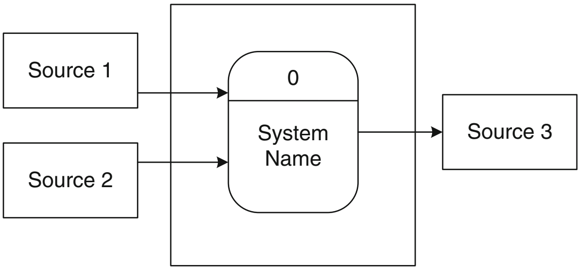
In many cases, we may find that the same source is connected with a number of processes within the diagram. To avoid crossing data flows in such cases, and to make the diagram less complex, the same source can be drawn in the diagram several times.

Data Flow. A data flow is represented by an arrow whose direction shows the direction of data movement from one element to another in the diagram. For example, to show that data is sent from a certain source to a process, an arrow with the name of data written on it, should be drawn from the source toward the process.

Process. A process is shown by a rectangle with rounded corners, which is divided into two parts. The upper part includes the unique number of the process within the DFD. The process number usually consists of two numbers, except the context diagram and diagram 0. The first number is the number of the diagram that comprises the process and the second number is the sequence number of the process within the diagram.

The lower part of the rectangle contains the name of the process. The name of the process should mean what kind of work is executed by the process. The process means a certain work that transforms the input entered as a data flow from other elements into an output, or a data flow sent to one or more DFD elements, such as source, another process, or data store.

Fig. 3.2 Context diagram



Data Store. A data store is represented by a narrow rectangle open on the right side and means storage of data, such as a manual store, data file, or database. Each data store is usually indicated by a unique label, such as D1, D2, etc.

3.2.1.2 DFD Modeling

As was mentioned before, the DFD technique is a top-down approach that starts with the development of diagrams that represent the process model from a general at system level to a specific at elementary process level. It starts with the context diagram, continues with diagram level 0, and goes on with process decomposition until achieving elementary processes.

Context Diagram. The context diagram is developed as the first and highest level diagram. The context diagram contains only one process, which represents the system discussed (for example, the whole business process). The process is indicated by number 0 and connected to different external sources by a number of data flows, as shown in Fig. 3.2.

Diagram 0. The diagram at level 0 is developed by decomposition of the process 0 in the context diagram into a set of processes at lower level. Kendal and Kendal (2008) wrote: "Diagram 0 is the explosion of the context diagram and may include up to nine processes".

Each process within diagram 0 is numbered by an integer sequence number. All sources represented in the context diagram are also represented in Diagram 0. In addition, all data stores, which are connected by data flows with the processes of diagram 0, are also shown in this diagram, see Fig. 3.3.

Lower Diagrams. From each process within diagram 0, a new diagram at a lower level is developed by decomposing the process within diagram 0 into a group of processes at more elementary level.

The new diagram is numbered by the number of the process from diagram 0 that is the subject of decomposition. Every process within the new diagram is given a number that consists of two parts: the first is the number of the new diagram and the second part is a sequence number of the processes within the new diagram. The new diagram also contains all sources and data stores that are connected to its processes by data flows (Fig. 3.4).

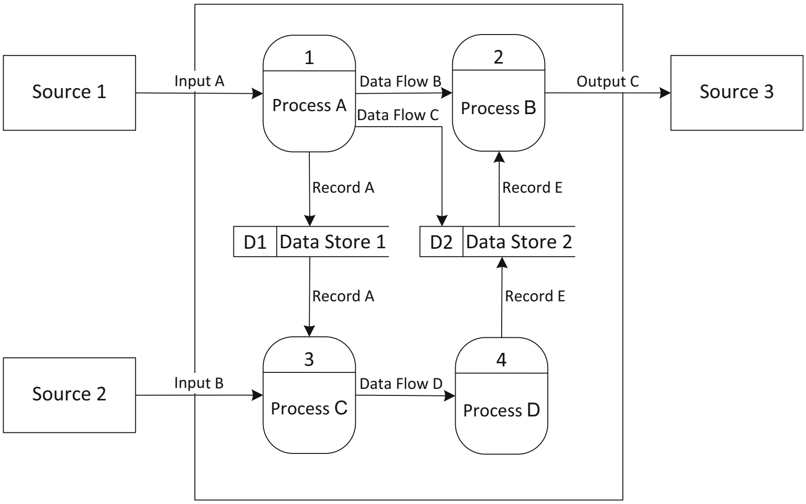


Fig. 3.3 Diagram 0

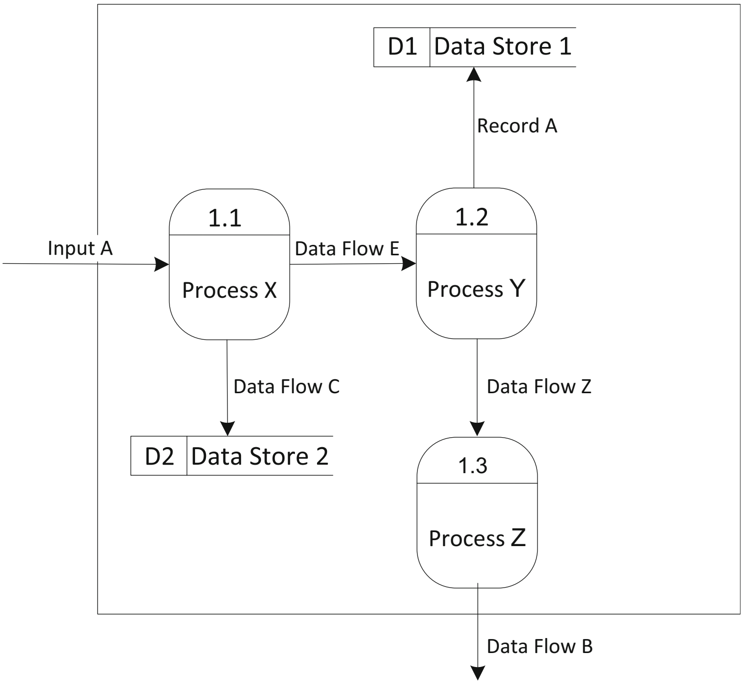


Fig. 3.4 Diagram 1

As was mentioned before, process decomposition continues until the elementary level of all processes is achieved. In the literature we may find that the number of decomposition levels is 7 ± 2 which makes follow-up of the processes from higher toward lower levels very difficult, complex, and confusing.

3.2.2 Unified Modeling Language

Unified Modeling Language (UML) is an object-oriented modeling technique, which was developed by Booch, Rambough, and Jacobson. In 1994 these authors, who are authors of the Booch, OMT (Object Modeling Technique), OOSE (Object-Oriented Software Engineering) methods, started the process of merging their three methods to form a united modeling concept, called UML.

The reason for development UML was to create a common object-oriented modeling technique, which comprises several types of diagram that are useful in creating a system model from different points of view. In addition, the authors wanted to develop a modeling language that would be accepted as a standard to unify the different techniques and methods used in this field.

UML has progressed through different versions, revisions, and extensions that lead to UML version 2.0, which was developed in 2005. UML 2.0 consists of fourteen different diagrams, which are grouped into two groups.

The first group are called structure diagrams, used to model the structure of the system. This group includes six diagrams: class, object, package, deployment, component, and composite diagrams.

The second group are called behavior diagrams, used to model the behavior of the system. This group contains eight diagrams: activity, sequence, communication, interaction, timing, behavior state machine, protocol state machine, and use case diagrams.

In accordance with the purpose of the current section, which is to discusses business process modeling, two of the above listed behavior diagrams are described briefly. These are the use case and activity diagrams, which can be used to model the functioning of a business process. The reader may find many interesting descriptions of the complete UML 2.0 in various books and websites on the internet.

3.2.2.1 Use Case Diagram

A use case diagram is a diagram that is used to capture a well-defined functioning of the system, when an interaction enters the system from a user or other system that exists in the environment outside the border of the system discussed.

The use case diagram is portrayed using three basic elements; these are: actor, use case, and communication lines.

Actor. An actor is a role that is played by a user while having interaction with the system. An actor may be a person or other system that plays a certain role by contacting the system with the purpose of sending an input into the system or getting an output from it, or both.

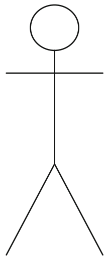


Fig. 3.5 Actor

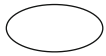


Fig. 3.6 Use case

An actor is portrayed outside the system border as a “stick figure” labeled by the name of the role, or by a box with a stereotype <<actor>> and named by the role inside the box, which could be used when the actor is not a person, such as another system or organization, as in B2B application, see Fig. 3.5.

Use Case. A use case represents a determined and well-defined work within the system functionality. Use case is very similar to the term “activity” defined in the previous section, which describes a sequence of tasks that must be performed in the system as a response to an input entering from the system’s environment, when an actor interacts with the system.

Furthermore, we may say that a use case is a basic piece of system behavior at a suitable level (for example, Create an Order), which represents a description that determines which actor can trigger which system’s function.

A use case is represented by an oval with the name of the use case inside it. The name should introduce the meaning of the work or system functionality that is carried out by the use case, see Fig. 3.6.

Relationships. There are four basic relationships, which are used in the use case diagram; these are Association, Extend, Include, and Generalization.

Association: An Association shows a relationship between an actor that uses the system and a use case that represents the system’s response to the actor’s action. Such an Association is represented by a solid line that connects the actor with the use case that the actor uses, see Fig. 3.7.

Extend: An “Extend” relationship introduces a connection that may be used between two use cases within a use case diagram. The “Extend” relationship means that the functionality of a certain use case, called a base use case, may be extended by the functionality of another use case.

In other words, an “Extend” relationship means that some use case includes the behavior of another use case, which is optional behavior and depends on a certain condition. For example, a use case “Create an Order” extended by the use case “Create VIP Order”, which means that if the customer is a VIP customer, then creating an order is done using the procedure defined by the use case “Create VIP

Fig. 3.7 Relationships

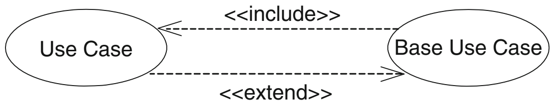
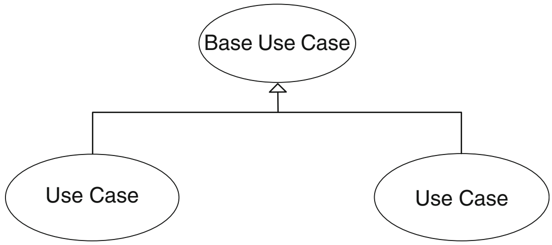


Fig. 3.8 Generalization



Order". The "Extend" relationship is shown by an arrow from the extended use case toward the base use case, see Fig. 3.7.

Include: An "Include" relationship enables a use case, a base use case, to include the behavior of another use case into its functionality whenever it is performed. It is similar to the call of a subprogram from a program. For example, a use case "Create an Order" includes the use case "Create a Customer", which means that the functionality of "Create a Customer" is included whenever the use case "Create an Order" is performed.

The "Include" relationship may enable the analyst to decompose a complex use case into more defined minor use cases. The "Include" relationship is represented by an arrow from the base use case toward the included use case, see Fig. 3.7.

Generalization: A "Generalization" relationship enables use cases, called specialized use cases, to inherit the behavior of a use case called a base use case. In addition to the inherited behavior, each specialized use case may also have its own behavior. The "Generalization" relationship is represented by a solid arrow drawn from the specialized to the base use case, see (Fig. 3.8).

Developing a use case diagram should start after the problem concerned is understood and analyzed carefully. Development of the diagram starts by identifying the actors that interact with the system concerned. For each actor identified, the number of use cases used by this actor is identified. This work is continued by drawing a use case diagram by:

– Firstly, defining the system's border that should be drawn around it to differentiate the diagram from its environment;
– Secondly, drawing actors outside the diagram's border and drawing use cases inside the diagram;
– Thirdly, connecting each use case with the actor(s) that use it through the Association relationship;
– Fourthly, connecting use cases by means of the Include and Extend relationships.

Use case name	Create a new Blog Account	
Related Requirements	Requirements A.1.	
Goal in Context	A new or existing author requests a new blog account from the Administrator.	
Preconditions	The author has appropriate proof of identity.	
Successful End Condition	A new blog account is created for the author.	
Failed End Condition	The application for a new blog account is rejected.	
Primary Actors	Administrator.	
Secondary Actors	None.	
Trigger	The Administrator asks the CMS to create a new blog account.	
Included Cases	Check Identity.	
Main Flow	**Step**	**Action**
	1	The Administrator asks the system to create a new blog account.
	2	The Administrator selects an account type.
	3	The Administrator enters the author's details.
	4 include::Check Identity	The author's details are checked.
	5	The new account is created.
	6	A summary of the new blog account's details are emailed to the author.

Fig. 3.9 Use case description form (Source: Miles and Hamilton 2006)

For each use case diagram defined within the framework of the diagram, a detailed description of the use case should be made by means of different forms, such as the one shown in Fig. 3.9.

3.2.2.2 Activity Diagram

An Activity diagram is an extension to the well-known flowchart or object-oriented flowchart as some authors name it. The activity diagram is used to model processes at different levels. In addition, it is also very useful for a detailed description of a use case by showing the tasks or actions performed within the framework of the use case described.

An Activity diagram consists of a number of elements that are shown in Fig. 3.10, such as initial node, final node, action, activity, edge, decision, fork, and join. In the following, these elements are introduced briefly:

– Initial node: indicates the start of a diagram and is represented by a circle;
– Final node: represented by two concentric circles with a filled inner circle and indicates the end of a diagram or a certain path of a diagram;
– Action: represented by a rounded rectangle and means a step or an elementary work that takes place within the diagram;
– Activity: in UML represents a process or a number of actions;

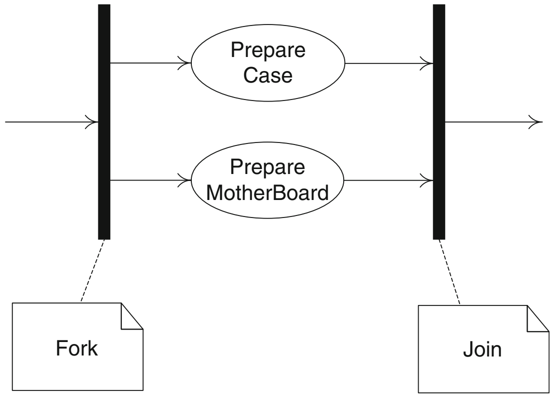


Fig. 3.10 Fork and join

– Edge: shows the direction of the flow within a diagram using an arrow; an incoming edge is an arrow that enters into a node, and an outgoing edge is an arrow that exits a node;
– Decision: shown by a diamond-shaped node with one incoming edge and multiple outgoing edges and used when one or more actions are executed depending on testing a determined condition;
– Fork: used for representing splitting a flow into a number of flows; it has one incoming edge and several outgoing edges, and is represented by a thick line;
– Join: used to join more flows into one flow; it has more incoming edges and one outgoing edge;
– Swimlane: used to partition the diagram into columns or rows to indicate that a group of actions are performed by a certain group or within a department.

The activity diagram is also used for describing the logic of a use case diagram by showing how the system should accomplish the work defined and the follow up of the diagram's use cases, see Fig. 3.11. This Figure shows an example of an activity diagram with swim lanes and join and fork.

3.2.3 Business Process Management Notations

BPMN is a recently developed modeling technique; version 1.0 was published in 2004 by BPMI (Business Process Management Initiation), BPMN 1.1 was published in 2008, and recently BPMN version 2.0 was announced. In addition, BPMN became widely known very quickly and was also adapted by OMG (Object Management Group) in 2006.

BPMN is based on the flowchart diagram, which became a common tool that is used in different modeling techniques, similar to what we can witness in the programming area, where C code is used by different programming languages, such as Java, C++, C#, and so on.

To model a certain process, BPMN uses three different process modeling categories and a number of well-known flowchart elements, as well as many new

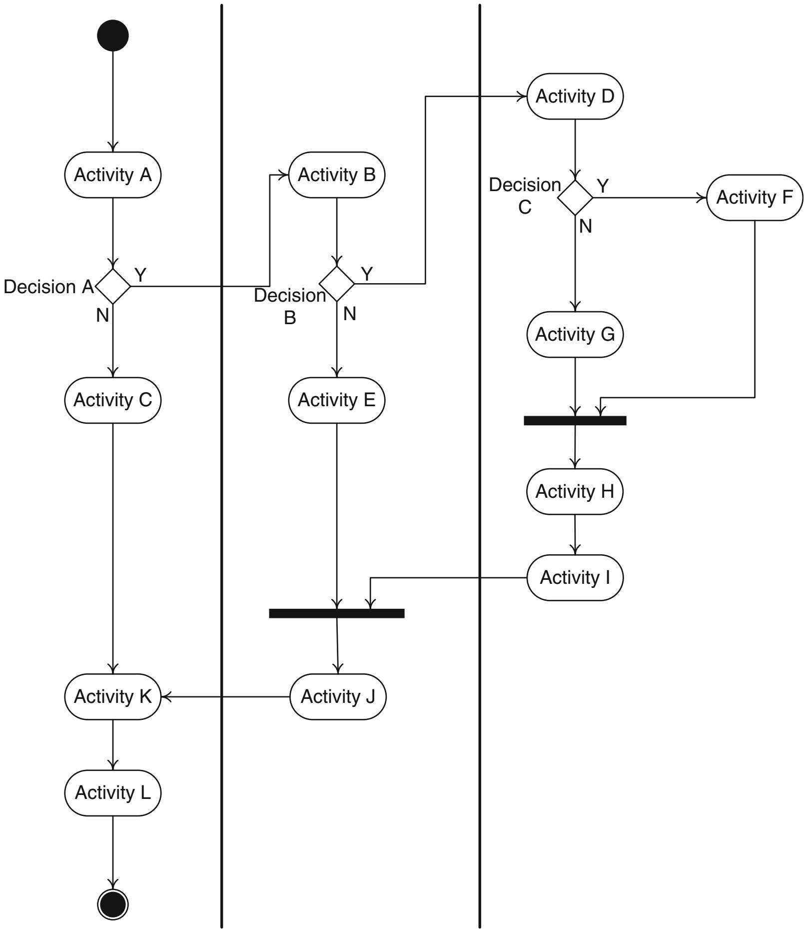


Fig. 3.11 Activity diagram

elements, which are grouped into four groups. BPMN categories and elements are described in the following briefly.

3.2.3.1 Categories

BPMN defines three categories for business process modeling; these are Orchestration, Choreography, and Collaboration. A short description of these categories follows. The reader may refer to specialized books and websites to find more detail.

Orchestration. An orchestration within BPMN represents the behavior of a single process model within the framework of a certain organizational entity. In other words, an orchestration is a process model shown inside the boundaries of a business entity, called pool, see Fig. 3.12.

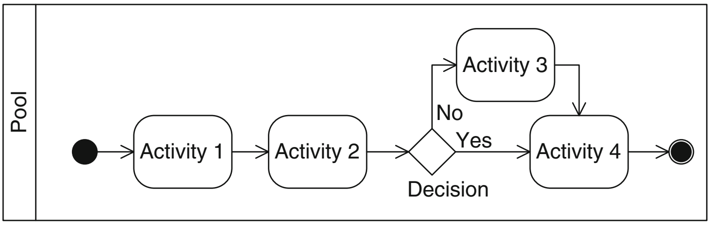


Fig. 3.12 Orchestration

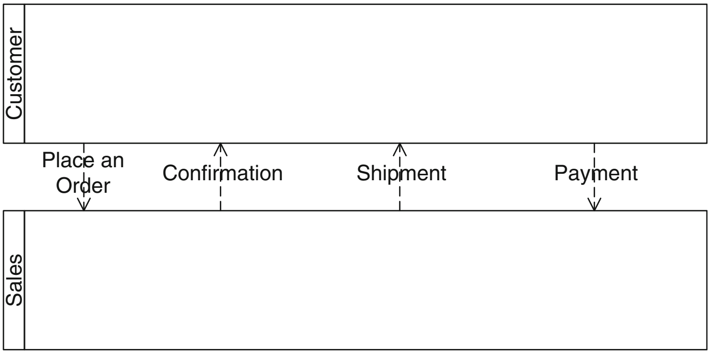


Fig. 3.13 Choreography

Moreover, a business process model may have a number of orchestrations depending on the number of business entities that are involved in performing the business process discussed.

Choreography. A choreography represents interactions between different participants within the process model. In other words, choreography describes how participants in different orchestrations are connected to each other. Therefore, a choreography is used to show the interactions that exist between pools of the process model.

A participant means a business entity or business role. Interactions mean kinds of communications or associations existing between participants. Such communications are represented as messages exchanged between participants, see Fig. 3.13.

White and Miers (2008) defined differences between orchestration and choreography as follow:

– An orchestration is contained within a Pool and normally has a well-formed context.
– A choreography does not exist within a well-formed context or locus of control. There is no central mechanism that drives or keeps track of a choreography. Therefore, there are no shared data available to all the elements of the choreography.
– To place choreography within BPMN diagrams is to put them between the Pools.

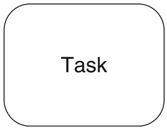


Fig. 3.14 A task

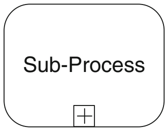


Fig. 3.15 A subprocess

Collaboration. A collaboration represents both the above introduced categories. Collaboration shows the participants of the process model and the connections existing between the participants.

In other words, a collaboration is a diagram that consists of a number of pools (at least two), which represent participants, and messages exchanged between them, which represent interactions. Therefore, collaboration contains two or more orchestrations, see Fig. 3.13.

Collaboration is specified by White and Miers (2008) as: a collaboration is any BPMN diagram that contains two or more participants as shown by pools. The pools have Message Flow between them. Any of the pools may contain an orchestration (a Process), but this is not necessary.

3.2.3.2 Elements

As was mentioned before, BPMN uses a number of elements, which are divided into four groups, as follows:

- Flow Objects (activities, events, and gateways);
- Connecting objects (sequence flow, message flow, and association);
- Swimlanes (pool and pool with lanes)
- Artifacts (data object, text annotation, and group).

Activities. An activity represents a work performed within a business process (White and Miers 2008). BPMN differentiates two types of activities; these are task and subprocess.

Task. A task is an atomic activity, which means performing an elementary work. A task is represented by a rounded-corner rectangle, as is shown in Fig. 3.14.

Subprocess. A subprocess is a compound activity, which consists of a number of elementary works. A subprocess is represented by a rounded-corner rectangle with a "plus sign" inside it, as shown in Fig. 3.15.

An activity could be performed a number of times depending on a repeating condition. An activity with a looping symbol is shown in Fig. 3.16.

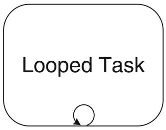


Fig. 3.16 An activity with a loop

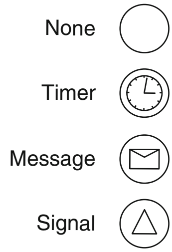


Fig. 3.17 Core start events

There are two kinds of activity looping:

– A while loop, where the repeating condition is checked before the activity is executed; and
– An until loop, where the repeating condition is checked after the activity is executed.

Events. An event is something that happens during the course of a process (White and Miers 2008). An activity may be triggered, interrupted, delayed, or ended by an event. There are three types of events: start, intermediate, and end events.

Start Events. A start event causes the initiation of a process. Such an event is represented by a single thin lined circle. There are core and advanced start events. Only core start events are introduced in this short introduction of BPMN. For a complete list of start events, see the website BPMN.com.

Core start events are:

– None: In this event no trigger is defined to start a process;
– Timer: In this event a date and time is defined as a trigger that starts a process;
– Message: In this event a message, which arrives from another business entity, is defined as a trigger that starts a process; and
– Signal: In this event a signal, which arrives from another process, is defined as a trigger that starts a process (Fig. 3.17).

Intermediate Events. An intermediate event indicates where something happens after a process has started and before it has ended (White and Miers 2008).

An intermediate event is represented by a double circle. There are four core intermediate and six intermediate advanced events. In the following the core intermediate events are introduced very briefly:

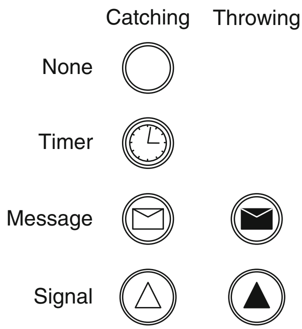


Fig. 3.18 Core intermediate events

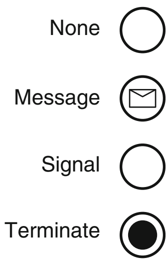


Fig. 3.19 Core end events

Core intermediate events are classified as follows:

– None: In this event no trigger is defined;
– Timer: an event where a date and time is defined to trigger a process;
– Message: an event where a message, which arrives from another business entity, is defined to trigger a process ; and
– Signal: In this event a signal, which arrives from another process, is defined to trigger a process (Fig. 3.18).

End Events. An end event marks where a process, more specifically a path within a process, ends (White and Miers 2008).

An end event is represented by a single thick circle. There are four core end and four advanced end events. In the following, the core end events are described very shortly:

Core end events are:

– None: This end event does not define any result;
– Message: This event ends a path in a process by creating and sending a message;
– Signal: This event ends a path in a process by broadcasting a signal;
– Terminate: this event ends the whole process (Fig. 3.19).

Gateways. A gateway is an element that controls the process flow by examining a certain condition. A gateway splits the flow into a number of outgoing flows or merges several incoming flows into one flow (Fig. 3.20).

There are two kinds of gateway, three core and two advanced. The core gateways are:

Fig. 3.20 Gateways

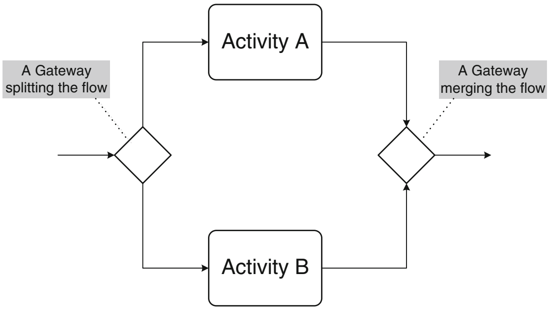
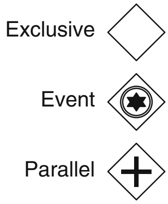


Fig. 3.21 Kinds of gateways



- Exclusive:
  - In the splitting case, depending on testing a certain condition, the gateway sends the flow through only one outgoing path
  - In the merging case, all incoming flows go through the gateway;
- Event:
  - In the splitting case, depending on the occurrence of an event, the gateway sends the flow through only one outgoing path
  - In the merging case, all incoming flows go through the gateway;
- Parallel:
  - In the splitting case, depending on testing a certain condition, the gateway sends the flow through all outgoing paths
  - In the merging case, the flow passes through, when all incoming flows have entered the gateway (Fig. 3.21);

Swimlanes. Swimlanes enable the modeler to divide a process model into different parts of the diagram developed. There are two kinds of swimlanes:
- Pool: used to place a process that represents participants within a collaboration; and
- Lanes: used to partition a pool into different parts (Fig. 3.22).

Artifacts. Artifacts enable the modeler to write additional information about elements within a process. There are three artifacts, see Figs. 3.23, 3.24 and 3.25:
- Data objects: this artifact is used to indicate a document used within a process;
- Groups: used for grouping a number of elements within a certain segment of a process; and
- Text Annotations: used to write additional information about elements of a process.

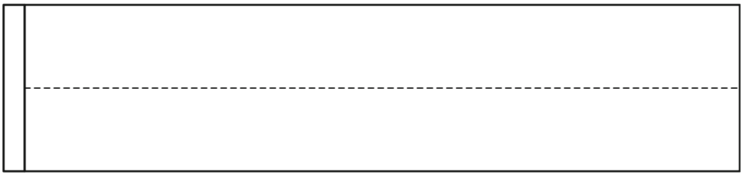


Fig. 3.22 Swimlanes

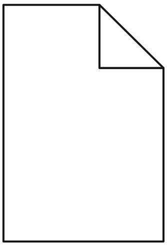


Fig. 3.23 Data object

Fig. 3.24 Group

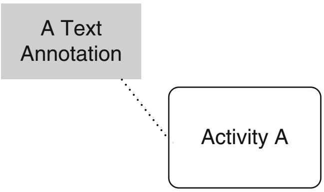


Fig. 3.25 Text annotations

References

Kendal, E., & Kendal, E. J. (2008). *Systems analysis & design*. Upper Saddle River: Pearson Prentice Hall.
Miles, R., & Hamilton, K. (2006). *Learning UML 2.0*. Cambridge: O'Reilly Media.
Paul, D., & Yeates, D. (2008). *Business analysis*. Swindon: BCS.
Weske, M. (2007). *Business process management: Concepts, languages, architectures*. New York: Springer.
White, S. A., & Miers, D. (2008). *BPMN modeling and reference guide*. Lighthouse Pt: Future strategies.

4 Business Process Approaches

Goals. In this chapter the following questions and themes are explored:
– What is business process reengineering
– The difference between efficiency and effectiveness
– Characteristics of business process reengineering
– An approach to business process reengineering
– What is business process improvement
– Characteristics of business process improvement
– An approach to business process improvement
– What is business process management
– What is a business process management system
– What is a business process lifecycle
– An approach to business process management

In recent years, understanding and analyzing the functioning of an organization from the business process view point became widely accepted and adopted compared to the functional understanding of the organization. This is because the process-oriented understanding of the organization represents an important way of ensuring changes in the organization's structure and functioning in order to create a better, more competitive and successful enterprise.

Improving the organization's business processes also became an essential step prior to business information system development whose role is to implement in practice all the necessary changes and new ideas identified in the process improvement. This approach ensures that the company benefits in the maximum way from the newly developed information system, ensuring the use of new ideas in its daily work.

Conducting improvements in business processes at different levels of the company became popular and attracted the attention of many researchers, managers, and practitioners since the publication of two very interesting papers by Hammer "Reengineering Work: Don't Automate, Obliterate " and by Davenport and Short

N. Damij and T. Damij, *Process Management*, Progress in IS,
DOI 10.1007/978-3-642-36639-0_4, © Springer-Verlag Berlin Heidelberg 2014

"The New Industrial Engineering: Information Technology and Business Process Redesign" in 1990.

In addition to the above mentioned authors, there are many other researchers who came out with new ideas, views, and methodologies to solve the process improvement problem. Since that time, many interesting studies have been conducted by many outstanding researchers in this field. Furthermore, many companies have been established and groups organized to tackle this problem and offer their services in carrying out process improvement projects in various kinds of organizations.

This field has advanced rapidly since 1990 and simultaneously with this advancement a number of well-known approaches were developed for use in solving process improvement problems, such as business process reengineering or innovation, business process improvement or redesign, and business process management. The advancement of these approaches could be understood as a process of developing ideas to achieve the same goal, which is how to help organizations to become more competitive and successful in the very dynamic environment of the business world.

4.1 Business Process Reengineering

As was mentioned before, the business process reengineering approach started with the publication of two well-known papers. One of them by Hammer "Reengineering Work: Don't Automate, Obliterate" and the other by Davenport and Short "The New Industrial Engineering: Information Technology and Business Process Redesign" in 1990.

Since then many very interesting papers and books have been published by different authors, among which we may mention two important books. The first was published in 1993 by Hammer and Champy "Reengineering the Corporation, A Manifesto for Business Revolution". This book was republished in 2003 and became a national bestseller in the USA, which gives a clear signal that the approach is still widely used and popular among practitioners and academics. The second is an excellent book from the practical point of view, which was published by Robson and Ullah in 1996 entitled "A Practical Guide to Business Process Reengineering".

There are actually older similar concepts of management on which the idea of business process reengineering is based, such as Total Quality and other approaches, which were used for many years.

Interesting definitions were published by Drucker (2006) that are important in providing simple and accurate exšlanations the terms of efficiency and effectiveness, which are essential in the field of management, as well as being very useful in business process improvement. These definitions are:

– "Efficiency is doing things right" and
– "Effectiveness is doing the right things".

Harrington et al. (1997) also developed important definitions of efficiency and effectiveness, as follows:

- "Efficiency is a measurement of how well a process uses its resources", and this includes resources such as people, time, space, and equipment;
- "Effectiveness is the degree to which an item provides the right output at the right place, at the right time, at the right price".

On the same topic, Robson and Ullah (1996) wrote "It has been pointed out that we often tend to concentrate on becoming more and more efficient, not realizing that we spend much of our time doing the wrong things. So organizations are full of people who spend a large proportion of their working lives producing outputs that are accurate, on time, well presented and so on; but unfortunately are neither necessary nor used by the people for whom they were produced".

On the other hand, it is well known that there are processes in many organizations that produce the right products that are needed by the customers but these processes are slow, complicated, contain many problems, and the quality is far from what it should be.

Both of the above mentioned extreme situations are very dangerous and either of them could be the main reason for the organization to find itself behind its competitors. Therefore, it is obvious that searching for new ideas for changes and improvements is essential to the survival and prosperity of the organization in today's dynamic world. Management should provide possibilities for continuous evaluation of the situation in their organization and whenever they find it in one of the above mentioned situations then the organization is mature for business process reengineering.

Business process reengineering is the most radical approach. It starts with creation of a business process from scratch by using the company's strategic goals as foundations to develop new business processes suitable for the implementation of these goals. For this reason, it is also called by some authors business process innovation. This name indicates that this approach depends on the reengineering team who should be very knowledgeable and experienced in order to work as an innovative group capable of creating new ideas on how to develop breakthrough business processes.

This approach could be useful and should be implemented when the business process discussed is out of time, inefficient, and has accumulated many problems and obstacles. In such cases, many authors suggest that the approach should start with a blank page of paper, building a new business process with a different organizational structure and optimized functioning. Meanwhile, other authors think that understanding and analyzing the existing business process is a very important concept and should be used as the starting point for building a new business process.

Hammer and Champy (1993) provided a definition of business process reengineering as: "The fundamental rethinking and radical redesign of business processes to achieve dramatic improvements in critical, contemporary measures of performance, such as cost, quality, service, and speed".

Robson and Ullah (1996) defined business process reengineering as: "BPR is the creation of entirely new and more effective business processes, without regard for what has gone before".

Concerning business process reengineering Harrington et al. (1997) mention in their book the following interesting conclusions, which could be beneficial:

– Process reengineering, when applied correctly, reduces cost and cycle time between 60 % and 90 % and error rates between 40 % and 70 %;
– Process reengineering is the correct answer for 5–20 % of the major processes within an organization;
– The process reengineering approach provides the biggest improvement but is the most costly and time consuming approach;
– Process reengineering is associated with the highest degree of risk;
– It includes organizational restructuring and can be very disruptive to the organization.

There are number of approaches or methods of how to carry out business process reengineering. In the following, two of these concepts are introduced briefly.

Harrington et al. (1997) suggested a process reengineering approach that consists of four steps, which are listed briefly, as follows:

1. Big picture analysis:

   The team should study the organization's mission and strategy. In addition, the team must understand the present situation and future goals of the organization, how the new process could support the organization's future needs, and what changes the new process should provide to achieve the organization's business goals.

2. Theory of ones:

   After the big picture is completed, the reengineering team begins dealing with defining the business process starting from its input, continuing with defining each piece of work carried out within the process, and completing it with the process's output.

3. Process simulation:

   After completing the process design theoretically, the team starts developing its simulation model, which is then tested and its functioning evaluated. Testing the process's simulation model continues until the team is satisfied with it.

4. Process modeling:

   When the newly designed process meets the vision statement and the process model is put into reality by verifying the details at a pilot location or a small part of the organization, then completing the process implementation is continued in the whole organization.

Robson an Ullah (1996) suggested a very interesting business process reengineering approach that is based on creating a new organizational structure. The approach consists of a number of steps; some of these are introduced briefly, as follows:

1. Organizational structure:

   The starting point is a blank sheet of paper on which work is concentrated on defining the organization's structure by collecting different assumptions about what the organization can be and what it should be.

2. Brainstorming:

   In this step the brainstorming technique is used for eliciting answers and ideas from members of the team involved in discussing the question of "What do we want the suggested structure to do for us".

3. Key characteristics:

   The team in this step is involved in discussing, analyzing, and agreeing on the key characteristics that the structure should be built around. The authors believe that in their experience there are five to eight key characteristics, which could be selected as the fundamental design features.

4. Evaluation:

   In this step the team is occupied with evaluating the current structure in terms of the key characteristics identified in the previous step, which should include areas where the current organizational structure meets the designated requirements and where it does not.

5. Transition to the new structure:

   This step deals with defining the key issues in managing the transition from the current structure to the new one.

As was mentioned before, the idea of these authors is based on defining a new organizational structure, which in their opinion is a very important ingredient of any comprehensive business process reengineering. Otherwise, the new processes that are put in place will be undermined by the restrictions of the previous mode of organization.

4.2 Business Process Improvement

Business process improvement is an alternative approach to business process reengineering. Business process improvement is concentrated on making the functioning of existing business processes better by looking for ways and solutions to increase their performance, quality, and lowering their cost.

The improvement team tries to understand the business processes selected one by one, by:

– Firstly, carefully identifying and analyzing its functioning and organization and
– Secondly, trying to find solutions to the problems and obstacles discovered that obstruct the expected functioning of the process analyzed.

Harrington et al. (1997) give the following very important conclusions about using the improvement approach:

– It is applied to processes that are working with fair success to well;
– It will reduce cost, cycle time, and error rates between 30 % and 60 %;
– It is the correct approach to use with approximately 70–90 % of major business processes; and
– It is the right approach if improving the process performance by 30–60 % would give the organization a competitive advantage.

The same authors suggested a list of tools or steps to be applied in order to carry out the approach, such as:

– Bureaucracy elimination,
– Value-added analysis,
– Duplication elimination,
– Simplification methods,
– Cycle time reduction,
– Error proofing,
– Process upgrading,
– Simple language,
– Standardization,
– Supplier partnership,
– Automation, mechanization, and information technology.

Davenport (1993) published important conclusions of a comparison analysis between the approaches of business process improvement and innovation (business process reengineering), which could be very useful for students and practitioners. In the following some of them are listed:

– Process innovation means performing a work activity in a radically new way;
– Process innovation has the following characteristics:
  • Implements radical changes
  • Starts from the beginning
  • Is carried out one-time
  • Requires a long-time
  • Has high risk
  • Cultural/structural changes are included;
– Process improvement involves performing the same business process with slightly increased efficiency or effectiveness;
– Process improvement has the following characteristics:
  • Implements incremental changes
  • Starts with the existing process
  • Is curried out one-time/continuous
  • Requires a short period of time
  • Has moderate risk
  • Cultural changes are included.

It must be emphasized that after carrying out the improvement of a certain business process, the company may expect that the process concerned gains a number of different advantages concerning its performance, cost, and quality in comparison with other competitive business processes.

Nevertheless, after some time these advantages start decreasing until reaching the point of their complete disappearance. This fact happens mainly because the competition also works to improve their business processes. On the other hand, the company or more precisely the management does not implement a continuous improvement plan and does not follow the dynamic changes that occur continuously in the organization's environment.

To solve this problem, the company should follow and apply a continuous business process improvement plan to ensure that the organization is always a step ahead of its competitors or at least not behind them.

To achieve this goal, real support by the management at the highest level of the organization should be provided, the needed resources should be available to the improvement approach, and an improvement plan should be prepared and implemented in order to ensure that the implementation of a continuous process improvement plan is going on constantly throughout the organization.

Harrington et al. (1997) mentioned that continuous business process improvement should result in a 10–15 % yearly ongoing improvement in the process.

These authors developed a methodology, which could be used to improve an existing business process or to develop a new one. In this section, phases of this methodology, such as: documenting, analysis, implementation, and management are introduced briefly.

1. Documenting

This phase begins by choosing business processes for improvement. The mentioned authors defined a number of criteria for choosing business processes for improvement. In the following, some of these criteria are:

– High frequency with which the processes are performed;
– The particular departments that are involved in the process
  It is sometimes specified that particular departments should be first discussed regarding changes;
– The financial significance of the process;
– The required effectiveness of the administrative product;
– The cost of the process.

The improvement team starts by describing the functioning of each business process that is selected for improvement using different tools and techniques, such as the process diagram, the organizational structure diagram, and other techniques that enable the team to create a good understanding of the process chosen.

To describe the business process concerned, a number of interviews should be planned and conducted with the relevant employees to explore how the process works by identifying its activities and following the order in which they are executed from the start to the end of the process.

In addition to this, interviews are important as opportunities to collect various kinds of documents that enter the process from other processes or from outside the system as inputs, and also documents that leave the process to other processes or to the system's environment as outputs. Furthermore, the team gathers detailed descriptions of different procedures and activities performed within the framework of the process.

The description of the work done within the process and the procedures used should be presented to all the people who are involved in executing different jobs within the process in order to correct mistakes and misunderstandings that usually occur through the interviews.

The team's work continues by presenting all the information gathered about the business process discussed to the operational management in those departments through which the process passes. The purpose of such presentations is to elicit management's opinion and to find out if the team has created a complete understanding of the process.

2. Analysis

The authors identified a number of reasons that cause flaws in business processes and make it inefficient and ineffective. In the following, some of them are mentioned, such as:

– The requirements placed on the administrative organization change with the passage of time;
– Developments in the field of automated office procedures and equipment or of automated transaction processing information systems.

On the other hand, there are various indicators that the business process contains flaws that affect its effectiveness and efficiency. Such flaws include, for example, a long delivery time or the loss of clients. If the process is performed within one department or it goes through only a few departments, then reasons for long delivery times and delays may be found easily. Otherwise, if the process crosses a number of departments then the problem could be more complicated and needs to be analyzed carefully.

In order to remove such flaws from the process, the team, in our opinion, should possess a deep understanding of the process, which could be achieved by completing a detailed documentation of the business process before starting the analysis phase of the process.

It is important that the employees who are involved in performing different activities within the process are also involved with the analysis of the process. This fact is essential because these are experienced people who may provide very important ideas or suggestions for finding solutions, making necessary changes, and improvements on the basis of their working experience.

When the analysis results are collected and the suggestions for making changes seem acceptable, then the improvement team should introduce these suggestions for change to the management at departmental level. For this purpose, the team should organize a meeting with each department to discuss the results of the analysis phase.

3. Implementation

The result of the analysis phase is a set of improvement suggestions and ideas that look promising in achieving the team's goal of creating a more effective and better business process in terms of performance, quality and cost. This phase consists of a number of steps. Some of them are introduced shortly.

In the first step, the improvement team creates a design of the improved version of the business process and implements the suggestions and ideas identified, discussed and accepted in the previous phase.

In the next step, the team introduces the improved process to the management at departmental level. Possible problems raised and questions should be discussed in order to find convenient solutions.

The work continues by creating an implementation team that develops software to implement the improved version of the process. The software is then tested and evaluated. When the users are satisfied with the improved process, then the existing process could be replaced by the new improved one.

4. Management
The last phase deals with management of the improved and implemented process by maintaining changes in it corresponding to changes happening in the environment of the company. To achieve this, the process owner should actively look after the improved process in order to find solution for any problem appearing at the time and place it occurs. The process owner should also insist on conducting new necessary improvements in accordance with a continuous improvement plan.

4.3 Business Process Management

In recent years business process management attracted the attention of many researchers and practitioners as a new approach in the field of business process studies that could contribute a great deal in enabling organizations to improve their business processes and bring them as close as possible to their planned operational, business and strategic goals.

This approach is well covered by many very good and contemporary books which contribute an important role in introducing the approach successfully from different points of view. For example such a book is “Business Process Management: Concepts, Languages, Architecture”, published by Weske in 2009. In addition to this, the reader may find many other interesting books and research papers published by various researchers.

The business process management approach could be understood as the continued development of the two previously introduced approaches. The approach is based on new ideas, which combine possibilities for optimization of business processes with the use of contemporary information technology in order to create a new and an as effective and efficient environment as possible to implement the business process analyzed.

Business process management needs multidisciplinary knowledge and in general links professionals and researchers involved in at least two fields that are important to the functioning of an organization; these are: Business and Information Systems.

Experts from the field of information systems try to invest their knowledge of techniques, methods, technology, and the experience gained from different areas of information management not only in developing software systems as in the past, but also in contributing actively to solving the organization’s problems, particularly in creating effective and efficient business processes in order to enable the company to become as successful and competitive as possible.

On the other hand, business people face deep changes in the business environment and also aggressive, dynamic, and challenging competitors. For this reason, many managers in the business field accepted the idea of a process-oriented organizational view of the company, completely or partially, as a way that offers better possibilities of achieving their business goals in such a turbulent environment, in comparison with the functional organization approach.

Business process management associates ideas from both fields (business and information systems) to enable professionals from these disciplines to experiment with their ideas for creating a better organization.

Information system experts may invest their knowledge of process modeling techniques and methods, improvement methodologies, and IT technology to optimize business processes and consequently play an important role in creating better organizational operation that leads to business success.

Business managers may invest their knowledge and expertise in carrying out business as well as providing all the needed resources to support the use of up to-date information technology. In addition, they are also responsible for offering maximal possible support to the organization's business processes, which may contribute a great deal in optimizing the functioning of the organization and consequently making it as prosperous and competitive as possible.

To understand properly the meaning of business process management, let us present definitions given by Weske (2007) for the business process, business process management, and business process management system.

– Business process: A business process consists of a set of activities that are performed in coordination in an organizational and technical environment. These activities jointly realize a business goal. Each business process is enacted by a single organization, but it may interact with business processes performed by other organizations.
– Business process management: Business process management includes concepts, methods, and techniques to support the design, administration, configuration, enactment, and analysis of business processes.
– Business process management system: A business process management system is a generic software system that is driven by explicit process representations to coordinate the enactment of business processes.

Business process management is defined by Khan (2004) in his book "Business Process Management" as: "Business process management is the discipline of modeling, automating, managing and optimizing business processes throughout their lifecycle to increase profitability".

Considering the above two definitions of business process management given by the authors Weske and Khan, shows that both definitions are actually developed on the basis of the business process lifecycle. For this reason, the business process lifecycle is introduced briefly to enable the reader, particularly students, to understand this important subject.

4.3.1 Business Process Lifecycle

The business process lifecycle is an iterative process through which each business process passes via different stages. Any iteration of the process lifecycle starts by process modeling, continues by process implementation, and finishes by process improvement and optimization.

Corresponding to Weske (2007), the business process lifecycle consists of four phases, which are design and analysis, configuration, enactment, and evaluation. These phases are connected to each other and represent the foundation for understanding business process management.

1. Design and Analysis

This phase consists, as evident, of two subphases, which are design and analysis.

Design. Within the framework of this subphase, two steps are performed:

– Business process identification
  This step is carried out using different techniques, such as surveys, interviews, or documentation of the business process discussed. The purpose of this step is to discover the organizational structure and functioning of the business process selected.
– Business process modeling
  On the basis of the information collected in the previous step, a process model of the business processes concerned is developed by choosing and using a determined process modeling technique from the many techniques available for this purpose. The process model developed is then analyzed and improved by implementing different improvement ideas and necessary changes.

Analysis. This subphase consists of the following three steps:

– Business process validation
  In the validation step, a workshop is organized to discuss and validate the process model developed and improved in the previous step. Experienced employees knowledgeable about the business process discussed, are invited to participate in the validation of the process model developed in order to find out whether the model reflects the real functioning of the business process modeled.
– Business process simulation
  In this step, the simulation technique is used to identify the behavior of the business process modeled in order to analyze carefully other possibilities for taking further actions, whose purpose is to increase the performance of the process's activities and to remove any obstacle existing within it.
– Business process verification
  In the verification step, after the business process has been improved and simulated, the work continues to verify the functioning of the new process. The aim is to find out if the business process performance and other characteristics are in accordance with the expectations of the management and reflect the desired business process, which the company intended to achieve to satisfy customer requirements and changes in its environment.

2. Configuration

The Configuration phase consists of three steps; these are business process management system development, system testing, and system integration.

Business Process Management System Development. The development step deals with developing a software system. This is done firstly by choosing a proper systems platform that enables the implementation of the software in accordance with the information requirements and organizational structure of the company. And secondly, by developing and implementing its models, which result in creating a software system that provides complete support to all aspects of the new business process created in the previous phase.

Business Process Management System Testing. The testing step carries out checking of the software system in all phases of its development by choosing and using a certain testing technique. This step should ensure that each activity within the business process is implemented and tested carefully. In addition to this, the testing step should make sure that each work process, subprocess, and the business process as a whole is tested carefully in order to implement a software system that behaves in the same way as the real business process does.

Business Process Management System Integration After completing the steps of systems development and testing successfully, the configuration phase continues with finding possibilities for integrating the new software system developed with the existing software systems within the organization.

3. Enactment

The enactment phase consists of three steps; these are operation, monitoring, and maintenance.

Operation. In the operation step, the business process management system is enacted using real business process instances. For this purpose, a number of business process instances are prepared and real time execution of these instances is measured and the output quality is checked to find out if the results of using the software system fulfill the company's expectations.

Monitoring. In this step, the monitoring possibility is provided by the software system developed. This means that the business process management system installed should provide a monitoring component, which enables the responsible employees to monitor the status of a business process instance at any time and also follow it on its way from the beginning until the end of the business process.

The monitoring component of the system is very necessary and should include a visualization of the current state of the process instances that flow throughout the business process. This important property of the system could be achieved using different visualization techniques, such as using different colors that indicate what is going on with the instance. Such a possibility enables the responsible employees to provide the customers with accurate information about their inquiries. On the other hand, it also enables the management to take proper and immediate action, when a certain problem is identified.

Maintenance. Maintenance of the business process management system is a very important task. To implement it, the system should generate a log file that registers detailed data about all events happening to the business process instance during its way through the business process activities. In such a way the software system provides the system developers with all the data needed for its maintenance.

4. Evaluation

In the evaluation phase, the business process management system is evaluated using the results of the system monitoring and the log file generated in the previous phase. These outputs enable the system developers to identify if there are still obstacles that need to be removed or problems that need to be solved. For example, if the performance times of some activities are not as expected, then such problems should be analyzed carefully in order to find out what causes them and also to determine which actions should be taken to accelerate them.

Furthermore, the management should evaluate the functioning of the software system to check if the new system provides a value-adding to the functioning of the organization by increasing the business process's effectiveness, efficiency, and quality of its outputs. Otherwise, necessary changes should be made to improve it.

In addition to the above phases of the business process lifecycle presented by Weske (2007), another author Khan (2004) classified four stages of business process management, namely modeling, automation, management, and optimization. To provide the reader with a wider view of this very important field, the above mentioned stages are also introduced shortly.

1. Modeling

In the modeling stage, a business process model is developed. Khan stated that in general it is the responsibility of business managers to create a description of the business process discussed. In this stage the following tasks are done:

– Developing a flowchart of the business process,
– Documenting the business process,
– Defining what role is played by each of the people involved in the business process by understanding its rules, responsibilities, and purpose.

2. Automation

The automation stage deals with developing a software system that implements the model of the business process developed in the first stage. For this purpose, software designers and programmers are brought together to convert the process model and users' requirements into a working application system. This stage also takes care of testing the system before its deployment.

3. Management

In the management stage of the lifecycle, the software system developed is implemented by deploying it on the computer systems of the company. The employees involved within the business process have to start using the business process management system and practicing with it their daily work. Business managers have to monitor the use of the software system.

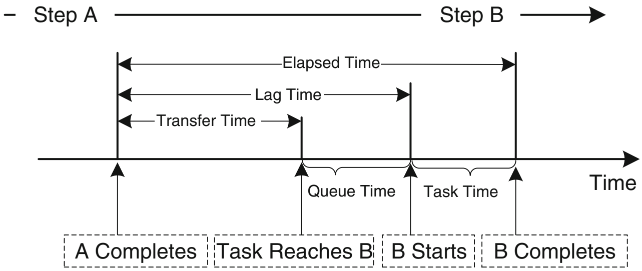


Fig. 4.1 Time components of a process step (Source: Khan 2004)

4. Optimization
In the last stage of the process lifecycle, different information is gained from the system about performance problems, bottlenecks, costs, etc. that may exist in the system. The information obtained is essential in enabling the responsible IT professionals and business managers to find solutions and take appropriate actions in order to make the necessary changes to improve the business process management system.

4.3.2 Business Process Management Benefits

The organization may gain several benefits by implementing business process management in its working environment. Khan (2004) listed a number of benefits, such as speed, satisfaction through feedback, parallelism, process integrity, process optimization, incorporate customers and partners, and organizational agility. In the following the first three of the listed benefits are introduced.

1. Speed
Automation of the business process leads to dramatic acceleration in completing tasks, which otherwise would need much time to be performed.

Figure 4.1 introduces an interesting example, which shows the different components of time needed to carry out a task after completing step A if the task is carried out manually. As the example shows, the following time components are involved: transfer time, queue time, and task time. Elapsed time means the total time of all three time components.

Transfer time: this is the time after the completion of step A that is needed to transfer manually or via mail all documents and other things related to the task from the employee at step A to the employee at step B. This time could be eliminated completely by using business process management.

Queue time: this is the time that starts when the documents and other things reach step B and finishes when the employee starts performing the task. The queue time could be eliminated or at least reduced to a minimum by using business process management. The queue and transfer times do not add any value to the business process discussed. The sum of the time components represents a time called the lag time.

Fig. 4.2 Lag time and task time (Source: Khan 2004)

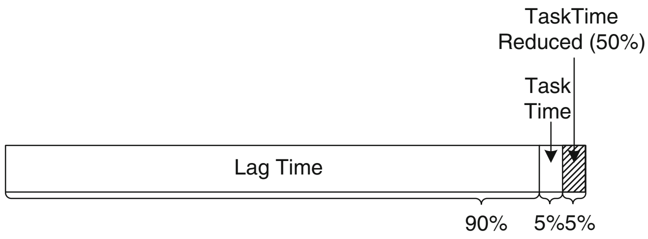


Fig. 4.3 Reducing task time by 50 % (Source: Khan 2004)

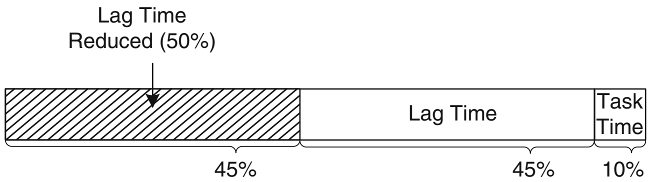


Fig. 4.4 Reducing lag time by 50 % (Source: Khan 2004)

Task time: This is the time required for executing the task by the employee at step B. This time is also known in the field of project management as "Effort". This is the only time, which adds value to the business process. Task time could be also reduced by business process management

Khan (2004) wrote that the lag time may represent 90 % of the elapsed time, as shown in Fig. 4.2.

In addition, even if we succeed in reducing the task time by 50 %, this reduction actually means only a 5 % improvement of the elapsed time, as is shown in Fig. 4.3.

On the other hand, if we succeed in reducing the lag time by 50 %, this actually means 45 % reduction of the total elapsed time, see Fig. 4.4.

2. Satisfaction Through Feedback

One of the very important factors in keeping customers and connecting them to the organization is building confidence in the organization and its products. This is achieved by providing customers with feedback about their orders, shipments, complaints, and so on, which leads to building customer satisfaction with the way in which the organization works.

Ensuring customer satisfaction is a very difficult task, which is hard to achieve without implementing a business process management system. Such a system increases the effectiveness and efficiency of the organization's processes and enables the customers to gain accurate feedback information about their requirements quickly.

3. Parallelism

Business processes are usually carrying out sequentially when the work is done manually, even if many tasks could be performed in parallel.

Khan (2004) mentioned two reasons for performing tasks sequentially, these are:

– It is easier and more convenient to control a business process if it is sequential rather than parallel.
– Manual business processes rely on paper forms and documents. Information carried on paper cannot be easily split into many parallel paths.

However, business process management enables parallel execution of many tasks without losing track of them or failing to control them effectively. Such a system also has no problems with splitting information and forwarding it to different employees. So, a business process management system enables the organization to eliminate the above listed reasons for performing tasks sequentially and supports parallel execution of tasks.

References

Davenport, H. T. (1993). *Process innovation, reengineering work through information technology*. Boston: Harvard Business School Press.

Davenport, T., & Short, J. (1990). *The new industrial engineering: Information technology and business process redesign*. Cambridge: Sloan Management Review.

Drucker, F. P. (2006). *The effective executive: The definitive guide to getting the right things done*. New York: HarperCollins.

Hammer, M. (1990). Reengineering work: Don't automate, obliterate. *Harvard Business Review*, 68(4), 104–112.

Hammer, M., & Champy, J. (1993). *Reengineering the corporation: A manifesto for business revolution*. New York: HarpeCollins.

Harrington, H. J., Esseling, E., & van Nimwegen, H. (1997). *Business process improvement workbook*. New York: McGraw-Hill.

Khan, N. R. (2004). *Business process management: A practical guide*. Tampa: Meghan-Kiffer Press.

Robson, M., & Ullah, P. (1996). *A practical guide to business process re-engineering*. Hampshire: Gower.

Weske, M. (2007). *Business process management: Concepts, languages, architectures*. New York: Springer.

Process Analysis

5

Goals. In this chapter the following questions and themes are explored:
– Calculating process performance
– Using process performance measures
– What are cycle time, flow rate, and inventory
– The meaning of Little's law
– Computing process cycle time
– Identifying the critical path of a process
– Calculating cycle time efficiency
– What is process capacity
– The meaning of process capacity utilization

5.1 Process Performance

As was mentioned in Chap. 1, a process is the transformation of inputs into outputs. Anupindi et al. (2006) in their book "Management Business Process Flows, Principles of Operations Management" state that a process view considers any organization, or any part of an organization, to be a process that transforms inputs into outputs. The authors also define five elements that characterize this transformation; these are inputs and outputs, flow units, network of activities and buffers, resources, and information structure, see Fig. 5.1. In the following, definitions of these elements are introduced:

– Inputs and outputs
  • Inputs are any tangible or intangible items that flow into the process from the environment.
  • Outputs are any tangible or intangible items that flow from the process back into the environment.

N. Damij and T. Damij, *Process Management*, Progress in IS,
DOI 10.1007/978-3-642-36639-0_5,

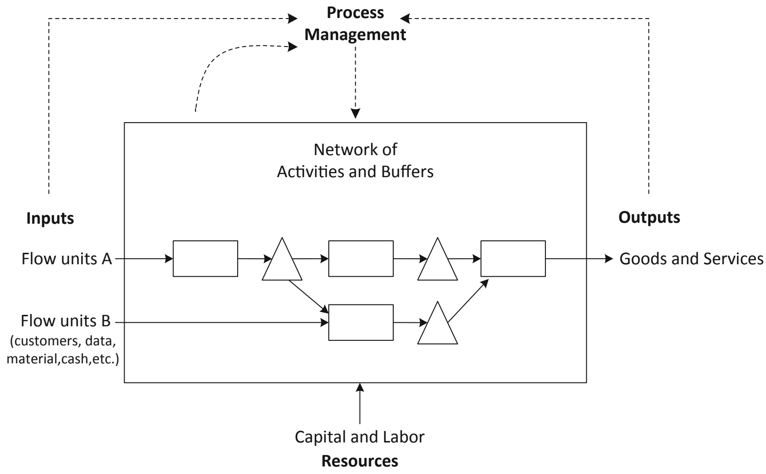


Fig. 5.1 A network of activities and buffers (Source: Anupindi et al. 2006)

– Flow units
  A flow unit or a job, as it is called by some authors, is an item that flows throughout the process. Depending on the process, the flow unit may be a unit of input, such as a customer order, or a unit of output, such as a finished product.
– Network of activities and buffers
  • An activity is the simplest form of transformation; it is actually a miniprocess in itself.
  • A buffer stores flow units that have finished one activity but are waiting for the next activity to start.

A network of activities and buffers describes specific precedence relationships among activities linked so that output of one becomes an input into another, often through an intermediate buffer.

– Resources
  Resources are tangible assets that are usually divided into two categories: capital and labor.
– Information Structure
  Is the information needed and available in order to perform activities or to make managerial decisions.

The process flow is a dynamic process that starts when an input (a flow unit or job) enters a process, continues processing throughout different kinds of process activities, and ends when it leaves the process as its output.

There are three basic or key process flow measures, which represent important process analysis tools in the hands of the process owner or process improvement team. These tools could be used with the purpose of creating a better understanding of the business process discussed, discovering problems existing within it, developing an improved version of the process or inventing a completely new process, and making a comparative analysis between the existing business process on one hand and the improved or new one on the other.

The three key measures of the process flow are cycle time, flow rate, and inventory. These measures are essential for analyzing the process performance and answering three important questions generated by Anupindi et al. (2006) and related to how a flow unit or job passes through the process. The three questions are:

(a) On average, how much time does a typical flow unit spend within the process boundaries?
(b) On average, how many flow units pass through the process per unit of time?
(c) On average, how many flow units are within the process boundaries at any point in time?

5.1.1 Cycle Time

Cycle time is also called “Flow time” by Anupindi et al. (2006) and other authors. The term cycle time is widely used particularly in simulation packages, such as for example iGarfx. To keep track of the terms used in simulation, we decided to use the term cycle time rather than the term flow time.

Cycle time or flow time is defined by Anupindi et al. (2006) as: “The total time spent by a flow unit within the process boundaries”.

Cycle time is the time that it takes to complete an individual job from start to finish (Laguna and Marklund 2005).

For examples, the cycle time at a hospital is the total time that starts when the patient (flow unit) enters the hospital and ends when the patient leaves the hospital. In the Sales Claim process, the cycle time is the total time that starts when a customer places a claim (flow unit) and finishes when the customer gets a claim solution.

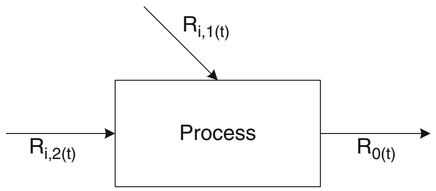
It is evident from the above given definitions of the process elements that each flow unit or job passes through a network of activities and buffers. Therefore, a flow unit at any time during its journey through a process could be found either under a certain work performed within an activity, or waiting in a buffer.

This means that a flow unit during a process could be within a value-adding or a non-value-adding activity. Furthermore, a flow unit usually spends only a small amount of time within value-adding activities compared to the amount of time spent within non-value-adding activities or to the whole cycle time.

According to Laguna and Marklund (2005), a typical cycle time of a flow unit includes the time associated with value-adding and non-value-adding activities, such as:

– Processing time (related to value-adding activities),
– Inspection time,
– Transporting time,
– Storage time,
– Waiting time (planned and unplanned delay time).

Fig. 5.2 Inflow and outflow rates (Source: Anupindi et al. 2006)



Cycle time is a key measure that represents the performance of a process by showing the time that a flow unit needs to go through the process, as well as the waiting activities of the process from its beginning to its end. For example, a sales claim takes 3–4 weeks to be completed, though the processing time lasts only a few hours.

5.1.2 Flow Rate

Flow rate is a very important measure of process performance. This measure of flow dynamics is also called "Throughput".

Flow rate is defined by Anupindi et al. (2006) as: "The number of flow units that flow through a specific point in the process per unit of time".

Laguna and Marklund (2005) defined throughput as: "The number of jobs per unit of time".

Flow rates have usually different values at various points of time throughout the process. Therefore, let us denote the following flow rates:

– R(t), means the flow rate at a certain point of time t
– R_i(t), means inflow; this is the flow rate of flow units that enter the process through its entry points
– R_o(t), means outflow; this is the flow rate of flow units that leave the process through its exit points.

Figure 5.2 shows a process with two inflow rates entering the process through two entry points and one outflow rate.

5.1.3 Inventory

Inventory is defined by Laguna and Marklund (2005) as "work-in-process". Inventory means the number of flow units that may be found within the framework of the process at any point of time.

Inventory is defined by Anupindi et al. (2006) as: "Inventory is the total number of flow units present within the process boundaries".

Inventory is denoted by I(t), which means the total number of flow units present within the process boundaries at time t.

The inventory within the framework of the process depends on the difference between the inflow rate and outflow rate because the inflow and outflow rates may differ over time throughout the process.

Let us denote the difference between inflow rate and outflow rate by $\Delta R(t)$, such as:

$$\Delta R(t) = R_i(t) - R_o(t)$$

Then the following alternatives are possible:

– If inflow rate $R_i(t) >$ outflow rate $R_o(t)$ then the inventory increases at a flow rate $\Delta R(t) > 0$;
– If inflow rate $R_i(t) =$ outflow rate $R_o(t)$ then the inventory is unchanged;
– If inflow rate $R_i(t) <$ outflow rate $R_o(t)$ then the inventory decreases at a flow rate $\Delta R(t) < 0$.

5.1.4 Little's Law

Little's law was proposed by Little (1961) in connection with queuing theory. This law defines the fundamental relationship between average inventory, average flow rate, and average cycle time in a stable process.

Therefore, let us first list definitions of average flow rate, average cycle time, average inventory, and a stable process.

Average Flow Rate or Throughput. Throughput is defined by Anupindi et al. (2006) as: "The average number of flow units that flow through (into and out of) the process per unit of time".

The average flow rate is a process performance measure that indicates the rate of producing the output of the process. However, if the process average flow rate is greater than the demand rate, then the process produces more than customers demand. Otherwise, if the average flow rate or throughput is less than the demand rate then the process is not capable of serving all customers. Therefore, an organization's ideal goal is that the process flow rate is equal to the demand rate.

Stable Process. A stable process is defined by Anupindi et al. (2006) as: "A stable process is one in which, in the long run, the average inflow rate is the same as the outflow rate".

In order to understand this definition, we may calculate the average inflow rate and the average outflow rate. To calculate the average inflow rate R_i, first calculate all $R_i(t)$ values in a number of periods of time t, then divide the sum of the calculated inflow rate values by the number of periods of time. The same procedure could be used to calculate the average outflow rate R_o. From this explanation, it may be concluded that in a stable process, the average flow rate equals to average inflow rate and average outflow rate:

$$R = R_i = R_o$$

Since different flow units may have different cycle times to pass through the process, it is possible to calculate the average cycle time.

Average Cycle Time. Because the actual cycle time could be different from one flow unit to another, it is important to define and calculate the average cycle time.

The average cycle time is the average (of flow times) across all flow units that exit the process during a specific span of time (Anupindi et al. 2006).

Average Inventory. Because the inventory within a process changes over time, we may calculate the average inventory of a process.

The average inventory is the number of flow units within the process boundaries at any point in time (Anupindi et al. 2006).

Little's Law. Little's law states that "the average inventory equals the average flow rate times the average cycle time". Therefore, this law establishes a relationship between the three key process performance measures in a stable process. This is:

$$I = R^{*}T$$

In order to show the use of Little's law, let us solve the following two simple examples.

Example 1. A surgical clinic accepts 60 patients per month. The average number of patients staying in the clinic at any point in time is 20. A patient in the clinic is either waiting for surgery, undergoing surgery, or recovering after surgery. Our task is to find out the average time that a patient spends in the clinic. Because 60 patients enter the hospital per month then:

$$\begin{aligned} \text{Average flow rate R} &= 60/30 = 2\,\text{patient/day} \\ \text{Average inventory I} &= 20 \text{ patients} \\ \text{Average time cycle T} &= \text{I/R} = 20/2 = 10\,\text{days} \end{aligned}$$

Example 2. A trade company has 1,000 sales claims per year. The average time for solving a sales claim is three weeks. We would like to calculate the average number of sales claims in the company at any point of time.

Taking into the account that the company works 50 weeks per year, we may calculate the average flow rate:

$$\begin{aligned} &\text{Average flow rate R} = 1000/50 = 20 \text{ Sales claim/week} \\ &\text{Average time cycle T} = 3 \text{ weeks} \\ &\text{Average inventory I} = \text{R}^{*}\text{T} = 20^{*}3 = 60 \text{ Sales claims} \end{aligned}$$

From the above given explanation, we may conclude that the three process performance measures enable us to answer the previously raised three questions, which are:

– What is the average time a typical flow unit spends within the process boundaries?
– How many average flow units pass through the process per unit of time?
– How many average flow units are within the process boundaries at any point in time?

5.2 Process Cycle Time

As was mentioned in the previous section, the cycle time means the total time that is spent by a flow unit in its journey through the process, which starts at the moment when the flow unit enters the process and ends at the moment when it leaves the process. To analyze the cycle time, we first have to discuss various topics, such as theoretical cycle time, critical path, etc.

5.2.1 Theoretical Cycle Time

Any flow unit or job on its way from the beginning of a process until reaching its end goes through a sequence of activities and buffers. The cycle time of a flow unit within the process actually consists of the time taken by those activities, where the flow unit is processed by certain works, and the waiting time spent by the flow unit in different buffers.

It is very important to find out how much time the flow unit spends within various activities where specific works are carried out on it, and also how much time the flow unit spends waiting in buffers.

The following definitions for the theoretical cycle time and activity time can be found in Anupindi et al. (2006):

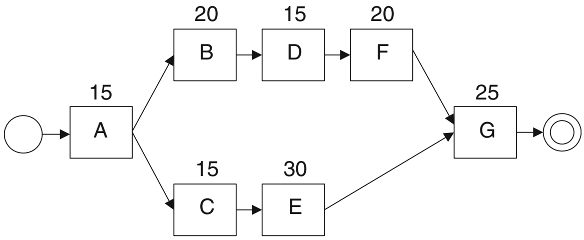
– Theoretical cycle time of a process: the minimum amount of time required for processing a typical flow unit without any waiting.
– Activity time: the time required by a typical flow unit to complete the activity once.

The theoretical cycle time is computed as a sum of the times of those process activities which the flow unit passes through and where specific kinds of work are done to process it. It is also obvious from the given definition that the theoretical cycle time is an idealized time, which is very difficult to achieve in reality.

Moreover, it is very important to understand that the theoretical cycle time usually represents only a small segment of the whole cycle time of the process.

Furthermore, for each activity within a process, the activity time in reality may differ from one flow unit to another. Consequently, the theoretical time cycle may be different for various flow units. For this reason, the average theoretical time is computed as the average of the theoretical times of all flow units.

Fig. 5.3 A process flowchart



5.2.2 Critical Path

A process flow is usually presented using a diagrammatic technique. One of the simplest and most widely spread techniques is the flowchart. A process flow or process flowchart may have many paths on the way from the start to the end of the diagram.

Let us consider the rare situation, where a process flowchart has only one path that consists of a number of sequential activities. In this case, the total cycle time of this diagram is equal to the sum of the times of these activities. For example, if the diagram consists of five activities, say A, B, C, D, E which last 20, 10, 15, 15, and 20 min successively, then the cycle time of the process is 80 min.

Usually a process flowchart is more complicated and is composed of a number of paths. Each of them may include different sequential, parallel activities, loops, and other possibilities. The theoretical cycle time of each path is equal to the sum of the times of the activities that form it.

A certain path of the process flowchart paths is called the critical path. The critical path represents the longest path in the process flowchart. Therefore, the theoretical cycle time of the process is actually the same as the theoretical cycle time of the critical path. Thus, all activities that construct the critical path of the process flowchart are called critical activities.

For example, Fig. 5.3 shows a process flowchart that has two paths. The length of the first path: A, B, D, F, G is 95, whereas the length of the second path A, C, E, G is 85. So the first path is the critical path of the process.

The critical path is very important because its actual cycle time defines the cycle time of the whole process. This means that any delay in any of the critical activities causes a delay in the entire process because the critical path is the longest path of the process. For this reason, management should pay special attention to the critical activities by providing them with all the needed resources and monitoring their execution very closely. On the other hand, non-critical activities are not so decisive for the process cycle time because any delay caused by a non-critical activity could be more easily made up and such a delay usually does not cause a delay in the whole process.

In cases where the process flowchart is complex and contains many paths, it is difficult to compute the longest path of the process. To solve this problem, a number of approaches were developed, one of them called the Critical Path Method, which could be used to determine the critical path of complex processes.

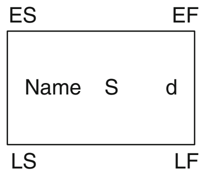


Fig. 5.4 An activity

5.2.2.1 Critical Path Method

CPM (Critical Path Method) is based on calculating a variable called the "Slack Time" of an activity. Anupindi et al. (2006) defines the slack time as: "The extent to which an activity could be delayed without affecting process flow time (cycle time)".

A critical activity is an activity whose slack time is equal to zero. Thus, the critical path consists of all those activities for which the slack time is equal to zero.

To determine the critical path, two schedules have to be calculated; the forward schedule and the backward schedule. In order to calculate these schedules, four time variables for each activity of the process must be computed. These variables are: ES, EF, LS and LF, see Fig. 5.4.

Forward Schedule. A forward Schedule is calculated starting from the first activity to the last one. This schedule calculates the earliest possible start time and the earliest possible finish time of each activity within the process. To compute the forward schedule, the variables ES and EF are calculated:

– ES (Earliest Start): means the earliest start time for an activity to begin after all its predecessor activities have been completed
  - For the first activity of the process, use the formula
    ES = 1, where 1 means 1 time unit
  - For other activities, use the formula
    ES = 1 + max(EF) ofimmediate predecessor activities.

– EF (Earliest Finish): means the earliest possible time for an activity to finish. EF is calculated using the formula
  EF = ES + d − 1, where d is duration time of the activity.

Backward Schedule. The backward Schedule is calculated in the opposite direction, is starting from the last activity to the first one. This schedule calculates the latest possible start time and the latest possible finish time for each activity of the process. To determine the backward schedule, the variables LF and LS are calculated:

– LF (Latest Finish): means the latest possible time for an activity to finish without causing a delay
  - For the last activity, use the formula
    LF = EF
  - For other activities, use the formula
    LF = min(LS) of immediate successor activities − 1

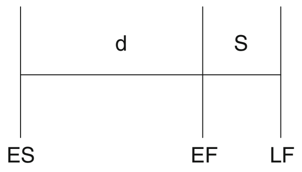


Fig. 5.5 Activity range of time

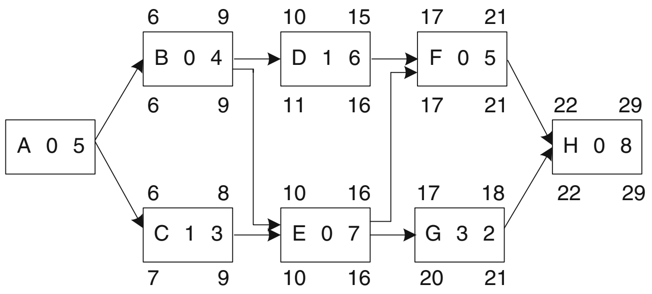


Fig. 5.6 Critical path

– LS (Latest Start): means the latest possible time for an activity to begin without causing a delay. LS is calculated using the formula
  - LS = LF − d + 1, where d is the duration time of the activity.

Slack Time. Calculating the forward and backward schedules enables us to compute the slack time (s) of each activity in the process using the following formula:

$$S = LF - EF = LS - ES$$

The slack time of an activity is the amount of time that could be spent in addition to the duration time of the activity, without causing a delay to the start times of immediate successor activities. Figure 5.5 shows the slack time and the range of time between ES and LF in which the activity should start and end.

Example. The following is an example of the process shown in Fig. 5.6 that has seven activities: A, B, C, D, E, F, G and H and five paths:
First path: A-B-D-F-H
Second path: A-B-E-F-H
Third path: A-B-E-G-H
Fourth path: A-C-E-F-H
Fifth path: A-C-E-G-H

Figure 5.6, shows an example of determining the critical path of the process by calculating the forward schedule, backward schedule, and slack time using the above given formulas. As Fig. 5.6 shows, the critical path is the second path because the slack time of the activities of this path is equal to zero.

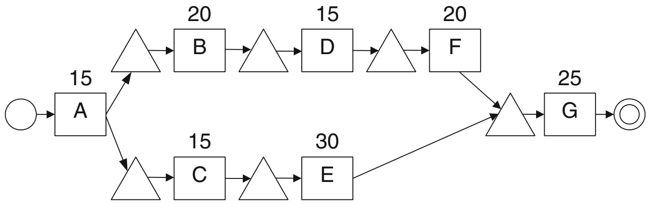


Fig. 5.7 A process flowchart with activities and buffers

5.2.3 Cycle Time Computing

To compute the cycle time of a process flow, we have to take into account that a flow unit on its journey from the beginning to the end of the process flow goes through a number of activities, as well as spending periods of waiting time in different buffers. There are a number of possibilities to compute the cycle time.

1. Computing the cycle time as the sum of the theoretical and waiting times
   In this case, the waiting times spent in buffers of the process are expected to be known. Therefore, the cycle time of a certain flow unit is:

$$\text{Cycle time} = \text{Theoretical cycle time} + \text{Waiting time}$$

   A simple three-step procedure could be used to obtain the average cycle time of a process (Anupindi et al. 2006):
   – Treat waiting in each buffer as an additional (passive) activity with an activity time equal to the amount of time in that buffer;
   – Add waiting times to the theoretical cycle time of the appropriate path;
   – Obtain the average cycle time of the process by finding the path whose overall length (activity plus waiting) is the longest.
2. Computing the cycle time using Little's law
   It is possible to use Little's law to compute the average cycle time of a process by finding the longest cycle time of the process flowchart, that is by finding the critical path of the process.
   Figure 5.7 shows an example of a process flowchart that contains two paths. Each of them consists of a number activities and buffers, where buffers are indicated by triangles. Considering Fig. 5.7, we find that the theoretical cycle time of path 1 is 95 min and the theoretical cycle time of path 2 is 85 min. Let us also assume that the following values are known:
   – Average flow rate (T) is 12.8 flow units per hour,
   – Average number of flow units (I) in buffers of path 1 is 60, and
   – Average number of flow units in buffers of path 2 is 50.
   Using Little's law enables us to calculate the waiting time spent by flow units in buffers of each path:

$$\text{Path 1}: \mathrm{T} = \mathrm{I}/\mathrm{R} = 60/12.8 = 4.687 \ \text{hours} = 281 \ \text{minutes}$$

$$\begin{aligned}\text{Cycle time} &= \text{theoretical cycle time} + \text{Waiting time}\\ &= 95 + 281 = 376 \text{ minutes}\end{aligned}$$

$$\begin{aligned}\text{Path 2: T} &= \text{I/R} = 50/12.8 = 3.906 \text{ hours} = 234 \text{ minutes}\\ \text{Cycle time} &= \text{theoretical cycle time} + \text{Waiting time}\\ &= 85 + 234 = 319 \text{ minutes}\end{aligned}$$

The longest cycle time of the paths is 376 min, which represents the average cycle time of the process flowchart.

3. Computing cycle time using value-adding and non-value-adding activities
   The activities of a process could be differentiated as value-adding and non-value-adding activities.
   Anupindi et al. (2006) gave the following definition of value-adding and non-value-adding activities:
   – Value-adding activities are those activities that increase the economic value of a flow unit because the customer values them.
   – Non-value-adding activities are activities that, while required by the firm's process, do not directly increase the value of a flow unit.

Waiting is usually considered as non-value-adding. It is then possible to compute cycle time using the following formula:

$$\text{Cycle time} = \text{Value-adding cycle time} + \text{Non-value-adding cycle time}$$

5.2.4 Rework

A process flowchart may contain one or more segments of a number of sequential activities, whose execution needs to be repeated several times, depending on a decision activity, where the value of a certain condition is defined. This is usually known as a rework or execution loop. Each repetition of a rework loop is called a visit.

In cases of an inspection condition, the activities of the loop are not repeated the same number of times for each flow unit. Therefore, the average number of visits over all flow units is less than one. In such cases, the work content is calculated instead of the activity time.

The work content of an the activity is the activity time multiplied by the average number of visits at that activity (Anupindi et al. 2006). The work content enables us to calculate a more precise estimation of the theoretical cycle time, in order to compute the critical path of the process.

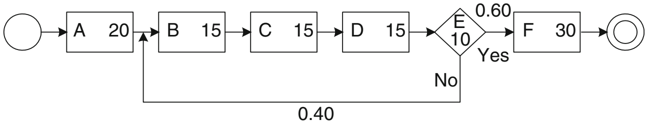


Fig. 5.8 Rework loop

The work content is used for computing the average cycle time of the process flowchart given in Fig. 5.8 as follow:

$$T = 20 + 1.40^{*}(15 + 15 + 15 + 10) + 30 = 127 \text{ minutes}$$

The work content can be computed using the following formula, which assumes that the rework is repeated only once.

$$W = (1 + r)^{*}L$$

Where W is the work content of the loop, r is the percentage of repetition of the work loop, and L is the sum of the times of the loop activities.

Using this formula to compute the work content in our example given in Fig. 5.8 yields:

$$W = (1 + 0.40) * 55 = 77$$

The average cycle time of the process is:

$$T = 20 + 77 + 30 = 127 \text{ minutes}$$

There is another formula that can be used regardless of the number of times that the flow unit goes through the loop. This formula is:

$$W = L/(1 - r)$$

In our example, rework time is:

$$W = 55/0.60 = 91.66$$

The average cycle time of the process is:

$$T = 20 + 91.66 + 30 = 141.66$$

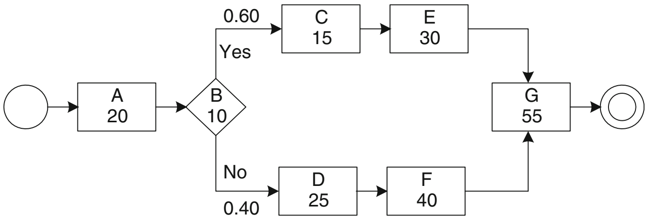


Fig. 5.9 A process flowchart with multiple paths

5.2.5 Multiple Paths

There are a number of cases in a process flowchart where after a decision activity the process flow splits into two or more paths. The following general formula can be used to compute the average cycle time for a process flow that splits into multiple paths after a decision activity:

$$T = p_1{}^* \ T_1 + p_2{}^* \ T_2 + \ldots + p_m{}^* \ T_m$$

where p_i is the probability of following the flow of path i, T_i is the sum of times of activities within path i, and m is the number of paths.

Consider Fig. 5.9 that shows an example of a process flowchart, which splits into two paths after decision activity B.

The average cycle time of the process:

$$T = 20 + 10 + 0.60\ ^* \ (15 + 30) + 0.40\ ^*(25 + 40) + 55 = 138 \text{ minutes}$$

5.2.6 Parallel Paths

There are also cases where the process flowchart may contain one or more segments that are constructed from parallel activities. This happens when the output of a certain activity is needed as the input for a number of successor activities in different parallel paths.

The cycle time of the part of the process with parallel paths is represented by the maximum sum of times of activities in the parallel paths. This sum can be computed using the following formula:

$$T = \max(T_1,\ T_2, \ldots,\ T_m)$$

where T_i is the sum of times of activities within path i and m is the number of paths.

Using this above given formula to calculate the average cycle time of the process shown in Fig. 5.10 that contains parallel paths yields:

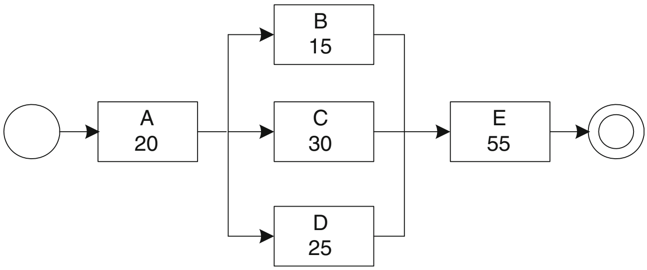


Fig. 5.10 A process flowchart with parallel paths

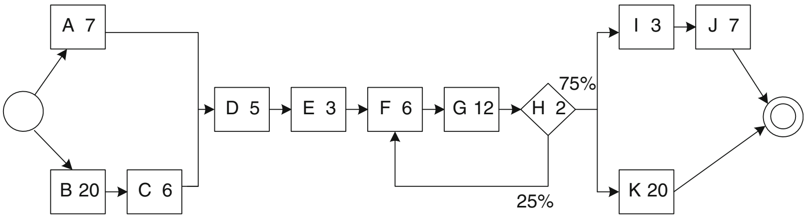


Fig. 5.11 Cycle-time efficiency (Source: Adapted from Anupindi et al. 2006)

Maximum cycle time of paths:

$$T = \max(15,\ 30,\ 25) = 30 \text{ minutes}$$

The average cycle time of the process:

$$T = 20 + 30 + 55 = 105 \text{ minutes}$$

5.2.7 Cycle-Time Efficiency

Cycle-time efficiency can be obtained by dividing the theoretical cycle time by the average cycle time of the process. Therefore, the cycle-time efficiency is the ratio between the theoretical cycle time and the average cycle time.

As discussed before, the average cycle time also includes the waiting time in the process flow.

$$\text{Cycle-time efficiency} = \text{Theoretical cycle time}/\text{Average Cycle Time}$$

Let us at the end of the current section compute the cycle-time of the processes given in Figs. 5.11 and 5.12 using two approaches.

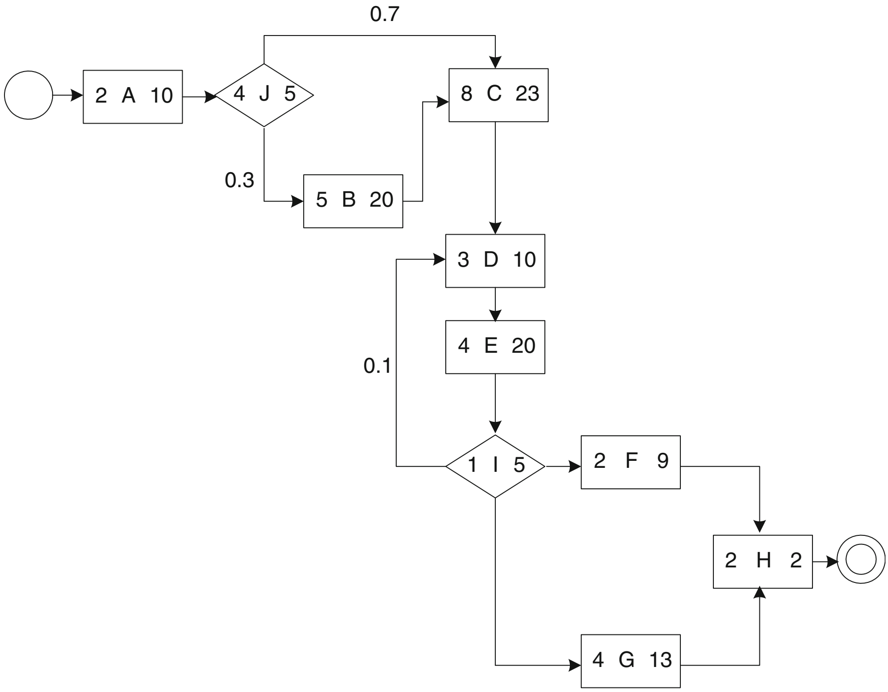


Fig. 5.12 Cycle-time efficiency (Source: Adapted from Laguna and Marklund)

Figure 5.11 shows that the process has four paths, as follows:

$$\text{Path 1}: \text{ A, D, E, F, G, H, I, J}$$
$$T = 7 + 5 + 3 + 1.25 * (6 + 12 + 2) + 3 + 7 = 50$$

$$\text{Path 2}: \text{ A, D, E, F, G, H, K}$$
$$T = 7 + 5 + 3 + 1.25 * (6 + 12 + 2) + 20 = 60$$

$$\text{Path 3}: \text{ B, C, D, E, F, G, H, I, J}$$
$$T = 20 + 6 + 5 + 3 + 1.25 * (6 + 12 + 2) + 3 + 7 = 69$$

$$\text{Path 4}: \text{ B, C, D, E, F, G, H, K}$$
$$T = 20 + 6 + 5 + 3 + 1.25 * (6 + 12 + 2) + 20 = 79$$

From this analysis we may conclude that path 4 is the critical path, which represents the theoretical cycle time of the process as 79 min.

Let us assume that the actual average cycle time is 154 min including waiting time. The cycle-time efficiency is:

$$\text{Cycle-time efficiency} = 79/154 = 51\%$$

Figure 5.12 shows a process flowchart. For each activity of the flowchart, the processing time is shown on the left side of the activity name and the actual activity time is on the right side. The average cycle time of the process is:

$$\mathrm{T} = 10 + 5 + 0.3 * 20 + 23 + 1.1 * (10 + 20 + 5) + \max(9,\ 13) + 2 = 97.5$$

The theoretical time of the process is:

$$\mathrm{T} = 2 + 4 + 0.3 * 5 + 8 + 1.1 * (3 + 4 + 1) + \max(2,\ 4) + 2 = 30.3$$

$$\text{Cycle time efficiency} = 30.3/97.5 = 31\%$$

5.3 Process Capacity

In order to explain the process capacity, let us first recall the definition of the average flow rate in a stable process given in Sect. 5.1. The average flow rate or throughput is defined as the average number of flow units or jobs that flow through the process per unit of time.

The definition of the process capacity given by Anupindi et al. (2006) is: "The process capacity is the maximum sustainable flow rate of a process".

From both definitions introduced it is obvious that the throughput and process capacity are essential tools to measure process performance, which is one of the important factors that leads a company to make a decision concerning improvement of their business processes.

The capacity of a process is closely related to the process resources, which play a very important role in determining whether the process capacity is as it should be. For this reason, the current section tries to explore the meaning and role of resources in process functioning.

5.3.1 Resources

The capacity of a process depends on the resources (capital and labor) that are used in the process, because the resources are essential for performing the process activities. Moreover, every activity actually depends on the availability and ability of the resources required for its execution.

It is important to emphasize that the resources of the process, not only the activities, are those that need deep analysis and consideration when deciding about process improvement. For this reason, process modelers, improvement teams, and process owners and managers should consider carefully and pay maximum attention to the problem of resource availability.

It is known that performing any activity requires one or more resources and it is also true that every resource may be involved in performing one or more activities.

A group of resources, which are involved in carrying out similar kinds of activities is called a resource pool. Anupindi et al. (2006) defines a resource pool as: "A collection of interchangeable resources that can perform an identical set of activities".

Any resource is actually a member of a pool and therefore is called a unit of the resource pool. For example, in the process of "Sales_Claim", the claim clerks form a resource pool that deals with solving sales claims and each of them represents a resource unit in this resource pool.

In reality, there are a number of resource pools in an organization that are involved in performing different activities of a process. Combining resource pools into a single pool is called resource pooling. Thus, resource pooling means associating different resource pools into a joint resource pool in order to carry out a set of activities within a process.

As was mentioned above, performing an activity may involve different resources and also a resource may be involved in processing a number of activities. Therefore, the sum of the working times that the resource spends in performing a number of activities concerning a flow unit that goes through the process is called the unit load of a resource.

The unit load of a resource unit is the total amount of time the resource works to process each flow unit (Anupindi et al. 2006). Notation T_p is used to indicate the unit load of a resource unit in a resource pool p.

For example, let us assume that if the resource Claim clerk needs 15 min for registering a claim note and 45 min to collect the claim documentation, then the unit load T_p of the Claim clerk is 60 min per sales claim.

Fig. 5.13 shows the work content for resource units that perform some activities within a process that deals with sales claims in a large trading company. The table shows only five activities performed by three resources. Let us assume that the activities have the listed work contents given in the last column.

The following Fig. 5.14 shows the resource unit loads needed to perform the activities of the sales claim process listed in the Fig. 5.13.

Fig. 5.13 shows that the resource Sales claim clerk performs three activities with work contents of 60, 30 and 30 min successively for each claim. The sum of these work contents is 120 min, which represents the unit load of the Sales claim clerk, see 5.14. Meanwhile, both the resources Sales clerk and the Warehouse claim clerk perform one activity and therefore the given work content in Fig. 5.13 is also their unit load.

Activity	Resource	Short Description	Work Content (Minutes per claim)
Collect claim docs	Sales claim clerk	Sales claim clerk collects claim docs	60 min
Send claim docs	Sales claim clerk	Sales claim clerk sends claim docs to Sales clerk	30 min
Determine claim solution	Sales clerk	Sales clerk analyzes claim docs and determines solution path	60 min
Start claim solution path	Sales claim clerk	Sales claim clerk starts one of four claim solution paths	30 min
Analyze products quantity	Warehouse claim clerk	Warehouse claim clerk analyzes ordered and shipped products quantity	90 min

Fig. 5.13 Work content

Resource	Unit Load (Minutes per claim)
Sales claim clerk	120 min
Sales clerk	60 min
Warehouse claim clerk	90 min

Fig. 5.14 Resource unit loads

5.3.2 Theoretical Capacity

As was stated before, the availability of resources is an essential factor that impacts the capacity of the process. On the other hand, resources in reality are not available the whole time for processing activities because in addition to the processing time, there are also the waiting, idle, and other period of times when the resources are unavailable.

Anupindi et al. (2006) defined the theoretical capacity of a resource unit as: "Its maximum sustainable flow rate if it were fully utilized (without interruptions, downtime, times wasted to setups, idle periods, and so on)".

The authors extended this definition to define the theoretical capacity of a resource pool as: "The sum of theoretical capacities of all resource units in that pool".

The flow unit on its way through different activities is processed by a number of resource pools. Each of these resource pools has a determined capacity, which could be differentiated from the capacities of other resource pools.

Determining the capacity of each resource pool leads us to identify the resource pool with the lowest capacity. This resource pool is called the bottleneck of the process, which in fact determines the capacity of the whole process.

In addition to the bottleneck resource pool, Anupindi et al. (2006) defined the theoretical bottleneck resource pool and the theoretical capacity of the process as follows:

- The bottleneck resource pool is the slowest resource pool in the process.
- The theoretical bottleneck resource pool is a resource pool with the minimum theoretical capacity.
- The theoretical capacity of a process is the theoretical capacity of the theoretical bottleneck.

From these definitions we may conclude that the capacity of a process cannot be better than the process's bottleneck resource pool. This fact means that the bottleneck resource pool is the key element to which the improvement teams should pay maximum attention in order to achieve the desired improvement of the process.

To compute the value of the theoretical capacity of a resource pool, we need information about the unit loads of the resources and their number within the resource pool.

Therefore, let us assume that we have a resource pool p with 1 resource unit. The theoretical capacity of the resource unit, which in this case is also the theoretical capacity of the resource pool, is:

$$R_p = 1/T_p$$

where R_p is theoretical capacity of a resource pool and T_p is the unit load of the resource unit.

A resource pool may have a number of resource units. If all the resource units in a resource pool are identical, then the following formula can be used:

$$R_p = c_p/T_p$$

where c_p is the number of resource units in the resource pool p.

In the case that the resource units in a certain resource pool are not identical regarding the theoretical capacity achieved by each of them, then the theoretical capacity of this resource pool is computed as the sum of all the theoretical capacities of its resource units. Table 4.3 shows examples of computing the theoretical capacity of a resource unit, a resource pool, and a bottleneck.

The above shown formulas for computing the theoretical capacity of a resource pool are based on the following two premises:

– The flow units are performed by resource units sequentially one by one
– The resource units are available the same quantity of time.

These premises are usually not valid in reality. For this reason, other factors that affect the theoretical capacity need to be discussed such as load batching and scheduled availability.

Load Batching. Load batching means the ability of a resource unit to process a number of flow units simultaneously. For example, a waiter serves several customers at the same time or a lecturer lectures to a group of students simultaneously.

Scheduled Availability. Usually resources carry out their work in accordance with a scheduled work time. For example, 5 days a week and 8 h per day from 9 am to 5 pm. The quantity of time in which a resource unit is scheduled to perform a determined work is called the scheduled availability of the resource unit.

Resource Pool (p)	Unit Load (Minutes per claim)	Number of Units in Resource Pool (c_p)	Scheduled Availability (minutes per day)	Theoretical Capacity of a Resource Pool (claims per day) (R_p)	Theoretical Capacity of a Resource Unit (claims per day)
Sales claim clerk	120 min	4	450	4/120*1*450 = 15	15/4 = 3.75
Sales clerk	60 min	1	240	1/60*1*240 = 4	4
Warehouse claim clerk	90 min	2	240	2/90*1*240 = 5	5/2 = 2.5

Fig. 5.15 Theoretical capacity

Because different resources may have different working schedules, which may include shift work or a different number of hours per day, the scheduled availability should be calculated in hours per week.

Load batching and scheduled availability are important factors that have a real effect on the theoretical capacity of the process. Thus, these factors should be taken into the account when calculating the theoretical capacity. For this purpose, the following two general formulas are used:

$$R_p = 1/T_p{}^{*} \text{ Load Batch } {}^{*} \text{ Scheduled Availability}$$
$$R_p = c_p/T_p{}^{*} \text{ Load Batch } {}^{*} \text{ Scheduled Availability}$$

The first formula is used to compute the theoretical capacity of a resource pool with one resource and the second is used to compute the theoretical capacity of resource pool p with c_p resources.

For example, assume that a coffee bar has two waiters, who work 6 h per day; a customer is served in 10 min, and the waiter may carry drinks for four customers simultaneously (four customers around a table). So, the following data is available:

$$\begin{aligned} \text{Number of resource units } c_p &= 2 \text{ waiters} \\ \text{Unit load } T_p &= 10 \text{ minutes} \\ \text{Load batch} &= 4 \text{ customers} \\ \text{Scheduled availability} &= 6 * 60 = 360 \text{ minutes} \end{aligned}$$

$$\begin{aligned} R_p &= c_p/T_p{}^{*} \text{ Load Batch } {}^{*} \text{ Scheduled Availability} \\ &= 2/10 {}^{*} 4 {}^{*} 360 = 288 \text{ customers per day} \end{aligned}$$

Fig. 5.15 continues with the example of sales claims shown in Figs. 5.13 and 5.14 by calculating the theoretical capacity of a resource unit and the theoretical capacity of a resource pool.

Fig. 5.16 Capacity utilization

Resource Pool (p)	Theoretical Capacity of Resource Pool (claims per day) (R_p)	Capacity Utilization (ρ_p=R/R_p)
Sales claim clerk	15	3/15 = 20%
Sales clerk	4	3/4 = 75%
Warehouse claim clerk	5	3/5= 60%

The results given in the column of theoretical capacity of the resource pool (R_p) of Fig. 5.15 show that Sales clerk is the theoretical bottleneck resource pool because it is the resource pool with the minimum theoretical capacity, which is also the theoretical capacity of the process.

5.3.3 Capacity Utilization

Throughput and theoretical capacity are used to measure the number of flow units that go through the process. Let us remember again the following definitions:

– The throughput or flow rate is the number of flow units that flow through a specific point in the process per unit of time;
– The theoretical capacity of a resource unit is the maximum sustainable flow rate if the resource is fully utilized; and
– The theoretical capacity of a resource pool is the sum of theoretical capacities of all resource units in that pool.

Considering both measures, throughput and theoretical capacity, leads us to the conclusion that it is rare in reality that the theoretical capacity equals the throughput of a process. This is due to both internal and external reasons. Internal ones are caused by problems that result in resource unavailability and idleness, whereas external reasons are caused by problems such as a low outflow rate or low inflow rate because of low demand rate in the market or problems with supply rate.

Capacity utilization is defined for each resource pool. Capacity utilization of the process is defined as the capacity utilization of the bottleneck resource pool (Anupindi et al. 2006).

Capacity utilization of a resource pool is denoted by ρ_p. Capacity utilization of a resource pool can be calculated using the following formula:

$$\rho_p = R/R_p$$

Where, as was denoted before, R is throughput and R_p is the theoretical capacity of a resource pool.

Capacity utilization measures the degree to which resources are effectively utilized by a process. Capacity utilization indicates the extent to which resources, which represent invested capital, are utilized to generate outputs (flow units and ultimately profits) (Anupindi et al. 2006).

Fig. 5.15 shows that the theoretical capacity of the process is 4. Furthermore, we know that the theoretical capacity is usually less than the throughput of a process. Therefore, let us assume that the average number of claims processed is 3 per day, which means that the throughput is three claims per day. In addition to this, using the values of the theoretical capacity of the resource pools presented in Fig. 5.15 enables us to calculate the capacity utilization of the resource pools, as shown in Fig. 5.16.

Fig. 5.16 shows that the theoretical capacity of the process is four sales claims per day and the capacity utilization of the whole process of sales claim is 75 %. This is because the capacity utilization of the process is actually the capacity utilization of the bottleneck resource pool.

To improve the theoretical capacity, Anupindi et al. (2006) suggests the following measures:

(a) Decrease the unit load on the bottleneck resource pool (work faster, work smarter).
(b) Increase the load batch of resources in the bottleneck resource pool (increase the scale of the resource).
(c) Increase the number of units in the bottleneck resource pool (increase the scale of the process).
(d) Increase the scheduled availability of the bottleneck resource pool (work longer).

References

Anupindi, R., Chopra, S., Deshmukh, D. S., Van Mieghem, A. J., & Zemel, E. (2006). *Management business process flows: Principles of operations management*. Upper Saddle River: Pearson Education.

Laguna, M., & Marklund, J. (2005). *Business process modeling, simulation, and design*. Upper Saddle River: Pearson Prentice Hall.

Little, J. D. C. (1961). A proof of queuing formula L=λW. *Operations Research, 9*, 383–387.

Knowledge Management

6

Goals. In this chapter the following questions and themes are explored:

– Introducing knowledge management and its meaning
– Introducing knowledge management models, particularly the Nonaka and Tekeuchi model
– Explaining the knowledge management cycle
– Eliciting and capturing knowledge from knowledgeable employees
– Sharing and disseminating knowledge within an organization
– Acquisition and implementing knowledge
– Using captured or created knowledge in improving the organization's functioning

6.1 What is Knowledge Management

In recent years knowledge management became a very important factor for identifying, capturing, and finally applying the knowledge that is accumulated by knowledgeable employees in order to preserve and create the organization's knowledge base. Spreading this knowledge within the framework of the organization and its use by employees contributes a great deal in improving its functioning, which consequently leads to creating a competitive and successful organization.

Considering the use of knowledge management concepts is essential for an organization's functioning because implementing such a system helps the organization in identifying, eliciting, and storing the knowledge of its experienced employees that is created as a result of long term experience. This enables the organization to preserve and update its knowledge and prevent its loss when employees leave the organization or go into retirement.

Therefore, using knowledge management concepts is very important for capturing the knowledge from internal sources within the borders of the system or from

N. Damij and T. Damij, *Process Management*, Progress in IS,
DOI 10.1007/978-3-642-36639-0_6,

external sources in the system's environment. In addition, it is also important for creating the knowledge necessary to carry out business process management that brings quality and effectiveness to the functioning of the organization. For this reason, Chap. 11 introduces a procedure, which enables implementation of the ideas of knowledge management concepts within the business process improvement approach.

In order to clarify what knowledge management is, some important thoughts of well-known researchers in this field are listed in the following paragraphs.

Initially knowledge management was defined by Nonaka and Takeuchi (1995) and others as: "A process of applying a systematic approach to the capture, structure, management, and dissemination of knowledge throughout an organization in order to work faster, reuse best practices, and reduce costly rework from project to project".

Dalkir (2005) considered that knowledge management solutions have proven to be most successful in the capture, storage, and subsequent dissemination of knowledge that has been rendered explicit – particularly lessons learned and best practices.

Bontis and Nikitopoulos (2001) described intellectual capital or assets as: "Those pieces of knowledge that are of business value to the organization".

Klein (1998) and Stewart (1997) stated that although some of the intellectual assets are more visible (e.g. patents), the majority consist of know-how, know-why, experience, and expertise that tend to reside within the mind(s) of one or a few employees.

Dalkir (2005) wrote that a good definition of knowledge management should incorporate both the capture and the storage of the knowledge, together with the evaluation of intellectual assets and gave an example of such a definition as follows: "Knowledge management is the deliberate and systematic coordination of an organization's people, technology, processes, and organizational structure in order to add value through reuse and innovation. This coordination is achieved through creating, sharing, and applying knowledge, as well as through feeding the valuable lesson learned and best practices into corporate memory in order to foster continued organizational learning".

It is recognized that the most important intellectual assets that an organization may have is the knowledge of its experienced employees. This knowledge should be captured, stored and applied in order to enable the organization to use it and also to prevent it being lost.

Stewart (1997) mentioned that the best way to retain valuable knowledge is to identify intellectual assets and then to ensure that legacy materials are produced and subsequently stored in such a way as to make their future retrieval and reuse as easy as possible.

Knowledge management deals with firstly identifying and capturing knowledge at individual employee, group of employees, and organizational levels and secondly, applying the knowledge captured at these three levels by development a system that provides it and requires its use.

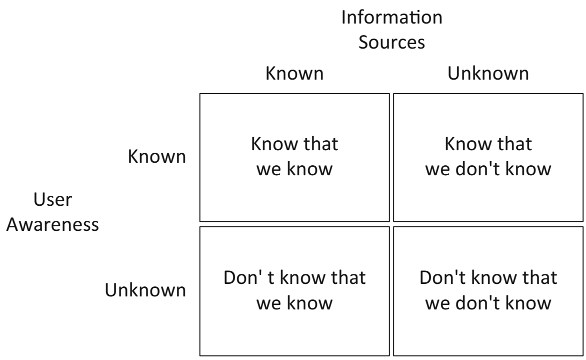


Fig. 6.1 Known-unknown matrix (Source: Frappoalo 2004)

Nickols (2000) determined the purpose of knowledge management as: "The basic aim of knowledge management is to leverage knowledge to the organization's advantage".

Dalkir (2005) defined four knowledge management objectives as follows:

– Facilitate a smooth transition from those retiring to their successors who are recruited to fill their positions;
– Minimize loss of corporate memory due to attrition and retirement;
– Identify critical resources and critical areas of knowledge so that the corporation knows what it knows;
– Build up a toolkit of methods that can be used with individuals, with groups, and with the organization to stem the potential loss of intellectual capital.

To achieve these goals the management needs to identify and capture the knowledge existing at all three above mentioned levels, that is at individual, group, and organization level.

Dalkir (2005) defined knowledge as: "Subjective and valuable information that has been validated and that has been organized into a model (mental model); used to make sense of our world; typically originating from accumulated experience; incorporating perceptions, beliefs, and values".

Frappoalo (2004) published a matrix, called the Known-Unknown matrix, which should be considered by the management of any organization carefully in order to learn and discover which kinds of knowledge exist within their organization.

As Fig. 6.1 shows, the Known-Unknown matrix is structured from two columns and two rows. The columns represent known and unknown information sources and the rows represent known and unknown user awareness. In the following, the matrix content is described shortly.

– The first row contains information about what knowledge the organization knows and also what knowledge they do not know:
  • Know that we know: The management knows that there are knowledge sources within the organization that contain important knowledge about a particular working area that needs to be captured and applied;
  • Know that we don't know: The management knows that the organization doesn't possess certain knowledge and therefore such new knowledge should be created as an innovation in this area;

- The second row contains information about what knowledge the organization does have but does not know about, and also what knowledge it does not have and does not know that:
  - Don't know that we know: The management does not know that there is within the organization undiscovered knowledge that is held in the minds of knowledgeable employees, which should be captured using special techniques in order to apply and use it.
  - Don't know that we don't know: The management thinks it knows everything about its specialty but it doesn't know that there is knowledge it doesn't know about, which may be held by competitors.

The Known-Unknown matrix is considered as an excellent tool of knowledge management that could be used to identify and capture the knowledge that exists within the framework of an organization, and also the knowledge that should be created.

6.2 Knowledge Management Models

There are a number of well-known knowledge management models, such as those of Nonaka and Takeuchi (1995); Wiig (1993); von Krogh and Roos (1995); Choo (1998); Boisot (1998); Weick (2001); Bennet and Bennet (2004), which were developed with the purpose of providing a theoretical foundation for the field of knowledge management.

In this section, the knowledge management model developed by Nonaka and Tekeuchi is introduced briefly. The authors analyzed the reasons for the business success achieved by Japanese companies worldwide. They found that the basis for such successful achievements is gained by identifying and using the knowledge of individual employees involved in daily work within these companies, which consequently lead to implementing into practice new ideas, discoveries, and innovations.

Nonaka and Takeuchi (1995) argue that a key factor behind the Japanese enterprises' successful track record lies in innovation stemming from the more tacit-driven approach to knowledge management.

Tacit knowledge is as yet unidentified knowledge, which has been developed during a long period in the working experience of individuals, and is therefore hidden in the minds of these individuals. For this reason, it is difficult to write down, articulate, or store such knowledge.

On the contrary, explicit knowledge is articulated and well defined knowledge that exists in the organization's documents and is stored on different types of media and practiced in daily working procedures.

Nonaka and Tekeuchi's knowledge model, called the knowledge spiral model, is based on four types of knowledge conversion, as is shown in Fig. 6.2. These knowledge conversion types are:

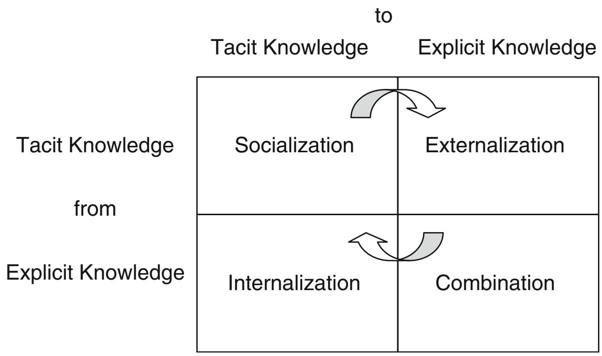


Fig. 6.2 Nonaka and Tekeuchi model (Source: Nonaka and Tekeuchi 1995)

- Socialization: a process of conversion from tacit knowledge to tacit knowledge;
- Externalization: a process of conversion from tacit knowledge to explicit knowledge;
- Combination: a process of conversion from explicit knowledge to explicit knowledge; and
- Internalization: a process of conversion from explicit knowledge to tacit knowledge.

1. Socialization

Socialization (tacit to tacit knowledge) is a type of conversion of knowledge elicited from knowers to other individuals and groups, or the exchange and sharing of knowledge between individuals and groups when they meet unofficially or socially and start discussing different working problems and their solutions.

The advantage of socialization is that it represents the easiest and also the cheapest way of transferring knowledge between individual professionals and groups. An example of socialization is the exchange of ideas and solutions for different programming problems that face programmers, which usually happen in unofficial meeting, coffee and lunch breaks, social events, or through the internet.

However, a lack of socialization means that the sharing of knowledge is very limited because the group of experts that exchange knowledge between themselves still represents only a very small number of employees compared to the whole organization. Therefore, such knowledge remains tacit because it is not written down, put into a certain form, or stored in the database of the organization in order to enable the management to provide the tools needed for sharing and disseminating it at organizational level.

Thus, from the above given explanation, we may conclude that socialization represents a type of knowledge conversion that actually means exchanging experiences and skills between experts in the same field as a consequence of long periods of work practice, which are to be considered as lessons learned.

2. Externalization

Externalization (tacit to explicit knowledge) is a kind of conversion of the knowledge held by the knowledgeable into well-defined and articulated forms of explicit knowledge. Externalization is a process that helps the organization to translate tacit and undiscovered knowledge into explicit knowledge that is written down or stored on some kinds of media.

Externalization of knowledge is defined by Nonaka and Takeuchi (1995) as: "A quintessential knowledge creation process in that tacit knowledge becomes explicit, taking the shapes of metaphors, analogies, concepts, hypotheses, or models".

The purpose of transferring knowledge from tacit to explicit is that the organization discovers the knowledge that exists within its boundaries; this is the knowledge contained in the heads of its employees, in order to make possible the sharing and dissemination of this knowledge between employees at the organizational level.

Externalization is an iterative process that enables the organization to discover new knowledge continuously, and this plays an important role in updating the organization's knowledge base.

3. Combination

Combination (explicit to explicit knowledge) is a type of knowledge conversion that enables the organization to add newly obtained explicit knowledge gained by externalization and provides the possibility for updating the stored and shared explicit knowledge already in the organization's corporate memory.

This means that formation of new explicit knowledge is a continuous process and the newly created explicit knowledge should be integrated within the existing organization's memory by updating the already stored knowledge to make it available for use and sharing by employees. Such knowledge is also an important source for generating different analyses or reports that are required and needed for decision making.

4. Internalization

Internalization (explicit to tacit knowledge) is a type of conversion of new explicit knowledge gained from the previous stage of externalization into tacit knowledge. This happens after the new explicit knowledge is implemented, shared, and put to use on a daily basis. The employees of the organization after a certain period of time gain again enough experience to enable them to develop new tacit knowledge about better ways of performing the work they are responsible for.

The process of internalization enables employees through carrying out their duties and practicing their daily work to develop new ideas, lessons learned, and best practices, which become new individual knowledge held by these people and therefore represents new tacit knowledge.

In addition to capturing knowledge from sources within the organization, knowledge should also be created using other sources in order to preserve the company's position relative to its competitors.

The process of knowledge creation in general is a continuous and iterative process of converting knowledge between tacit and explicit. When a certain iteration finishes, a new one starts. For this reason, the knowledge creation process

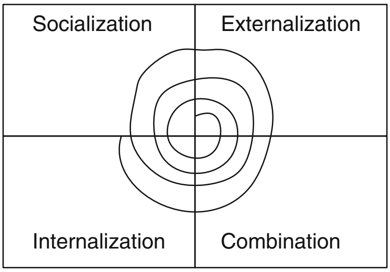


Fig. 6.3 Knowledge spiral (Source: Nonaka and Tekeuchi 1995)

could be presented as a spiral process, which flows from tacit knowledge to explicit and again to tacit, see Fig. 6.3.

Nonaka and Takeuchi (1995) stated that “In order for organizational knowledge creation to take place, however, the entire conversion process has to begin all over again: the tacit knowledge accumulated at the individual level needs to be socialized with other organizational members, thereby starting a new spiral of knowledge creation”.

6.3 Knowledge Management Cycle

The knowledge management cycle is an approach that indicates the path of knowledge from its identification to implementation in practice. The knowledge management cycle consists of a number of activities or processes, such as knowledge identification, capture, creation, codification, sharing, and implementation.

The knowledge management cycle starts by identifying knowledge sources and continues by identifying and capturing the knowledge from these sources. These stages are followed by codification of knowledge, which means transferring the knowledge from tacit to explicit with the purpose of sharing it between employees in accordance with their specializations. The next stage deals with bringing the knowledge to the organizational level by storing it in the organization’s repository, called the “corporate memory”.

There are a number of approaches to the knowledge cycle described in the literature by different authors, for example Wiig (1993); Mayer and Zack (1996); Bukowitz and Williams (2000); McElroy (1999).

In this section, an approach called “An integrated knowledge management cycle” is introduced; see Fig. 6.4. This knowledge management cycle consists of three phases:

- Knowledge capture and/or creation,
- Knowledge sharing and dissemination, and
- Knowledge acquisition and application.

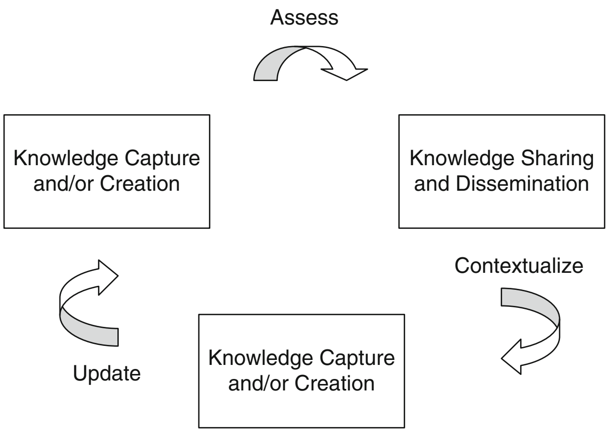


Fig. 6.4 Integrated knowledge management cycle (Source: Dalkir 2005)

6.3.1 Knowledge Capture and/or Creation

The first phase of the knowledge management cycle deals with identifying the knowledge existing within the boundary of an organization, which may have essential meaning for carrying out the necessary changes and improvements in its business processes. Discovering such hidden knowledge may lead to substantial changes in the organizational structure and functioning.

The way for a company to join the ranks of successful companies lies in the capability of the organization to target and discover the knowledge that is contained within its boundary and to manage it effectively. For this purpose, a knowledge management system should be developed, which could enable the company to use the knowledge discovered efficiently by storing, applying, and updating it continuously.

Such a knowledge management system is based on the development of a knowledge base, whose content represents key factors of the organization's competitive advantages and therefore must be stored, shared between employees, and also secured carefully and responsibly.

A knowledge base is the fundamental body of knowledge available to an organization, including the knowledge in people's heads, supported by the organization's collections of information and data (Dalkir 2005).

In addition to this, every organization has some kind of memory, which was developed within the certain period of time since the organization started its business history of functioning. Walsh and Ungson (1991) wrote that "The embodiment of the organizational memory is the experience of its employees, combined with the tangible data and knowledge stores in the organization".

As was mentioned before, there are actually two types of knowledge: explicit and tacit and the company in its daily functioning needs to identify, define and implement both of them.

As already stated, explicit knowledge is articulated and well defined knowledge that exists in the organization's documents stored in certain media. Therefore, concerning the functioning of the organization, there are different documented descriptions of regulations, processes, activities, procedures, and so on that represent the explicit knowledge existing within the organization.

For this reason, it is relatively easy to identify, describe, and model explicit knowledge and also there are a number of effective techniques and tools that could be used for this purpose. In fact, the majority of companies and organizations, if not all, have already identified and used their explicit knowledge through development of various different developed information systems.

Wikipedia offers an interesting definition and description of what explicit knowledge is, as follows: "Knowledge that has been or can be articulated, codified, and stored in certain media. It can be readily transformed to others. The information contained in encyclopedias (including Wikipedia), are good examples of explicit knowledge" (www.wikipedia.org).

However, it is important to realize that the explicit knowledge contained within the information system of the organization in fact represents only a small part of the total knowledge existing within the framework of the whole organization.

Dalkir (2005) stated that "Traditional information system departments deal primarily with highly structured (record or form-oriented) data that makes up much less than 5 % of a company's information". This is a very revealing estimate, which shows that how much knowledge is still unused and which the company needs to identify, capture, and implement.

On the other hand, tacit knowledge is the kind of knowledge that has been developed over a long period of experience of individual employees and therefore is held by these individuals. This kind of knowledge enables these employees to be more productive and effective compared to others because they possess unidentified hidden knowledge, which represents their advantage against other employees. In addition, such knowledge is difficult to elicit, write down, or store.

The sources of tacit knowledge are mainly employees with a long experience in practicing their work, performing a set of tasks within a process or processes, which consequently results in creating conclusions, new ideas, lessons learned, and best practices about the optimum ways of conducting their job.

Lessons learned are actually better solutions or short cuts for accomplishing jobs, which have been developed by individuals or a group of employees usually over a long period of time in practicing their jobs. For this reason, such experienced employees usually find it very difficult to describe in detail their jobs or work when they interviewed by analysts. In accordance with this fact, Polanyi (1966) said "We know more than we can tell".

Wikipedia gives a clear definition of tacit knowledge as: "Knowledge that is difficult to transfer to another person by means of writing it down or verbalizing it" (www.wikipedia.org, 2011)

Polanyi defined tacit knowledge as: "Tacit knowledge comprises a range of conceptual and sensory information and images that can be brought to bear in an attempt to make sense of something" (Smith 2003).

Dalkir (2005) differentiates between the two types of knowledge as follows: tacit knowledge is difficult to articulate and also difficult to put into words, text, or drawings. In contrast, explicit knowledge represents content that has been captured in some tangible form such as words, audio recordings, or images.

The identification and capture of the tacit knowledge is a very difficult task and depends on the capability of the knowledge management team to find innovative ways and new approaches to elicit the knowledge from its owners, who have problems in describing it.

There are several tacit knowledge capture techniques, such as interviews with experts, questionnaires, surveys, observation, and simulation. The listed techniques for tacit knowledge capture are in fact known and have their origin in the field of artificial intelligence and expert systems development.

Organizing interviews with experts is probably the most important technique that is used widely and effectively. The result of using this technique depends on the ability of the knowledge management team to find proper ways to identify, elicit, and capture tacit knowledge from an individual or group of experts about their expertise.

Obtaining knowledge from knowledgeable people is called knowledge elicitation, which is defined by Dalkir (2005) as: "The process of interacting with experts using techniques to stimulate the articulation of the expertise to convert tacit knowledge into explicit knowledge".

After eliciting tacit knowledge from its owners, it is then articulated and transformed into explicit knowledge, which is presented in a certain form. This approach is called codification of knowledge.

Codification of knowledge is thus the next step to the knowledge capture step. The codification of knowledge provides transformation of knowledge into different explicit forms, such as documents or other forms, which could be shared between groups of employees, depending on their specialization. In such a way the tacit knowledge possessed by individuals within an organization becomes part of the organization's corporate memory.

Codification of knowledge is a process of producing knowledge or an intellectual artifact – anything that allows knowledge to be communicated independently of its holder (e.g., a document, a picture, a sound recording, a film, or a video) (Dalkir 2005).

After knowledge is captured from its sources or new knowledge is created by a knowledge management team, the knowledge gained is assessed in order to evaluate if it adds new value to the organization before it is transferred into the second phase of the knowledge management cycle.

6.3.2 Knowledge Sharing and Dissemination

The purpose of the capture, creation, and codification of knowledge is to share the knowledge that is otherwise hidden in the head of an individual or group of employees. As was mentioned before, possessing knowledge means an important advantage for its owner (individual or group) compared to other employees. After codification of this knowledge, the organization continues the process by sharing and disseminating it between employees at organizational level, which means gaining an important advantage compared to other organizations, or at least attaining the level of its competitors.

The knowledge sharing and dissemination phase is actually carried out within an organization in various ways, such as by interactions between members of a group or groups, using communication possibilities, and integrating the new knowledge into the organization's business processes.

Interactions between members of a group represent a very important source for sharing knowledge, especially between employees, who have the same specialization. This way is also the cheapest method of disseminating knowledge between employees. Therefore, the management should ensure good and benevolent working relationships between employees within the same department and also between employees of different departments, who have working connections and in such a way encourage the sharing and dissemination of knowledge throughout the whole organization.

This is the way used to share knowledge between many different groups or forums of programmers on the internet, which provide new and best solutions to tackling different programming problems and in such a way they actually share and disseminate new knowledge between themselves. Knowledge is also shared and disseminated between forums or groups of people concerning disease. Such forums play an important role in sharing the knowledge of experienced people about disease, medications, doctors, and so on. An example of sharing and disseminating knowledge between members of a group is shown in Fig. 6.5.

The second way of sharing and disseminating knowledge may be provided by the management in an organized manner by publishing and updating knowledge on special websites on the organization's intranet, as well as using other communication possibilities, such as documents, to disseminate the knowledge gained between employees at organizational level.

The third way used to share and disseminate discovered knowledge between employees is by integrating the knowledge within the organization's business processes models. The knowledge is then implemented by developing an information system to support these processes. Such an information system provides possibilities for ensuring the use of new knowledge by employees and contributes a great deal in changing the way in which the organization functions. Consequently, this method enables the management to invest the knowledge captured in making the functioning of the organization's business processes more effective and efficient. The advantage of using this way of sharing and disseminating of knowledge is that it cannot be ignored or forgotten, as is the case or likelihood accompanying publishing knowledge on the organization's intranet or using documents.

The result of the knowledge sharing and dissemination phase is that knowledge is contextualized, which means that it is organized in accordance with the context of the work activities performed within different work processes of the business

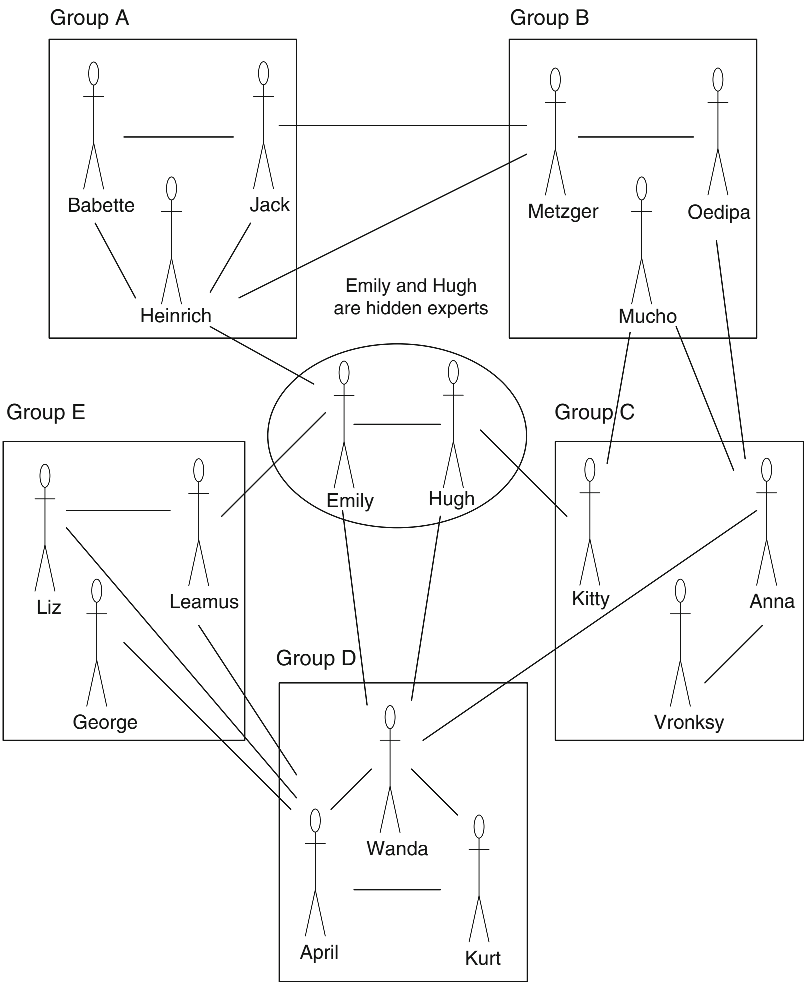


Fig. 6.5 Knowledge flow example (Source: Adapted by Dalkir 2005 from Kerbs, http://www.orgnet.com)

processes of the organization, before it is transformed into the third phase of the knowledge management cycle.

6.3.3 Knowledge Acquisition and Application

The third phase of the knowledge management cycle deals with two stages; these are acquisition and application of knowledge. This phase starts after the second phase is completed and the knowledge is contextualized by putting it into its context and at the level that fits the individual work activities of the business processes of the organization.

Knowledge acquisition means understanding, articulating, and preparing it for storage in the organization's knowledge base. This means preparing the discovered knowledge to be part of the knowledge management system and therefore part of the organization's corporate memory.

Organizational knowledge acquisition is the amplification and articulation of individual knowledge at the firm level so that it is internalized into the firm's knowledge base (Malhotra 2000).

Knowledge application means integrating the knowledge obtained from the second phase of the knowledge management cycle and prepared in the first stage of the current phase into the organization's knowledge base system, and in such a way becoming integrated with the existing knowledge management system of the organization. Knowledge application means that the acquired knowledge is applied to the process of adding new knowledge and updating already existing knowledge in the organization's knowledge management system.

In the end of this section, let us mention the following definition: "Knowledge application refers to the actual use of knowledge that has been captured or created and put into the knowledge management cycle" (Dalkir 2005).

References

Bennet, A., & Bennet, D. (2004). *Organizational survival in the new world, the intelligent complex adaptive system*. Burlington: Elsevier Science.

Boisot, M. (1998). *Knowledge assets*. New York: Oxford University Press.

Bontis, N., & Nikitopoulos, D. (2001). Thought leadership on intellectual capital. *Journal of Intellectual Capital, 12*(3), 183–191.

Bukowitz, W., & Williams, R. (2000). *The knowledge management fieldbook*. London: Prentice Hall.

Choo, C. (1998). *The knowing organization*. New York: Oxford University Press.

Dalkir, K. (2005). *Knowledge management in theory and practice*. Amsterdam: Elsevier Butterworth-Heinmann.

Frappoalo, C. (2004). What is your knowledge IQ? intelligent portals. http://www.intelligentkm.com/feature/08/feat1.jhtml?_requistid=4287.

Klein, D. (1998). *The strategic management of intellectual capital* (pp. 1–3). Oxford: Butterworth-Heinmann.

Malhotra, Y. (2000). *Knowledge management and virtual organizations*. London: Idea Group Publishing.

Mayer, M., & Zack, M. (1996). The design and implementation of information products. *Sloan Management Review, 37*(3), 43–59.

McElroy, M. (1999). *The new knowledge management: Complexity, learning and sustainable innovation*. Boston: Butterworth-Heinemann.

Nickols, F. (2000). KM overview. http//home.att.net/~discon/KM/KM_overview_context.htm.

Nonaka, I., & Tekeuchi, H. (1995). *The knowledge-creating company, how Japanese companies create the dynamics of innovation*. New York: Oxford University Press.

Polanyi, M. (1966). *The tacit dimension*. London/Routledge: University of Chicago Press.

Smith, M. K. (2003). Michael Polanyi and tacit knowledge, the encyclopedia of informal education. www.infed.org/thinkers/polanyi.htm.

Stewart, T. (1997). *Software intellectual capital*. New York: Doubleday.

von Krogh, G., & Roos, J. (1995). *Organizational epistemology*. New York: St. Martin's Press.

Walsh, J., & Ungson, G. (1991). Organizational memory. *Academy of Management Review, 16*, 57–91.

Weick, K. (2001). *Making sense of the organization*. Malden: Basil Blackwell.

Wiig, K. (1993). *Knowledge management foundation, thinking about thinking, how people and organization create, represent and use knowledge*. Arlington: Schema Press.

Wikipedia. (2011). www.wikipedia.org.

Simulation 7

Goals. In this chapter the following questions and themes are explored:
– Explaining the meaning of queues in real life
– Introducing a queuing system and its components
– Explaining simulation and its use in different areas
– Understanding a system, systems components, and system types
– Explaining a simulation model
– Understanding a discrete event simulation
– Introducing the steps needed for running a simulation
– Using the simulation technique for process improvement

7.1 Introduction to Queues

Queues have become part of our daily life because almost wherever we want to be served, we have to wait in a certain queue. For example, when we go to a store, visit a doctor, put an application into a governmental organization, place an order to buy some products, and so on, we usually have to join other people in a queue.

Queues can be found in various kinds of daily life services, such as a business service, a social service, medical service, and so forth. In a business service, the customer usually has to wait in a queue when she/he tries to contact an employee either at a personal level or by placing an order with the purpose of buying a certain product.

In a social service, a customer joins a queue when he/she places some kind of application into a governmental organization. For example, when placing an application for building a house, such an application may result in waiting for months before getting approval.

In a medical service, queues in this field became well-known and almost inevitable. When a patient tries to get any medical specialist service he or she is usually faced by long waiting lists, which could be sometimes life-threatening. Such queues

N. Damij and T. Damij, *Process Management*, Progress in IS,
DOI 10.1007/978-3-642-36639-0_7,

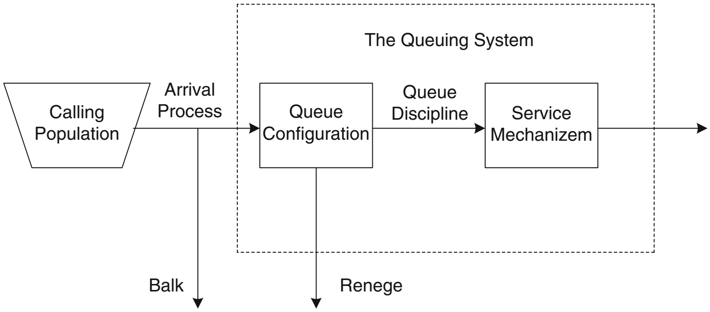


Fig. 7.1 The queuing process (Source: Laguna and Marklund 2005)

are everywhere: a queue for meeting any medical specialist, a queue for conducting an operation, and so on.

It is evident from the explanation given in the previous chapter that resource unavailability, for one reason or another, represents one of the main obstacles that causes the creation of queues and results in a decreased capacity of the system. In addition to this, there are organizational and other problems that cause waiting and delays, which consequently create queues and lead to the ineffectiveness of the organization.

7.1.1 Queuing Process

A flow unit, job, or transaction, as the flow unit is called by some simulation software packages, enters a business process from its environment and goes through the different activities of the process. The flow unit on its way through the process may join other flow units at the end of one or more queues waiting to be processed by the process's activities.

Therefore, when a flow unit, such as an application document, patient, or customer, enters a certain queue, it actually starts the queuing process. This process is represented by a set of actions that shows how a flow unit joins a queue and goes through a queuing system.

A queuing system is defined by Laguna and Marklund (2005) as: "An elementary queuing system consists of a service mechanism with servers providing service and one or more queues of customers or jobs waiting to receive service".

The basic queuing process consists of a group of components, as follows: calling population, arrival process, queue configuration, queue discipline, and service mechanism. Figure 7.1 shows such a queuing process and represents its elements, which are also explained briefly.

1. Calling Population

A calling population represents a group of flow units, for example customers, some of whom are associated with the queuing system for determined purposes. This means that a flow unit, such as a customer, joins one or more queues of flow units from a certain calling population; this is waiting in different buffers within a certain process.

The calling population may contain flow units of the same type or flow units of different types. The first is called a homogeneous whereas the second is called a heterogeneous calling population. Calling populations are usually heterogeneous. For example, patients enter a hospital for different purposes, such as hospitalization because of different health problems. Therefore, such a calling population consists of different subpopulations.

The calling population could be understood as an infinite or finite population. The calling population is considered as infinite when a flow unit joins a queue of such a large number of flow units that the queuing system is not affected by the arrival of the new flow unit. For example, a patient joins a waiting list of patients in a long queue that may last months of waiting, for the purpose conducting an operation.

Otherwise, the calling population is considered finite if the criterion for an infinite population is not valid. For example, a patient joins a queue of a number of patients in a waiting room to see a specialist physician or a customer joins a group of customers in a shop.

2. Arrival Process

The arrival process represents a determined way or path that every flow unit should follow after entering the queuing process. The path for each flow unit is determined depending on the type of flow unit. Such a path consists of a number of activities through which the flow unit passes.

There are queues, particularly when people (customers) as flow units form the queue, where the person who joins the queue may decide for one of the following three possible actions. In the first case, called a balk, the person decides to leave and not to join the queue because of the large number of people already in the queue. In the second case, called a renege, the person joins the queue but after some time decides to leave the queue. In the last case, the person decides to wait in the queue regardless of the time spent waiting.

3. Queue Configuration

The queue configuration indicates the type of queue that the flow unit joins, which determines the requirements to join a queue and the behavior of a flow unit or customer who joins the queue. There are two types of queue: the single-line queue configuration and multiple-line queue configuration.

As shown in Fig. 7.2, the single-line queue configuration requires that a flow unit joins the queue at the end of a single line and the flow unit is served after all the flow units before it are served. On the other hand, a multiple-line queue configuration enables the flow unit to choose one of several queue lines.

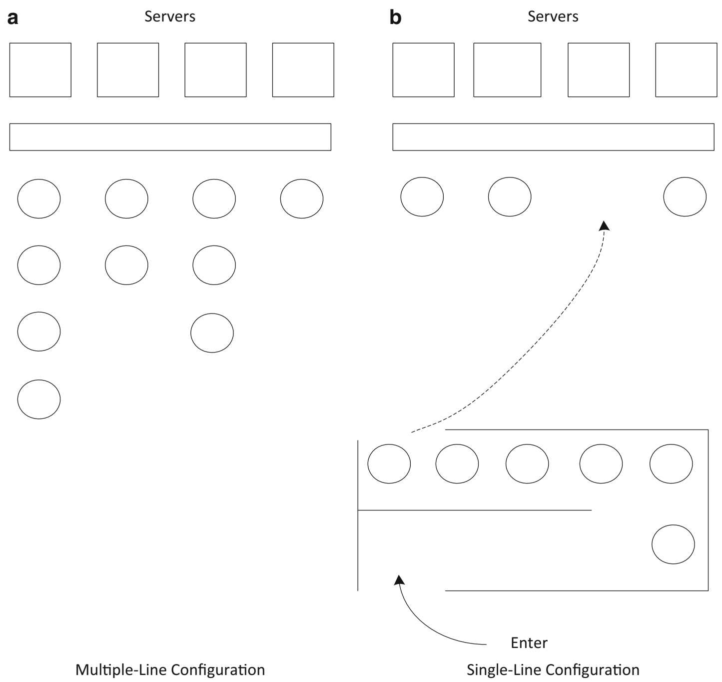


Fig. 7.2 Queue configuration (Source: Laguna and Marklund 2005)

4. Queue Discipline
Queue discipline represents the rule or discipline used to choose the next flow unit for serving. There are different disciplines used depending on the purpose of the queuing system. The most used rule is known as first-in-first-out. Some queue disciplines also use priority of the flow unit. This rule is, for example, used in medical institutions, where patients with life-threatening cases or children have the highest priority to be served first.

5. Service Mechanism
The service mechanism consists of a number of services that perform a set of tasks on the flow unit within a process. The flow unit enters the service facility when the resource is available to provide the flow unit with the service it needs. The time spent by the service in performing the work on the flow unit is called the service time.

7.2 Understanding Simulation

Simulation is a technique that enables us to define and launch an imitation of the behavior of a certain real system in order to analyze its functionality and performance in detail. For this purpose, real life input data is required and collected for use in running, observing the system's behavior over time, and conducting different experiments without disturbing the functioning of the original system.

Simulation may be used for many purposes, enabling experts from various fields to tackle particular problems by comparing the existing systems with improved or new ones in order to search for better possible solutions. Simulation is used in areas such as engineering, economics, business, management, medicine, social services, etc. For example, pilots, astronauts, financial experts, process improvement teams, project management teams, and others use simulation to carry out experimentation in their individual fields.

One of the most important properties of the simulation technique is to enable experts to carry out experiments on the behavior of a system by generating various options of what-if questions. This characteristic of simulation gives a possibility for exploring ideas and creating different scenarios that are based on understanding of the system's operation and deep analysis of the simulation output results. This actually represents simulation's main advantage, which consequently has led to the widespread use of the technique in various fields for both academic and practical purposes.

Simulation is the imitation or representation of the behavior of some real thing, state of affairs, or process. The act of simulating something generally entails representing certain key characteristics or behavior of a selected physical or abstract system (www.wikipedia.com, 2011).

Fujimoto (2000) in his book "Parallel and Distributed Simulation Systems" defined simulation as: "Simulation is a system that represents or emulates the behavior of another system over time".

In "Discrete-Event System Simulation", a book published by Banks et al. (2001) simulation is defined as: "A simulation is the imitation of the operation of a real-world process or system over time".

Furthermore, Laguna and Marklund (2005) in their above mentioned book described simulation simply as: to simulate means to mimic the reality in some way.

Simulation could be used to solve problems in many different areas. Banks et al. (2001) list many cases in which simulation can be used as an appropriate analysis tool. In the following, some important conclusions, which are related to the subject of process management, are listed:

- Simulation enables the study and experimentation of the internal interactions of a complex system or a subsystem of a complex system;
- The knowledge gained in designing a simulation model may be of great value toward suggesting improvement in the system under investigation;
- By changing simulation inputs and observing the resulting outputs, valuable insight may be obtained into which variables are most important and how variables interact;
- Simulation can be used to experiment with new designs or policies prior to implementation, so as to prepare for what may happen;
- Simulation can be used to verify analytic solutions;
- Simulation models designed for training allow learning without cost and disruption; and

– Animation shows a system in simulated operation so that the plan can be visualized.

On the other hand, Banks and Gibson (1997) gave 10 rules for determining when simulation is not appropriate for use. Some of these rules are listed as follows:

– Simulation should not be used when the problem can be solved using common sense;
– Simulation should not be used if the problem can be solved analytically;
– Simulation should not be used if it is easier to perform direct experiments;
– Simulation should not be used if the resources or time are not available;
– Simulation takes data and should not be used if no data is available;
– Simulation should not be used if system behavior is too complex or cannot be defined.

Bustard and Kawalek (2000) in their book “Systems Modeling for Business Process Improvement” explained several characteristics of simulation that make it suitable for business process modeling, which had been introduced by Paul et al. (2006). Some of these characteristics are the following:

– A simulation model can be easily modified to follow changes in the real system, and as such can be used as a decision-support tool for continuous process improvement;
– A process-based approach in simulation modeling terminology relates to a time-ordered sequence of interrelated events that describes the entire experience of an entity as it flows through the system;
– The flow of information within and between business processes can be modeled as the flow of temporary entities between processing stations;
– A simulation model of nonexisting business processes can be developed and used for process design;
– Simulation models can capture the behavior of both human and technical resources in the system;
– The visual interactive features of many simulation packages available on the market enable a graphic display of the dynamic behavior of model entities, showing dynamic changes in state within processes;
– Simulation models can incorporate the stochastic nature of business processes and the random behavior of their resources.

In addition to the cases when simulation is appropriate and in accordance with the rules and when simulation is not appropriate, Pegden et al. (1995) listed nine advantages and four disadvantages of simulation. In the following, we list five advantages and one disadvantage selected from these, which we consider important for the subject of process management:

Five advantages are:

– New policies, operating procedures, decision rules, information flows, organizational procedures and so on can be explored without disrupting the ongoing operations of the real system;
– Time can be compressed or expanded allowing for a speed up or slowdown of the phenomena under investigation;

- Bottleneck analysis can be performed indicating where work-in-process, information, materials, and so on, are being excessively delayed;
- A simulation can help in understanding how the system operates;
- What-if questions can be answered, which is useful in the design of new systems.
  A disadvantage is:
- Model building requires special training, learned over time and through experience. Furthermore, if two models are constructed by two competent individuals, they may have similarities, but it is highly unlikely that they will be the same.

7.3 Systems Simulation

As was stated in the previous section, the simulation technique enables us to imitate the behavior of a real system. For this reason, the current section focuses on introducing a number of topics that define a system, such as: what is a system, which components does the system consist of, what types of systems are there, and what is a model of a system.

7.3.1 Systems Characteristics

System
Banks et al. (2001) defines a system as follows: "A system is a group of objects that are joined together in some regular interaction or interdependence toward the accomplishment of some purpose".

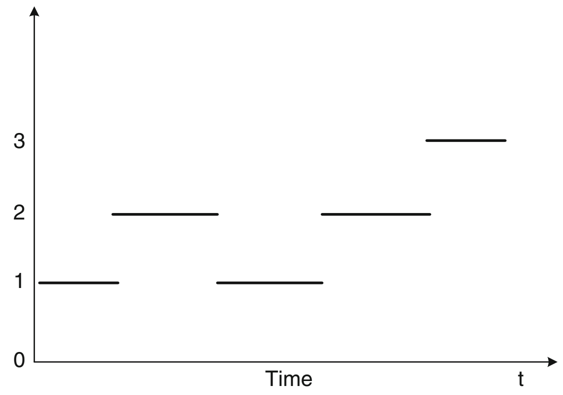
Therefore, each system consists of a group of objects or elements that clearly define or draw its boundaries and separate it from other systems that exist in its environment. The environment of a system represents a number of other systems that have different interactions with the system discussed whether by sending different inputs into the system, receiving from it various outputs, or both.

Therefore, in order to understand the system, it is essential to define which objects or elements belong to the system. This means that before starting a simulation or imitating the behavior of a system, we have to obtain a complete understanding of the system's functioning in order to develop a true scenario for imitation of its operation.

Systems Components
In order to understand what a system is, we have to identify from which components it is formed. According to Banks et al. (2001) a system consists of a set of components, such as entity, attribute, activity, state, and event. These components are defined by the mentioned authors as follows:

- Entity: An entity is an object of interest in the system;
- Attribute: An attribute is a property of an entity;

Fig. 7.3 Discrete-system state variable (Source: Banks et al. 2001)



– Activity: An activity represents a time period of specified length;
– State: A state is a collection of variables necessary to describe the system at any time;
– Event: An event is an instantaneous occurrence that may change the state of the system.

Systems Types
Two types of systems could be differentiated; these are discrete and continuous systems. Law and Kelton (2000) wrote in their book "Simulation Modeling and Analysis" that few systems in practice are wholly discrete or continuous, but since one type of change predominates for most systems, it will usually be possible to classify a system as being either discrete or continuous.

A discrete system is one in which the state variable(s) change only at a discrete set of points in time (Banks et al. 2001).

Inputs or flow units enter a business process at various points of time and cause changes in its state variables. Thus the business process is considered as a dynamic and discrete system. For example, customer orders enter a business process at different points of time and cause changes in the state variables of the process, which trigger a number of actions within the process. See Fig. 7.3, which shows an example of a discrete-system.

On the other hand, a continuous system is one in which the state variable(s) change continuously over time (Banks et al. 2001). Figure 7.4 shows an example of water that during and for some time after a rain storm, flows into the lake behind a dam.

System Model
To perform a simulation of a real system, a model of the system has to be first developed, which is usually based on understanding the behavior of the system discussed. The model of the system is a description of the system's functioning that should be a true reflection of its behavior. Banks et al. (2001) defined a model as "A representation of a system for the purpose of studying the system".

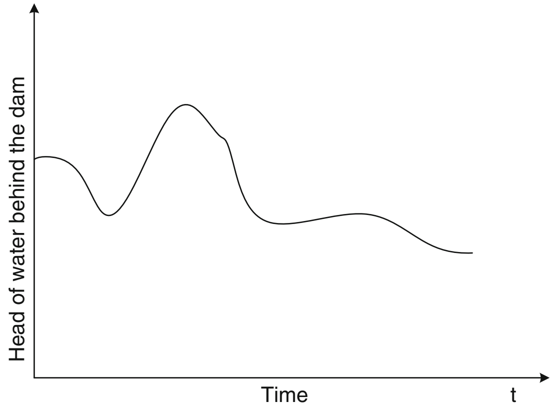


Fig. 7.4 Continuous-system state variable (Source: Banks et al. 2001)

Developing a model of a real system is a difficult task and, as was mentioned in the previous section, is considered as one of disadvantages of simulation. Actually developing a system model is a problem involving modeling techniques and systems modelers who should be well trained to perform such a task properly. In addition to this, systems modelers should define various systems parameters and properties in order to prepare the system model for simulation.

The source of the problem lies in the fact that the human factor plays a very important role in systems modeling. Consequently, the model developed reflects the modeler's vision and understanding of the functioning of the system studied. For this reason, if a certain system is modeled by two competent individuals, then the result would be that the two models developed may have similarities, but it is highly unlikely that they would be the same because the modelers, for different reasons, have a different understanding of the system's behavior.

Another reason could be related to the flexibility of the modeling techniques as they allow each modeler to unite various pieces of the system together to obtain the whole picture as he/she feels they fit best. In Chap. 10, a modeling technique is introduced, which tackles this problem by putting limitations on modeling flexibility and in such a way tries to lead the modeler to follow what is happening in the system more precisely.

7.3.2 Discrete Event Simulation

Discrete-event simulation means simulation of a system into which inputs enter from the environment at various points of time. A business process is such a system in which inputs (flow units or jobs), such as for example customer orders, enter the process from the process's environment at different points of time. The same is true for a healthcare process in which patients register at the reception office of a hospital at various points of time.

The simulation of a business process is a computer-based simulation, which means that such a simulation is carried out using a computer system. A computer-based simulation plays an essential role in shortening the time of business process operation because discrete-event simulation regards time as the only element that is taken into consideration.

This means that discrete-event simulation controls the changes happening in the system's state attributes, such as the availability of resources and number of flow units in a queue every time a certain discrete event occurs. This happens when a new flow unit or job joins the queue of flow units or when a flow unit leaves the system.

The above mentioned characteristic of discrete-event simulation enables the system to achieve a great deal of acceleration of simulation time by greatly compressing the processing time and by ignoring the time periods when no flow unit enters or leaves the system. This is when the flow units are waiting in queues and therefore the state of the system is unchanged.

For example, let us consider the simulation of a system of a patient registration office with one registration nurse as the server. When a patient comes to the hospital to register for hospitalization, she/he either joins the queue of other patients, or is served as she/he reaches the registration office. In the first case, the system's state is changed by adding one to the number of patients in the queue at the registration office, whereas in the second case, the status of the server changes from idle to busy. On the other hand, when the patient leaves the queue, or the registration is completed then the system performs one of the following actions. In the first case, the system state changes by subtracting one from the number of patients in the queue. In the second case, the status of the server changes from busy to idle.

In the following, an example of a single-server queuing process is presented. Figure 7.5 shows the time line and events of the example of a single-server process simulation. The figure indicates that the time is the only relevant element of the discrete-event simulation. For this purpose, let us assume the following notations:

$$
\begin{aligned}
t_j &= \text{arrival time of the jth flow unit} \\
A_j &= t_j - t_{j-1} \\
&= \text{time between the arrival of flow unit} \\
&\quad\ j-1 \text{ and the arrival of flow unit } j
\end{aligned}
$$

$$S_j = \text{service time for flow unit } j$$

$$D_j = \text{delay time for flow unit } j$$

$$c_j = t_j + D_j + S_j = \text{completion time for flow unit } j$$

$$e_i = \text{time of occurrence of event } i$$

The example has six events and aims to represent the simulation of a single-server process. Where the first event is denoted by e_0 and the last is $e_{5,}$ event e_0

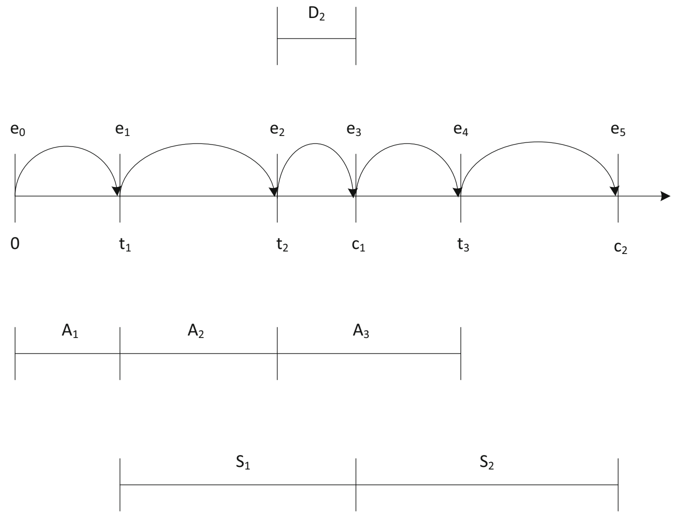


Fig. 7.5 Simulation of a single-server process (Source: Laguna and Marklund (2005))

represents the initialization of the simulation, event e_1 represents the arrival of the first flow unit at time t_1, and event e_2 the arrival of the second flow unit at time t_2.

The time of completing the first flow unit is computed as:

$$c_1 = t_1 + S_1$$

Therefore, first flow unit does not have any delay.

Figure 7.5 also shows that $c_1 > t_2$, which means that the second flow unit has a delay, which is represented by D_2 and computed as follows:

$$D_2 = c_1 - t_2$$

Event e_5 indicates the completion time of the second flow unit, which can be computed as follows:

$$c_2 = t_2 + D_2 + S_2$$

7.4 Simulation Procedure

Various authors have developed a number of approaches that describe how to carry out the simulation of a system. In the following, we introduce the approach for conducting a simulation, which is described in Banks et al. (2001). Figure 7.6 shows a flowchart that represents the steps of the approach. The first nine steps of the approach are described briefly as follows.

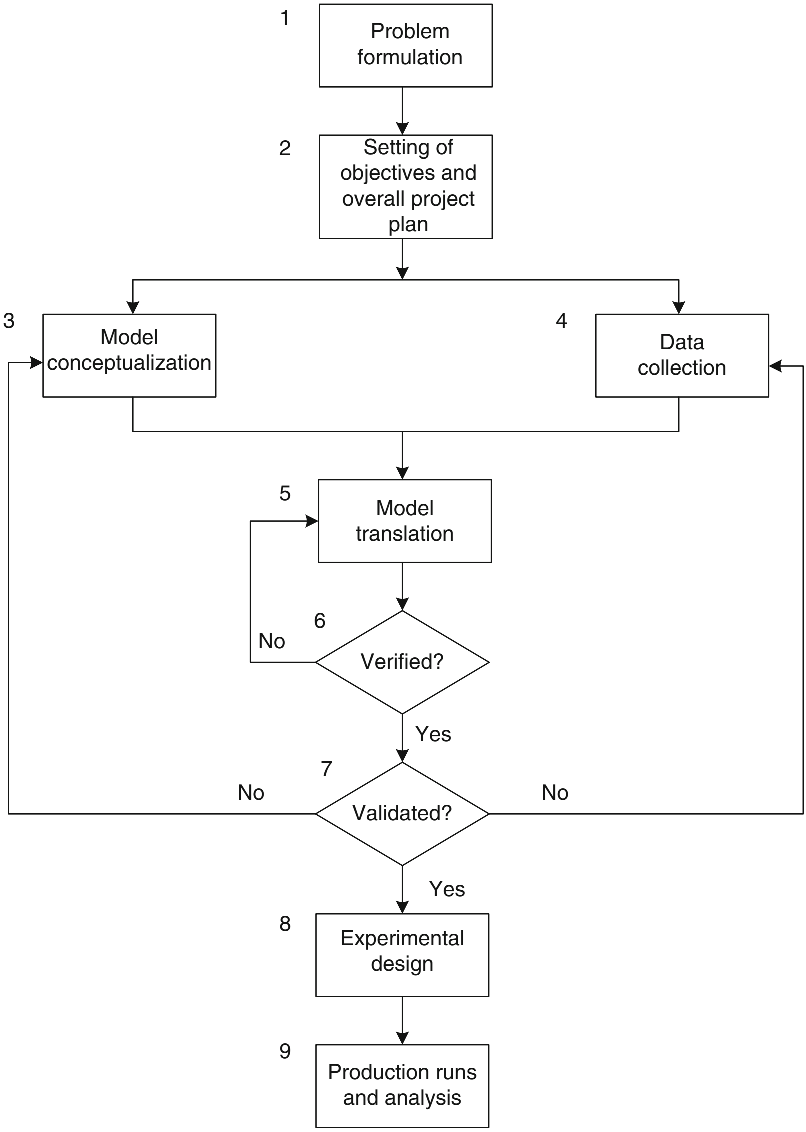


Fig. 7.6 Steps of simulation (Source: Banks et al. 2001)

1. Problem Formulation

In this step, a problem formulation statement should be prepared, which shows that the problem discussed is understood completely. The problem statement should be signed by the customer or organization that orders the simulation and also by the person or team manager, who is responsible for conducting the system simulation.

2. Setting of Objectives and Overall Project Plan

In this step, the simulation team should study if simulation is an appropriate method of solving the problem formulated in the first step. In addition to this, real goals should be defined, which could be expected to be achieved from carrying out the simulation.

In accordance with the defined goals, the simulation should be considered as an independent project or a subproject within a large project, for example a simulation subproject that deals with the preparation, running, and analysis of results of a simulation of a business process model within a project of business process management.

To achieve this, a simulation project or subproject should be opened and the project's or subproject's scope, manager, team, plan, phases, their activities, the duration time of each activity, and resources needed to perform every activity determined.

3. Model Conceptualization

The model conceptualization step deals with developing a model of the system that is intended to be simulated. To do this properly, the modeler should use a modeling technique that enables her/him to transfer the behavior of the system into the model developed as closely as possible. The model developed should be shown to the users in order to suggest corrections necessary to make it a true reflection of the original system discussed.

4. Data Collection

Simulation of any system requires collecting detailed data about the system's behavior and each activity performed within the framework of the system. Collecting data is usually done in connection with system modeling activities; this is when interviews are organized with users.

Concerning business process management projects, analysts usually collect data about the organization's business processes, their work processes, and each activity within every work process, such as its description, time duration, constraints, resources needed, costs, and other data.

5. Model Translation

The model of the system developed in the third step has to be translated into a simulation language program, such as GPSS/H, using the data collected in the previous step.

There are also a number of software packages, such as iGrafx, Arena and others, which enable modelers to translate their models into simple diagrams, such as a flowchart, before running the simulation process.

6. Verification

This step deals with of verification whether the accurately written program truly reflects translation of the systems model into the program. This step requires debugging the program carefully in order to remove any mistake that exists in it. The result of this step should be a program that represents the behavior of the system that is presented by model.

In cases where the simulation model is developed using a graphical interface, such as iGrafx Process, the simulation team should trace the model carefully step by step in order to discover and correct each mistake or incorrectness existing in the model.

7. Validation

The validation step examines the model developed in order to find out whether it is a true reflection to the original real system. This can be achieved by performing a comparison between the model and the system concerned. Such a comparison could be carried out by testing the simulation model using tests already used from real processes in which the input data and the expected output data are known in advance.

8. Experimental Design

In the experimental design step the simulation team prepares different alternative scenarios for running the simulation process. These scenarios are developed on the basis of a complete understanding the behavior of the system, generating different possible behavior possibilities of the system by using what-if questions, and trying to implement ideas for achieving improvements in the functioning of the system.

9. Runs and Analysis

In this step the simulation team deals with estimating and analyzing the performance results of the simulation in the prepared scenarios of the previous step.

On the basis of the results of the already completed simulation runs, the team may determine the need for conducting more simulation runs. New ideas may be considered for making changes in the existing scenarios or new scenarios developed on the basis of the carefully analyzed output data, leading to the performance of new simulation runs on the system concerned.

References

Banks,J., & Gibson,R. R. (1997) Don't simulate when: 10 Rules for determining when simulation is not appropriate. IIE Solutions.

Banks, J., Carson, S. J., Nelson, L. B., & Nicol, M. D. (2001). *Discrete-event system simulation*. Upper Saddle River: Prentice Hall.

Bustard, D., & Kawalek, P. (2000). *Systems modeling for business process improvement*. Boston: Artech House.

Fujimoto, R. M. (2000). *Parallel and distributed simulation systems*. New York: Wiley.

Laguna, M., & Marklund, J. (2005). *Business process modeling, simulation, and design*. Upper Saddle River: Pearson Prentice Hall.

Law, M. A., & Kelton, W. A. (2000). *Simulation modeling and analysis*. Boston: McGraw-Hill Higher Education.

Paul, D., & Yeates, D. (2006). *Business analysis*. Swindon: BCS.

Pegden, C. D., Sadowski, P. R., & Shannon, E. R. (1995). *Introduction to simulation using Siman*. Boston: McGraw-Hill Higher Education.

Wikipedia. (2011). www.wikipedia.com.

8 Data Modeling

Goals. In this chapter the following questions and themes are explored:

– Discussion of the fundamentals of relational data modeling
– Explanation of the meaning of a relation
– Introduction to the importance of functional dependence
– The basis of different data dependences
– Introduction to the meaning of normalization for developing a data model
– Explanation of the first, second, third, and fourth normal form

Within the framework of process modeling, we usually identify and collect many different documents. These documents are connected to various activities of the process analyzed, either as inputs that enter and trigger the execution of the activities, or as outputs that are created as the results of performing the process's activities.

The collected documents are very important for information systems development, whose purpose is to support the process discussed, because these documents are rich in information about the objects of the system, their attributes, and relationships. For this reason, such documents should be analyzed carefully in order to develop a class model of the system.

To develop the class model of the system, different approaches and techniques can be used. From the theory of relational data modeling, we may recall the normalization technique is an efficient approach that can be used to develop the systems data model. Such a data model is then transformed into an object class model by defining operations within its classes.

The aim of this chapter is to introduce relational data modeling principles. For this purpose, various types of data dependences and the normalization technique are explained briefly.

N. Damij and T. Damij, *Process Management*, Progress in IS,
DOI 10.1007/978-3-642-36639-0_8,

8.1 Data Dependences

Different types of data dependences exist between the attributes of a relation, such as functional, full functional, transitive and multi-valued dependences. These dependences should be explored in order to develop a data model that can be used without causing anomalies and problems related to storing, updating and deleting data.

A relation was defined by Date (1981), as follows: Given a collection of sets D_1, D_2, . . ., D_n (not necessarily distinct), R is a relation on those n sets if it is a set of ordered n-tuples $< d_1, d_2, \ldots, d_n >$ such that d_1 belongs to D_1, d_2 belongs to D_2, . . ., d_n belongs to D_n. D_1, D_2, . . ., D_n are the domains of R. The value n is the degree of R.

McFadden and Hoffer (1988) gave the following definitions:

- A relation is viewed as a two-dimensional table. A relation has the following properties:
  - Each column contains values about the same attribute, and each table cell value must be simple (a single value).
  - Each column has a distinct name (attribute name), and the order of columns is immaterial.
- A tuple is the collection of values that compose one row of a relation.
- An n-tuple is a tuple composed of n attribute values, where n is called the degree of the relation.
- The number of tuples in a relation is its cardinality.
- A primary key is the attribute (or attributes in combination) for which no more than one tuple may have the same (combined) value.

Therefore, a relation is a set of attributes, whose values are represented by a two dimensional data table. Each column of data values within the table represents a certain domain of the relation.

An attribute is a property of an entity of the system discussed. A key attribute is an attribute of a relation on which other attributes are fully functionally dependent.

In the following the above mentioned types of data dependence, namely functional, full functional, transitive and multi-valued, are briefly introduced.

8.1.1 Functional Dependence

The following definition given by Vetter and Maddison clarifies the importance of using functional dependence for identifying the associations existing between attributes of a determined relation.

An attribute B of a relation is functionally dependent on the attribute A of it if at every instant of time each A-value is associated with no more than one B-value (Vetter and Maddison 1981).

In a relation R(A, B), non-key attribute B is functionally dependent on a key attribute A if each value of attribute A is connected to one and only one value of attribute B.

This definition means that any non-key attribute of a relation must be functionally dependent on the key attribute to be part of the relation. Otherwise, the non-key attribute should be removed from the relation in order to avoid anomalies when inserting, updating or deleting data.

To show the functional dependence between attributes of a relation, the following notation is used to indicate that attribute B is functionally dependent on attribute A:

$$\mathrm{A} \quad \rightarrow \quad \mathrm{B}$$

For example, let us discuss the relation Patient:

$$\mathrm{Patient(PatientID,\ PatientName)}$$

The relation Patient has two attributes: PatientID is a key attribute and PatientName is a non-key attribute of the relation. Attribute PatientName is functionally dependent on attribute PatienID because each value of attribute PatientID is connected to one and only one value of attribute PatientName.

$$\mathrm{PatientID} \quad \rightarrow \quad \mathrm{PatientName}$$

8.1.2 Full Functional Dependence

There are many cases where a non-key attribute(s) of a relation is functionally dependent on a key attribute that consists of more than one attribute. In such examples, the concept of full functional dependence should be used to analyze the associations between the key and non-key attributes of each of these relations.

Vetter and Maddison (1981) defined full functional dependence as: “The attribute (or attribute collection) B in a relation R is fully functionally dependent on the attribute collection A in R if B is functionally dependent on A but not functionally dependent on any proper subset of A”.

In a relation R(A_1, A_2, B), where an attribute collection (A_1, A_2) is a key attribute and B is a non-key attribute of the relation, attribute B is fully functional dependent on the attribute collection (A_1, A_2) if attribute B is functionally dependent on the whole attribute collection (A_1, A_2) and not functionally dependent on attribute A_1 or attribute A_2.

Furthermore, an attribute collection (A_1, A_2) is a key attribute of the relation R if no functional dependence exists between the attributes of the collection (A_1, A_2).

For example, let us assume the relation Order(OrderID, MedicationID, Dose), where the attribute collection (OrderID and MedicationID) is a key attribute of the relation and attribute “Dose” is a non-key attribute of the relation. Attribute “Dose” is functionally dependent on the attribute collection (OrderID and MedicationID) because the attribute “Dose” is functionally dependent on the whole attribute collection and not functionally dependent on each of the attributes that form the collection.

This means that each value of the attribute collection is associated with one and only one value of attribute "Dose". Furthermore, any value of attribute OrderID could be associated with one or more values of attribute "Dose" and also each value of attribute MedicationID is associated with one or more values of attribute "Dose".

This functional dependence is written as follows:

$$\begin{aligned} &\text{OrderID, MedicationID} && \rightarrow && \text{Dose} \\ &\text{OrderID} && \twoheadrightarrow && \text{Dose} \\ &\text{MedicationID} && \twoheadrightarrow && \text{Dose} \end{aligned}$$

8.1.3 Transitive Dependence

Consider a relation R(A, B, C), where attribute B is functionally dependent on attribute A and attribute C is functionally dependent on attribute B:

$$\begin{aligned} A &\rightarrow B \\ B &\rightarrow C \end{aligned}$$

Therefore, we may conclude that attribute C is transitively dependent on attribute A.

$$A \rightarrow C$$

Such a relation is not suitable for use in a database and should be broken down into two relations R1(A, B) and R2(B, C) in order to avoid problems with inserting, updating and removing rows.

8.1.4 Multivalued Dependence

Multivalued dependence is important when analyzing a relation with a key attribute that consists of several attributes, such as relation R(A, B, C), where A, B, C is an attribute collection that represents a key attribute of the relation R.

The attribute collection A, B, C is a key attribute of the relation R if any subset of the collection is independent on any other subset of the attribute collection. So, A is independent on B and C, B is independent on A and C, and C is independent on A and B.

We need to be certain that such a relation does not contain a multivalued dependence. This dependence means that a determined set of C-values that appears with B-value, also appears with every combination of this B-value with A-values.

Fig. 8.1 Multivalued dependence

	A	B	C
1	a_1	b_1	c_1
2	a_1	b_1	c_2
3	a_2	b_2	c_3
4	a_2	b_2	c_4
5	a_3	b_1	c_1
6	a_3	b_1	c_2
7	a_4	b_2	c_3
8	a_4	b_2	c_4

To show multivalued dependence, Fig. 8.1 is created using a several rows of data values related to the attributes of relation R(A, B, C).

Let us consider the data given in Fig. 8.1 corresponding to the above given explanation of multivalued dependence. Rows 1 and 2 on one hand, and 5 and 6 on the other, show that the same C-values (c_1 and c_2) appear with B-value (b_1) and also appear with each combination of b_1 with A-values (a_1 and a_3). The same thing also happens in rows with value b_2, where (c_3 and c_4) appears with every combination of b_2 and A-values (a_2 and a_4); see rows 3 and 4 and also rows 7 and 8.

Such a relation contains a multivalued dependence and should be broken down into two relations R1(A, B) and R2(B, C) to avoid anomalies when inserting, updating or removing rows.

8.2 Normalization

Edgar F. Codd, the inventor of normalization, had this to say about it: We all have trouble organizing even our personal information. Businesses have those problems in spades. It seemed to me essential that some discipline be introduced into database design (Rapaport 1993).

Normalization is used to identify, analyze and organize the information contained in users' documents. It is a bottom-up technique that starts by analyzing attributes and linking them with their entities (relations), whereas other techniques such as ER diagrams represent a top-down approach that first identifies entities and then defines their attributes.

Normalization is an effective approach introduced in 1970 to organize records in database tables in such a way to ensure database stability and integrity, and avoid anomalies related to inserting, updating and deleting database records from happening.

This approach leads the database designer through successive steps; these are First Normal Form, Second Normal Form and Third Normal Form in order to transform an unnormalized relation into a number of normalized relations.

This work was continued by other researchers who discovered new normal forms, such as the Fourth Normal Form, Fifth Normal Form and Sixth Normal Form. The last normal form was developed by Date, Darwen, and Lorentzos in 2002.

In the following subsections the first four normal forms will be discussed briefly because relations in any database design must be at least in the third normal form to avoid the above mentioned anomalies. However, anomalies that could happen because a relation is not in higher normal forms are rare.

8.2.1 First Normal Form

To develop a data model of an information system, we first identify and collect the documents used by the users of the system. Each document is then analyzed carefully starting by transforming it into an unnormalized relation and continuing by implementing the normalization step by step until the unnormalized relation is transformed into a number of normalized relations.

Regarding the healthcare process "Surgery" presented in Part 2, a number of different documents were collected within the framework of the interviews organized, mainly with leading sisters in the clinic. From all the documents collected, we chose an important document called Temperature Sheet, which is created when each patient enters the clinic to register all events happening to the patient through every day of his/her stay in the clinic.

The document Temperature Sheet introduced in this chapter is a simplified version of a complex document, used to show the normalization technique. The document contains a number of attributes, which are placed at the head of the document; each of these attributes is connected with only one data value. In addition to this, it also contains a number of repeating groups that occupy different parts of the document. Each attribute of the repeating groups is associated with more data values listed in a number of rows.

To transform the document Temperature Sheet into a set of normalized relations, we first transfer the document into the following unnormalized relation:

TempSheet (TempSheetID, PatientID, PatientName, BirthDate, Address, AcceptDate, ReleaseDate, DiagnosisID, DiagName, SurgeryID, SugeryName, DocID, DocName, (MedicationID, MedName, Dose, Time/Day), (InterventionID, Description, InterDate, InterDocID), (Date, Time, Temperature, Pulse, Pressure))

The given unnormalized relation TempSheet shows that it contains three repeating groups, which are separated from other attributes by defining them inside additional inner parentheses.

Vetter and Maddison (1981) defined a relation in the first normal form (1NF) as: "A relation is in the first normal form if presented in table form contains at each row-column-intersection precisely one value, never a set of values".

This means that a relation is in the first normal form if it does not contain repeating groups. Thus, to transfer the unnormalized relation TempSheet into normalized relations in first normal form, the repeating groups must be removed from the unnormalized relation.

The following four relations are gained after removing the repeating groups from the relation TempSheet:

TempSheet	(TempSheetID, PatientID, PatientName, BirthDate, Address, AcceptDate, ReleaseDate, DiagnosisID, DiagName, SurgeryID, SugeryName, DocID, DocName)
Medication	(MedicationID, MedName, Dose, Time/Day)
Intervention	(InterventionID, Description, InterDate, InterDocID)
Parameters	(Date, Time, Temperature, Pulse, Pressure)

These relations are in the first normal form because they do not contain repeating groups, which means that each row-column-intersection of each relation contains only one value.

8.2.2 Second Normal Form

Codd defined a relation in the second normal form, as: "A relation R is in the second normal form (2NF) if it is in the first normal form (1NF) and every non-prime attribute of it is fully functionally dependent on each candidate key of R" (Vetter and Maddison 1981).

Sanders (1995) gave the following definition: "A relational table or file is in the second normal form when all non-key attributes are functionally dependent on the entire key".

So, a relation is in the second normal form if it does not contain repeating groups and every non-key attribute of it is fully functionally dependent on the key attribute of the relation.

Considering our relations, we may conclude the following:

– Relation TempSheet: All non-key attributes are functionally dependent on the relation's key attribute TempSheetID;
– Relation Medication:
  • The non-key attribute MedName is functionally dependent on the relation's key attribute MedicationID;
  • The non-key attribute Dose is independent on key attribute MedicationID because medication is usually prescribed in different doses for various patients;
  • The non-key attribute Time/Day is independent on the relation's key attribute MedicationID;
  • Therefore, the non-key attributes Dose and Time/Day are removed from the relation and a new relation called TempSheet-Medicatin is created to contain the non-key attributes Dose and Times/Day, in addition to the key attribute collection TempSheetID, MedicationID;
– Relation Intervention:
  • The non-key attribute Description is functionally dependent on the relation's key attribute InterventionID;
  • The non-key attributes InterDate and InterDoc are functionally independent on the key attribute InterventionID because a patient may have a number of interventions performed by different doctors;

Therefore, the non-key attributes InterDate and InterDoc are removed from the relation and a new relation called TempSheet-Intervention is created to contain the non-key attributes InterDate and InterDoc, and the key attribute collection TempSheetID, InterventionID;

– Relation Parameters:

Non-key attributes Pulse, Pressure and Temperature are parameters, which are measured a number of times per day and therefore are functionally independent on the attribute collection Date,Time because measures such as Pulse, Pressure and Temperature are registered on different Temperature Sheet documents. Therefore, the non-key attributes Pulse, Pressure and Temperature are dependent on only the key attribute collection TempSheet,Date,Time.

The result of this analysis is the following six relations:

TempSheet	(<u>TempSheetID</u>, PatientID, PatientName, BirthDate, Address, AcceptDate, ReleaseDate, DiagnosisID, DiagName, SurgeryID, SugeryName, DocID, DocName)
Medication	(<u>MedicationID</u>, MedName)
TempSheet-Medication	(<u>TempSheetID, MedicationID</u>, Dose, Times/Day)
Intervention	(<u>InterventionID</u>, Description)
TempSheet-Intervention	(<u>TempSheetID, InterventionID</u>, InterDate, InterDocID)
Parameters	(<u>TempSheetID, Date, Time</u>, Temperature, Pulse, Pressure)

All these relations are in the second normal form because each non-key attribute in any of the above listed relations is fully independent on the key attribute of its relation.

8.2.3 Third Normal Form

Codd defined a relation in the third normal form as: “A relation R is in the third normal form (3NF) if it is in second normal form (2NF) and every non-prime attribute of R is non-transitively dependent on each candidate key of R” (Vetter and Maddison 1981).

A relation R is in the third normal form if it is in the second normal form and each non-key attribute is functionally dependent on the relation’s key attribute and is independent on any other key attribute within the relation.

Considering the above given six relations, we find that there are a number of transitive dependences existing only in one relation. This relation is TempSheet in which the following transitive dependences are found:

– The attributes PatientName, BirthDate, and Address are functionally dependent on the attribute PatientID and therefore are transitively dependent on the relation’s key attribute TempSheetID;
– The attribute DiagName is transitively dependent on the relation’s key attribute TempSheetID because it is functionally dependent on the attribute DiagnosisID;

– The attribute SurgeryName is also transitively dependent on the relation's key attribute TempSheetID because it is functionally dependent on the attribute SurgeryID; and
– The attribute DocName is functionally dependent on the attribute DocID and so is transitively dependent on the relation's key attribute TempSheetID.

To transfer TempSheet into a relation in the third normal form, we have to remove all attributes, which are transitively dependent on the relation's key attribute and define them in new relations, as follows:

TempSheet	(TempSheetID, PatientID, AcceptDate, ReleaseDate, DiagnosisID, SurgeryID, DocID)
Patient	(PatientID, PatientName, BirthDate, Address)
Diagnosis	(DiagnosisID, DiagName)
Surgery	(SurgeryID, SugeryName)
Doctor	(DocID, DocName)

8.2.4 Fourth Normal Form

A relation R is in the fourth normal form if it is in third normal form and does not contain any multivalued dependence.

Considering the relation Parameters, we find that the key attribute collection of the relation consists of the three attributes TempSheetID, Date, and Time, which are functionally independent on each other. Analyzing this attribute collection shows that the relation does not contain any multivalued dependence. This is because no existing set of Time-values appears with a Date-value, which also appears with every combination of Date-value and TempSheetID-value. Therefore, the relation Parameters is in the fourth normal form.

The final result of normalization is the following set of relations in the fourth normal form.

TempSheet	(TempSheetID, PatientID, AcceptDate, ReleaseDate, DiagnosisID, SurgeryID, DocID)
Patient	(PatientID, PatientName, BirthDate, Address)
Diagnosis	(DiagnosisID, DiagName)
Surgery	(SurgeryID, SugeryName)
Doctor	(DocID, DocName)
Medication	(MedicationID, MedName)
TempSheet-Medication	(TempSheetID, MedicationID, Dose, Times/Day)
Intervention	(InterventionID, Description)
TempSheet-Intervention	(TempSheetID, InterventionID, InterDate, InterDocID)
Parameters	(TempSheetID, Date, Time, Temperature, Pulse, Pressure)

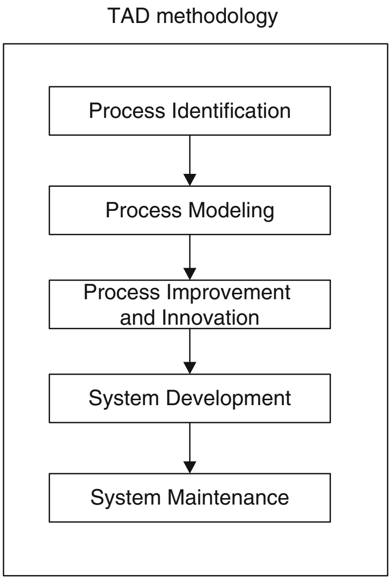
Other normal forms are rare in reality and therefore are not discussed in this short introduction to normalization.

References

Date, C. J. (1981). *An introduction to database systems*. Reading: Addison-Wesley.
McFadden, F. R., & Hoffer, J. A. (1988). *Database management systems*. Menlo Park: Benjamin/Cumming.
Rapaport, M. H. (1993). A fireside chat. *DBMS, 6*(13), 54–60.
Sanders, L. G. (1995). *Data modeling*. Danvers: Boyd & Fraser.
Vetter, M., & Maddison, R. N. (1981). *Database design methodology*. Englewood Cliffs: Prentice Hall.

Part II

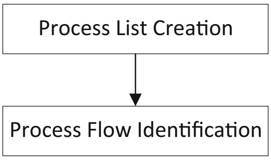
TAD Methodology



TAD methodology

Phase 1: Process Identification 9

Goals. In this chapter the following questions and themes are explored:
– Types of business processes
– Number of business processes within a company
– Identifying business processes of an organization
– Defining of the flow of business processes throughout the functional areas
– Representing the Process Table technique
– Understanding the organization's functioning



Phase 1: Process identification

The first phase of TAD methodology discusses the problem of identifying the organization's business processes starting with a set of core processes, which represent the processes that are essential for the functioning of the organization, with the purpose of analyzing and improving them.

The identification of a business process is not an easy task and its solution depends on the level of maturity of the organization. Thus, identifying business processes should be accomplished carefully because it affects the subsequent phases of process management, such as modeling, improvement/innovation, and system development.

In reality, an organization may have several tens or even hundreds of processes that are of different size and complexity. Some of them may be large and more demanding processes. Identifying, understanding, modeling, and analyzing such a

N. Damij and T. Damij, *Process Management*, Progress in IS,
DOI 10.1007/978-3-642-36639-0_9,

number of processes could be a very complicated and difficult task for the process management team to tackle.

To show the complexity of this problem, let us mention examples of well-known corporations, such as IBM and Xerox, published in Devenport (1993). The Xerox Corporation at the beginning had identified a large number of processes but afterward the company focused on those processes that it considered to be essential or core, and defined only 14 business processes. Similarly, IBM had defined at the beginning at least 140 processes, but after some years they reconsidered their processes and decided they have only 18 business processes.

Therefore, the solution to this problem is to consider carefully the experience and lessons learned from the above given examples and examples of other companies. Thus, the organization should focus mainly on core and usually large cross-functional processes. According to a number of researchers, the expected number of core or large business processes that pass through different functional areas of the organization may be between 10 and 20 business processes. This is important information that should be considered when process management in a certain company begins.

Let us also remember what types of business processes an organization may have. According to Robson and Ullah (1996), there are two types: core and support processes. The core processes are the operational processes of the business and result in the production of the outputs that are required by external customer. The support processes are those that enable the core process to exist. Ould (1995) in addition to core and support processes, identified a third type of processes; these are the management processes. Management processes concern themselves with managing the core processes or the support processes, or they concern themselves with planning at the business level.

Rockart and Short identified three major processes; developing new products, delivering products to customers, and managing customer relationships (Davenport 1993).

Identifying business processes in a company is usually done by organizing interviews with the management at different levels of the organization; these are at strategic, business, and operational levels. Organizing and conducting interviews with the management is a good and common technique, which is widely used by many methodologies of systems development.

The Process Identification phase consists of two steps: the first step identifies the business processes to be analyzed; the second step defines their flow through the organization's functional areas.

9.1 Process List Creation

In the first step of the current phase a number of interviews are organized with the management at the strategic and business levels. The purpose of the interviews with strategic management is to understand what role the organization plays and where it is heading (Damij 2001).

Our work in the first step starts by trying to elicit important information about the strategic orientation of the organization, which is done by analyzing the organization's documents and organizing interviews with people at the top level. To accomplish this, we try to gain the following two kinds of information:

1. Information about the strategy of the organization, its strategic plan, and strategic goals and objectives so as to develop an understanding of the purpose of the organization's existence and its way of doing business; and
2. Information about the structural scheme of the organization and the people in-charge at the business level in order to create a plan of interviews with the management at the business level.

The following are some of the results, which may be obtained on the basis of analyzing information collected during the interviews with the management at the strategic level:

– The process improvement team develops a good understanding of the strategic view of the organization;
– The team creates a plan of interviews with the management at the business level.

After accomplishing the plan of interviews at the strategic level, the process of collecting information is continued by conducting interviews with management at the business level in accordance with the plan of interviews created during the previous interviews (Damij and Damij 2005). The purpose of the interviews with business management is to identify the business processes of the organization, or more precisely, to select which processes are the ones targeted for analysis and improvement. The results of these interviews are the following:

1. Creating a list of selected business processes of the organization, which need improvement;
2. For each of the listed processes, gaining more detailed information that enables us to identify through which of the organization's departments or units the process passes; and
3. Extending the plan of interviews to responsible people at departmental or operational level in order to plan with them the interviews in the next step.

Case Studies

In order to introduce the ideas developed by TAD methodology into reality, examples of two interesting business processes are chosen to implement the steps of each phase of the methodology.

The first problem discusses the process of conducting an operation (surgery) in a clinic for abdominal surgery, which represents a department within a large university clinical centre. Thus, the interviews carried out in the first phase were organized only at the level of the management of the Clinic.

The second problem shows the process of sales claim, which represents a difficult problem in a large trading company. The Sales department of the company is responsible for processing and solving this problem. For this reason, interviews within the first phase were organized only with management at the Sales department level.

Both business processes discuss real and complex problems. To keep the methodological implementation simple and suitable to the purpose and objectives of this book, the processes are shown in a simplified manner.

The process of Surgery is shown throughout the explanation of the methodological phases in the first five chapters of the current part. The process of Sales_Claim is introduced in the final chapter.

Surgery

Corresponding to the first step of the current phase, the first round of interviews (these are interviews with the strategic management) was not carried out because there was no possibility to organize interviews with the management of the hospital at strategic level.

Therefore, the interviews were organized with management at the operational level of the clinic. Throughout these interviews with the leadership and physicians in-charge in the clinic, a number of goals were defined that represent their views on improving the process discussed. Accomplishing the business and operational goals listed below is possible only by implementing the necessary changes and improvements in the way of performing the process of surgical operations.

The defined goals are:

– Shortening the patients' waiting list,
– Shortening the patients' waiting time for surgery,
– Reducing post-surgical complications,
– Improving the conditions at the clinic for the patients' stay,
– Minimizing hospitalization time, and
– Minimizing hospitalization expenses.

In addition to the above defined goals, the management of the clinic throughout the interviews identified a number of work processes that are accomplished within the clinic, when the Surgery process is executed, such as:

– Registration,
– Hospitalization,
– Carrying out surgery, and
– Recovery.

Furthermore, the leading physicians informed the improvement team that in the process of carrying out surgery a patient goes through two main departments of the hospital. These departments are:

– Clinic and
– Surgery Block.

9.2 Process Flow Identification

The second step of the first phase deals with defining the flow of each of the listed business processes through the organization's various departments and units (Damij et al. 2008). This means that for each listed business process, we have to identify how the process as a link between a certain group of work processes performed within different departments of the organization is organized.

		Business Process	
Functional Area	Work Process	BP 1	BP 2
FA 1	WP 1	*	*
	WP 2		*
	WP 3	*	
FA 2	WP 4		*
	WP 5		*
	WP 6	*	

Fig. 9.1 Organizational structure of the process table

		Business Process
Functional Area	Work Process	Surgery
Clinic	Registration	*
	Hospitalization	*
	Recovery	*
Surgery Block	Carrying out anesthesia	*
	Carrying out surgery	*

Fig. 9.2 The process table of the business process surgery

To make sure this work is done properly, further interviews have to be arranged with management at operational level, which enables us to obtain the information needed to define the process flow using the following procedure:

(a) Develop a process table, presented later, that creates a linkage between each of the selected business processes and those work processes executed within the framework of the different departments of which it is comprised; and

(b) Obtain detailed information about the organizational structure of each department that is involved in performing a certain work process related to the business process discussed, in order to create a plan of interviews with the employees; these interviews are organized later in the next phase.

Creating a linkage between each business process and its work processes identified in different departments and units of the organization, even though it is not an easy task, is very important and contributes most to showing the actual structure of each business process. For this reason, we call it defining a process flow, which in our opinion is essential and in the end leads to a true identification of the functioning of each business process and consequently of the whole organization.

To achieve this, we create a table called the "Process Table". The Process Table is organized as follows: the first column presents functional areas or departments of the organization; the second column lists work processes grouped by the functional areas in the framework of which they are performed; in the following columns of the table, the business processes are defined where each business process occupies one column of the table.

An asterisk in any square(i, j) of the Process Table means that the work process defined in row i is performed within the framework of the business process defined in column j, where i ranges from 1 to the number of work processes and j ranges from 1 to the number of business processes. The following Fig. 9.1 shows the organizational structure of the Process Table.

Surgery
Using the information gained from the management of the clinic enabled us to develop a Process Table of the business process called Surgery. Fig. 9.2 shows the flow of the business process by connecting it to those work processes that are related to it within the Clinic and Surgery Block departments.

References

Damij, T. (2001). *Tabular application development for information systems*. New York: Springer.

Damij, N., & Damij, T. (2005). *Business process modelling and improvement using TAD methodology* (Lecture notes in computer science, pp. 380–385). Berlin: Springer.

Damij, N., Damij, T., Grad, J., & Jelenc, F. (2008). A methodology for business process improvement and IS development. *Information & Software Technology, 50*, 1127–1141.

Davenport, H. T. (1993). *Process innovation, reengineering work through information technology*. Boston: Harvard Business School Press.

Ould, A. M. (1995). *Business process modelling and analysis for re-engineering and improvement*. New York: Wiley.

Robson, M., & Ullah, P. (1996). *A practical guide to business process re-engineering*. Hampshire: Gower.

Phase 2: Process Modeling 10

Goals. In this chapter the following questions and themes are explored:

– Understanding the use of the Activity Table modeling technique
– Explaining the importance of the tabular-graphical modeling approach
– Introducing the parameters needed to describe process activities
– How to develop a model that truly reflects a real business process
– Describing the meaning of two dimensional connection of an activity
– Explaining the mean of a horizontal linkage
– Explain the mean of a vertical linkage

The second phase of TAD methodology deals with developing a process model for each of the business processes listed in the Process Table created in the previous phase. For this purpose, a special modeling technique, unique to the TAD methodology, is used. The main characteristics of this modeling technique are that it is more precise, strict, and less flexible in defining the flow of the activities of the process compared to other techniques. This fact in our opinion is very important in discovering and transferring the reality of the business process into a process model that truly represents it.

A process model is a description and logical presentation of a real process, whose development requires capturing all the information needed to create a complete understanding of the functioning of the process within the organization, in addition to identifying the process's interactions with its environment. This knowledge represents a precondition for developing a process model that is a true reflection of the original process.

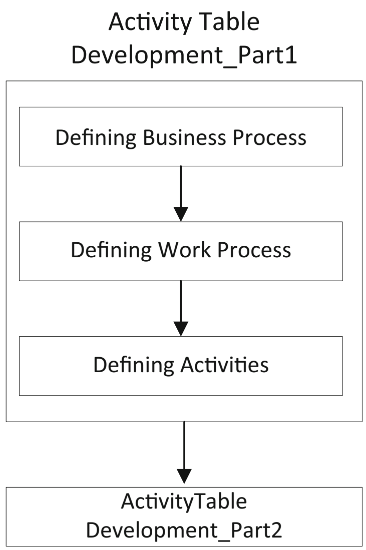
Business process modeling is carried out by organizing interviews with the management at departmental level, followed by conducting detailed interviews with the employees as groups or individuals in each department through which the business process flows. The aim of these interviews is to define and describe in detail each activity performed within the framework of every work process that is

N. Damij and T. Damij, *Process Management*, Progress in IS,
DOI 10.1007/978-3-642-36639-0_10,

related to the business process modeled corresponding to the content of the Process Table developed previously.

TAD methodology carries out business process modeling by developing a table called the Activity Table, which represents a model called the "as-is" process model. The model developed describes the behavior of the business process as it exists in reality in the organization.

The Activity Table consists of two parts and therefore the current phase consists of two subphases; the first discusses the creation of the first part of the Activity Table and the second subphase deals with developing the second part of the Table.



Phase 2: Process modeling

10.1 Activity Table Development – Part 1

In order to develop a process model that represents a true transference of the existing reality of a business process into the model, the state of the art of the process discussed should be first identified and understood completely. This goal is achieved by using the Activity Table technique; this is a powerful and effective modeling technique, whose advantage is in implementing a determined order in the process modeling that is unique to TAD methodology.

The first stage of discovering the reality of the business process is carried out by developing the Process Table, which represents the result of the first phase. The Process Table enables us to trace the flow of each of the selected business processes throughout those work processes that are performed within its framework in different functional areas.

Then our work in the first subphase of the second phase continues the work accomplished in the first phase by starting the development of the first part of the Activity Table of the process selected. The first part of the Activity Table is a tabular-graphical presentation of the process discussed.

This task is performed by defining the content in the columns of the mentioned part of the table and drawing connections that link the activities of the process to the resources that perform them and among themselves. Therefore, the current subphase consists of three steps: defining the business process, defining work processes, and defining activities.

10.1.1 Defining Business Process

We start the modeling process by discovering the behavior of the business processes listed in the Process Table one by one. For each of these business processes, we create a new Activity Table, which represents the "as-is" model of the process discussed. Therefore, the name of the business process selected is written in the first column of the new created Activity Table.

If the business process is large and complex, it needs to be partitioned into a set of subprocesses in order to be understood and explained. In such a situation, the subprocesses identified are listed in the second column of the Activity Table (Damij 1998).

10.1.2 Defining Work Processes

Our work continues by defining the content of the Work Process column, which is usually the second column of the table. This is done by entering the names of the work processes of the business process written in the first column.

Simultaneously with defining the content of the second column, the content of the first row of the Activity Table is created by entering the names of those departments in which the work processes listed are performed (Damij et al. 2008).

This work is performed by:

(a) Firstly: listing those work processes in the Work Process column of the Activity Table that are related to the business process discussed.

This is done in accordance with the connections existing in the Process Table between each business process and its work processes. Thus, following the connections indicated in the business process column of the Process Table leads us to identifying its work processes.

These work processes should be listed in the same sequence order as they are executed in reality.

(b) Secondly: for each work process listed in the Work Process column, we simultaneously write the name of the department (functional area) in which the work process is performed. This is also done in accordance with the relations defined in the Process Table between each work process and the department in which it is executed.

The information needed to implement the above given procedure for creating the Work Process column and the first row of the Activity Table is gained from the content of the Process Table. This table shows that the work processes that belong to a certain business process are indicated by asterisks in the cells of the business process column. In addition to this, each work process is also linked to the department in which it is performed. This is done by grouping work processes by departments or functional areas; see Figs. 9.1 and 9.2.

Furthermore, corresponding to the plan of interviews the process modeling team conducts interviews with the management at operational level; this means organizing interviews with the management of those departments defined in the first row of the Activity Table (Damij and Damij 2005). The aim of these interviews is to find answers to the following questions:

1. In what sequence order should the work processes be listed in the Work Process column of the Activity Table with the purpose of showing the business process discussed as a linkage between the set of work processes defined. This linkage shows that the work processes listed are performed within the framework of different connected departments as in reality.
2. Who are the people responsible for each of the work processes listed in the Work Process column and who are the most experienced and knowledgeable employees regarding its functioning, with whom further interviews should be organized.

10.1.3 Defining Activities

After completing the definition of work processes in the Work Process column of the Activity Table and listing them in the same sequence order as they executed in reality, the modeling team's work continues by identifying and describing the activities performed within each of the listed work processes. This is done by carefully analyzing the work processes, starting with the first one and continuing with others one by one until the activities of all the work processes are defined, described, and connected.

Before explaining this in detail, let us remember the definitions of an activity and a task:

- An activity is a simple microprocess that consists of one or more tasks that represent a well-defined work performed by one resource, or an activity may be understood as a simple algorithm that consists of a few instructions, such as creating a document or placing an order.

  The activity starts with an input or event that causes the execution of one or more successive tasks and ends by producing the anticipated output(s).
- A task could be understood as an elementary work within an activity, or as a well-defined segment within an algorithm, for example print a document or sign a document.

To identify the work accomplished within each work process, further interviews are conducted with previously identified experienced and knowledgeable employees responsible for the daily performance of the work process's activities. The purpose of these interviews is to identify, list, and gain detailed information about every process's activity. To do this, the following procedure is used:

For each work process defined in the Work Process column

For each activity identified within the work process:

(a) Write the name of the activity into the Activity (third) column of the Activity Table;
(b) Write the name of the resource, which performs the defined activity, into a certain column of the second row of the Activity Table under the first row segment, where the department is defined to which the resource belongs;
(c) Determine the inputs or events that enter the activity discussed from other activities or from the environment, and the output(s) that leaves the activity to other activities or to the environment;
(d) Identify the successor activities of the current activity;
(e) If the activity consists of tasks then list the tasks in the Task (fourth) column of the Activity Table successively as they are performed in reality;
(f) Connect the activity by a horizontal arrow(s) to the resource(s) that is/are involved with its execution;
(g) Connect the activity by a vertical arrow(s) to its successor activity or activities.

As was mentioned before, the development of the Activity Table represents the modeling technique used within TAD methodology. This table is capable of showing a complex and large business process in a single table that is simple and easy to develop, survey, and update. The Activity Table is usually structured as follows:

1. The first column shows the business process selected;
2. The second column is occupied by subprocesses if the business process is partitioned into subprocesses;
3. The next "Work Process" column lists the work processes of the business process;
4. The next "Activity" column lists the activities grouped by work processes;
5. If there are activities, which are decomposed into tasks, then the next "Task" column lists tasks grouped by activities;
6. The rest of the table is structured as follows:
   - The first row lists the organization's departments and units in which the business process as carried out;
   - The second row lists the resources, grouped by the departments in the first row, that perform the activities defined in the rows of the "Activity" column;
7. The last columns of the first part of the table are used to represent outside entities; each entity from the environment occupies one column.

To make the Activity Table reflect the realty of the business process modeled, we need to link all the activities horizontally and vertically. The purpose of making horizontal and vertical connections is to transfer the true behavior of the original process into the process model developed. This modeling concept is used because each activity in reality is connected to a resource that performs it and to a number of activities from which gets input(s) and to which it sends an output(s).

This means that the technique requires generating two dimensional connections for every activity identified in order to develop a model that truly reflects the process modeled. The first dimension connects the activity with the resources in the columns; while the second dimension connects it with other activities in the rows.

This modeling concept enables the Activity Table to be a very effective technique for developing a more accurate process model that represents the reality of the process behavior. The concept of two dimensional connections has the following advantages:

– Provides the modeler with a well-defined and more precise way of tracing the identification of activities one by one as they executed in reality; and
– Prevents the possibility that the modeler overlooking an activity or activities during interviews with users and in this way helps in generating a model without gaps or omissions.

On the other hand, the use of the Activity Table is a more demanding and less flexible technique compared to other modeling techniques.

Modeling techniques, such as the flowchart technique, usually link activities to each other sequentially; that is, a predecessor activity is linked to its successor activity or activities. This way of modeling is very flexible and depends on the modeler's understanding of the process discussed. For this reason, the flexibility of the modeling technique may lead to the creation of gaps in the process model developed, which means that a number of activities are missed and do not exist in the model. This happens when the modeler overlooks a number of activities existing in reality. In practice, we found a number of gaps in different process models that are developed using techniques such as the flowchart. In our opinion, the reason for this result lies in the flexibility of the modeling technique, in addition to an insufficient understanding of the process considered by the modeler.

The aim of using the Activity Table modeling technique is to attempt to make the process model independent of the modeler's understanding of the process studied by removing or at least reducing the flexibility problem. Therefore, the developed "as-is" process model should represent a true reflection of the reality of the original process.

As was mentioned before, in this modeling concept, every activity has to be connected horizontally to a resource(s) that is related to it and vertically to a successor activity or activities except the last one.

The horizontal linkage means that each activity must be linked to those resources defined in the columns of the second row of the table that are needed to perform it. Usually, each activity is linked to two resources; these are the resource that is involved in performing the activity and the resource that provides an input (for example, a customer), or a resource that receives an output produced by the activity (for example, a clerk, customer).

The vertical linkage is used to define the order in which the activities are followed and performed, as in reality. Therefore, each activity is connected with one or more predecessor activities, except the first one, and is also linked to one or more successor activities, except the last activity.

If an activity consists of several tasks then the same rules are used to connect every task to the resources in the columns and to the other tasks or activities in the rows of the table.

To carry out process modeling using the Activity Table technique, a small set of flowchart symbols is used either inside the cells of the Activity Table, such as: ○, ◎, □, ◊, |, or arrows that connect the symbols into the cells horizontally and vertically, such as: →, ←, ↓, ↑. The symbols used have the following meaning:

- Symbol ○ indicates the starting point of a process. The symbol ○ in cell(1,11) of Fig. 10.1, starts the Surgery business process.
- Symbol ◎ indicates the end point of a process or the end of a certain path of the process. For example, symbol ◎ in cell(32,11) ends the whole process.
- Symbol □ in cell(i,j) means that resource(j) performs activity(i), where j ranges from 1 to the number of resources and I ranges from 1 to the number of activities. For example, symbol □ in cell(1,1) means that resource(1) executes activity(1).
- Symbol ◊ in cell(i,j) means that activity(i) is a decision activity. Such an activity starts different alternative paths and is succeeded by different alternative successor activities. For example, Symbol ◊ in cell(7,2) means that activity(7) is a decision activity followed by activity(8) or activity(32) as alternative successor activities.
- Horizontal arrows →, ← are used to connect the activity horizontally. A horizontal arrow that is drawn from cell(i,j) to cell(i, k) shows a horizontal linkage from activity(i), which is performed by the resource(j), to resource(k), which is related to the activity's output. For example, an arrow from cell(2,1) to cell(2,2) means that resource(2) receives the output of activity(2); while an arrow from cell(3,2) to cell(3,1) means that the output of activity(3) is sent to resource(1).
- Vertical arrows ↓, ↑ are used to link the activities vertically. A vertical arrow that is drawn from cell(i,j) to cell(k, j) shows a vertical linkage from activity(i) to its successor activity(k). For example, an arrow from cell(1,1) to cell(2,1) means that activity(1) is linked vertically to its successor activity(2).

In our example, a horizontal arrow from cell(2,1) to cell(2,2) continued by a vertical arrow to cell(3,2) means that the output of activity(2) is received by resource(2), which as an input enters activity(3) and triggers its processing. This means in reality that resource "Nurse" executes activity(2); this is that she forwards the patient and patient's documents to resource "Doctor". The doctor receives the patient's documents and executes activity(3); that is he examines the patient.

- Symbol * in cell(i,j) and cell(i,k) means that activity(i) could be performed by resource(j) or resource(k) as alternative resources.
- Symbol | is used to fork outputs of an activity or merge inputs of different activities.

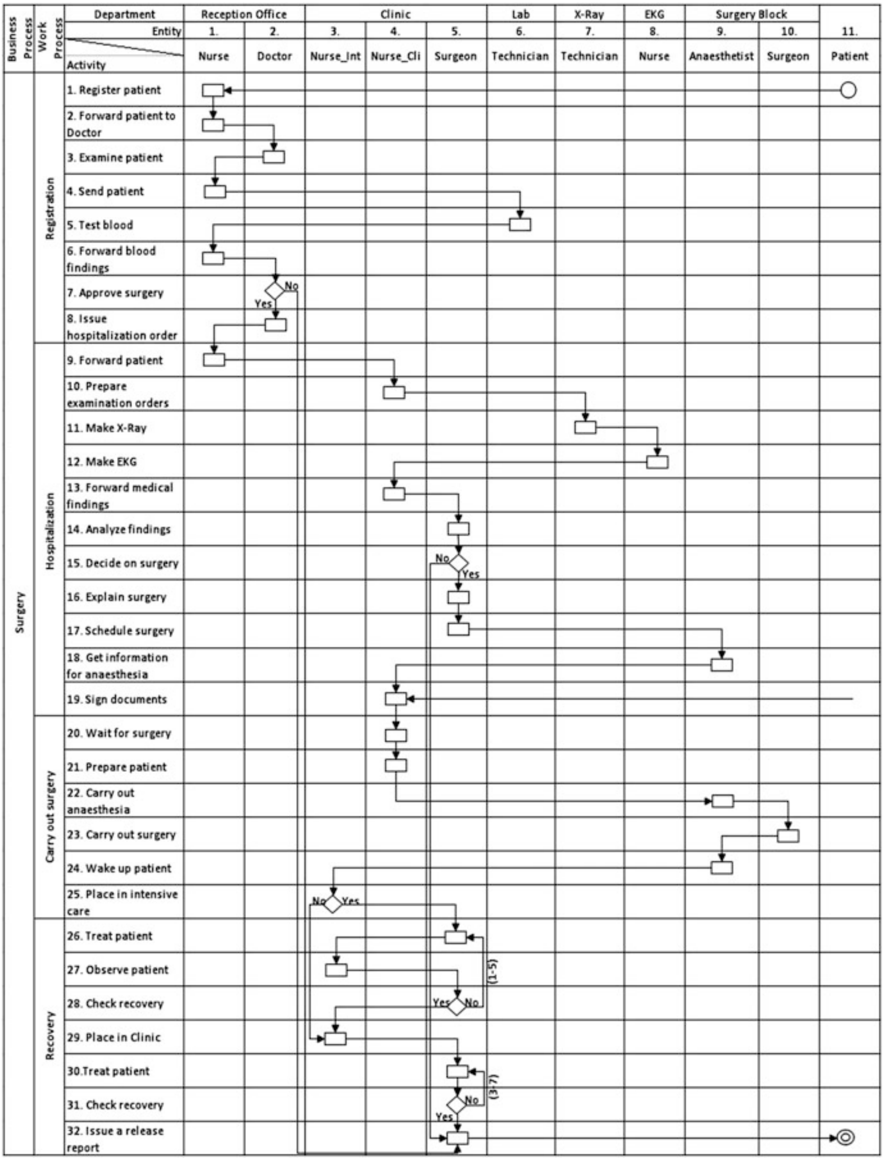


Fig. 10.1 Activity Table – Part 1 of "as-is" model of surgery process

Surgery.
Figure 10.1 introduces the first part of the Activity Table of the business process "Surgery", which represents the "as-is" model of the process. This is a tabular-graphical representation of the business process discussed that is completed later by the second part that describes the model in detail.

As Fig. 10.1 shows, the business process comprises four work processes; these are Registration, Hospitalization, Carrying out Surgery, and Recovery. The first work process contains 8, the second 11, the third 6, and the last 7 activities. The second row of the table shows 10 resources that are involved in carrying out the activities of the process. These resources are grouped into the 6 departments shown in the first row.

10.2 Activity Table Development – Part 2

Simultaneously with creation of the first part of the Activity Table or after its the completion of, we create the second part of the Activity Table. This part of the table completes the development of the model of the business process discussed, which is represented by the whole Activity Table.

The role of the second part of the table is to describe the process behavior and provide detailed information about each activity performed within it. The process description and the process flow presented in the first part of the table together create a complete and clear picture of the business process modeled.

The detailed information about the process's behavior is collected during interviews that are organized and conducted with the resources listed in the second row, which are responsible for performing the activities listed in the "Activity" column of the first part of the table.

In the current subphase, a number of parameters that describe activities are defined using the following procedure:

For each activity defined in the "Activity" column, detailed information or parameters must be identified, such as:

- A precise and short description of the activity,
- Input(s) that triggers the processing of the activity,
- Output(s) created by processing the activity,
- Constraints and rules related to the activity's execution,
- Duration of time estimated for performing the activity, and
- Resources needed for performing or related to the activity.

The above listed parameters are very important for understanding the functioning of the business process, developing the process model properly, and providing essential data needed for carrying out the improvement of the process performed in the third phase.

The Process and Activity Tables are simple yet very rich in information about each business process discussed and consequently about the functioning of the organization as a whole (Damij 2001). In addition, these tables represent a group of simple, efficient, and tightly connected techniques, which are unique to the methodology. On the other hand, both tables show that the TAD methodology is capable of solving the problems of identification and modeling complex processes in an easy manner. This represents the advantages of the methodology compared to other process management methodologies.

10.2.1 Activity Description

In the columns of the second part of the Activity Table significant parameters such as Description, Time, Rule, Input, Output, Cost, and Resource are defined for each activity(i), where i ranges from 1 to the number of activities (Damij et al. 2008).

- *Description*. This column is used to write a short and precise description of what exactly is the work carried out by the activity defined in row(i) of the table.
- *Resource*. This column is used to define the resource that performs the activity(i).
- *Time*. This parameter is used to denote the expected duration needed for activity (i) to be processed and accomplished. The processing time of the activity is a very important factor in carrying out business process improvement and innovation in the third phase.
- *Rule*. This characteristic is used to define one or more conditions or rules that must be satisfied in order for the activity(i) to be performed. A rule is a precise statement that defines a constraint, which must be satisfied in order for a certain activity to be executed.
- *Input*. This parameter is used to indicate which input(s) is needed to enter activity(i) to trigger its execution.
- *Output*. In this column the output(s) of activity(i) produced as a result of processing the activity is/are indicated.
- *Cost*. This is the sum of the expenses needed to accomplish the activity(i). This parameter is later used to calculate the cost of each work process and consequently the whole business process. Thus, this is an important parameter that needs to be calculated for the purpose of business process improvement and innovation.

Developing the whole Activity Table is an iterative process. Usually, it is necessary for a number of the interviews to be repeated to arrive at a precise understanding of the employees' work. If anything is misunderstood or overlooked, then new interviews should be organized with responsible and knowledgeable employees to clarify it.

Surgery.

Figure 10.2 shows the second part of the Activity Table of the business process "Surgery", which represents the detailed information that defines the values of the parameters that are related to each activity listed in the first part.

The first column of this part is actually a repetition of the "Activity" column of the first part of the table. The purpose of showing it again in this part is to enable the reader to follow the information about each listed activity provided by both parts. This is because although the two parts are usually presented separately, together they represent the whole process model.

The values shown in the Time column of Fig. 10.2 are approximate values obtained from the medical staff. Moreover, we were unable get any information about the costs of the listed activities from the management of the hospital, because this is regarded as a business secret.

Parameter / Activity	Description	Resource	Time	Rule	Input/ Output
1. Register patient	Nurse in Reception Office accepts patient's medical card, Doctor's order, registers her/him	Nurse-RO	10-20 min	Check medical card validity	Doctor's order, Medical card
2. Forward patient to Dr	Forward the patient and patient's documents to the doctor	Nurse-RO	5 min		Medical card
3. Examine patient	Doctor in Reception Office examines the Patient	Doctor-RO	15-30	Check patient's medical record	Medical record
4. Send patient to Lab	Nurse in Reception Office takes patient's blood sample and sends it to Laboratory	Nurse-RO	10 min		Blood examination order
5. Test blood	Technician in Laboratory tests blood sample and sends results back to reception office	Technician-Lab	30-60 min	Check blood examination order	Blood exam. order, Blood findings
6. Forward blood Findings	Nurse in Reception Office receives & prints patient's blood findings and gives it to Doctor	Nurse-RO	10-15 min		Blood findings
7. Approve Surgery	Doctor in Reception Office decides for a conservative treatment or surgery after analyzing blood and other findings	Doctor-RO	10-15 min	Check blood findings	Medical record,Blood findings
8. Issue hospitalization order	Doctor in Reception Office asks Nurse to prepare hospitalization order	Nurse-RO	30 min		Hospitalization order
9. Forward patient	Nurse in Reception Office forwards patient with a hospitalization order to the clinic for hospitalization		30 min	Check hospitalization order	Hospitalization order
10. Prepare Examination orders	Nurse in clinic opens temperature form and prepares examination orders for EKG, X-ray, Anaesthesia	Nurse-Cli	30-60 min		Temperature form, EKG, X-ray orders
11. Make X-Ray	X-Ray department accepts X-ray order and makes patient's X-ray	Technician-X-ray	30 min		X-ray
12. Make EKG	EKG department accepts EKG order and makes patient's EKG	Nurse-EKG	30 min		EKG
13. Forward medical findings	Nurse in clinic accepts X-ray and EKG, puts them in patient's file, and forwards it to the surgeon	Nurse-Cli	30-60 min		X-ray, EKG
14. Analyze findings	The surgeon analyzes patient's findings	Surgeon	30 min	Check medical findings	Findings
15. Decide on surgery	Surgeon on the basis of findings makes final decision on surgery	Surgeon	15 min		

Fig. 10.2 (continued)

16. Explain surgery	Surgeon provide a more detailed explanation of surgery to patient	Surgeon	30 min		
17. Schedule surgery	Surgeon determines the final date of surgery	Surgeon	30 min		
18. Get information for anesthesia	Anesthetist gets information from patient about anesthesia	Anesthetist	30 min	Check previous problems with anesthesia	Anesthesia Report
19. Sign documents	Patient signs anesthesia and surgery documents		60 min	Read documents carefully	Signed documents
20. Wait for surgery	Patient waits for surgery until is informed a day before		0-2 days		
21. Prepare patient	Nurse-Cli prepares patient for surgery	Nurse-Cli	30 min		
22. Carry out anesthesia	Anesthetist carries out anesthesia	Anesthetist	30 min	Check report of anesthesia	
23. Carry out Surgery	Surgeon carries out surgery	Surgeon	2-5 hours	Check medical findings	
24. Wake up Patient	Anesthetist wakes up patient	Anesthetist	5-10 min		
25. Place in intensive care	Nurse places patient in intensive care room. 10% of patients are placed in intensive care		10-15 min		
26. Treat patient	Nurse in intensive care provides patient with prescribed treatments 3 times per day, 0-5 days (most likely 1 day)	Nurse-Int	3(10-15) min (0-5) days		Temperature form
27. Observe patient	Nurse in intensive care observes patient's state and provides what patient needs 6 times per day, 0-5 days (most likely 1 day)	Nurse-Int	6*10 min (0-5) days		Temperature form
28. Check recovery	Surgeon checks patient's recovery state 2 times per day, 0-5 days (most likely 1 day)	Surgeon	2(10-15) min (0-5) days		Temperature form
29. Place in clinic	Nurse in clinic places patient in patient ward in clinic	Nurse-Cli	15 min		Temperature form
30. treat patient	Nurse in clinic provides patient with prescribed treatments 3 times per day, 5-10 days (most likely 6 days)	Nurse-Cli	3*10 min (5-10) days		Temperature form
31. Check recovery	Surgeon checks patient's recovery daily twice per day, 5-10 days (most likely 6 days)	Surgeon	2*10 min (5-10) days	Check temperature form	Temperature form
32. Issue release Report	Patient waits to receive a release report issued by the surgeon	Surgeon	1-3 Hours		Release report

Fig. 10.2 Activity Table – Part 2 of "as-is" model of surgery process

References

Damij, T. (1998). Development of a hospital information system using the TAD method. *Journal of the American Medical Informatics Association, 5*(2), 184–193.

Damij, T. (2001). *Tabular application development for information systems*. New York: Springer.

Damij, N. (2005). *Business process modelling and improvement using TAD methodology* (Lecture notes in computer science, Vol. 3649, pp. 380–385). Berlin: Springer.

Damij, N., Damij, T., Grad, J., & Jelenc, F. (2008). A methodology for business process improvement and IS development. *Information and Software Technology, 50*, 1127–1141.

Phase 3: Process Improvement and Innovation

11

Goals. In this chapter the following questions and themes are explored:

– Understanding the behavior of the "as-is" process by using the simulation technique
– Calculating the process performance parameters from the simulation results of the "as-is" process
– Identifying improvement ideas on the basis of the process performance analysis of the "as-is" process
– Developing the Improvement Table to store tacit knowledge and new ideas
– Using knowledge stored in the Improvement Table to create the "to-be" process model
– Creating a new "to-be" process model represented by a new Activity Table
– Identifying the behavior of the "to-be" process using the simulation technique
– Using the simulation results to calculate the "to-be" process performance parameters

Process improvement and innovation is a key phase within process management that in recent years has become an essential way of ensuring changes in an organization's structure and functioning in order to create a better, more competitive and successful enterprise.

Business process improvement and innovation is connected tightly with customer satisfaction. Therefore, when the customer is satisfied with the products or services of the organization, then there is probably no need for implementing changes in the organization's way of functioning and doing business.

If not, then the organization will discover that the customers are unsatisfied with its products or services. This fact becomes obvious when it finds a continuous decrease in the sales of its products or services, which consequently causes a major reduction in its profit. When this happens then the business processes of the organization need to be improved or innovated as soon as possible.

N. Damij and T. Damij, *Process Management*, Progress in IS,
DOI 10.1007/978-3-642-36639-0_11,

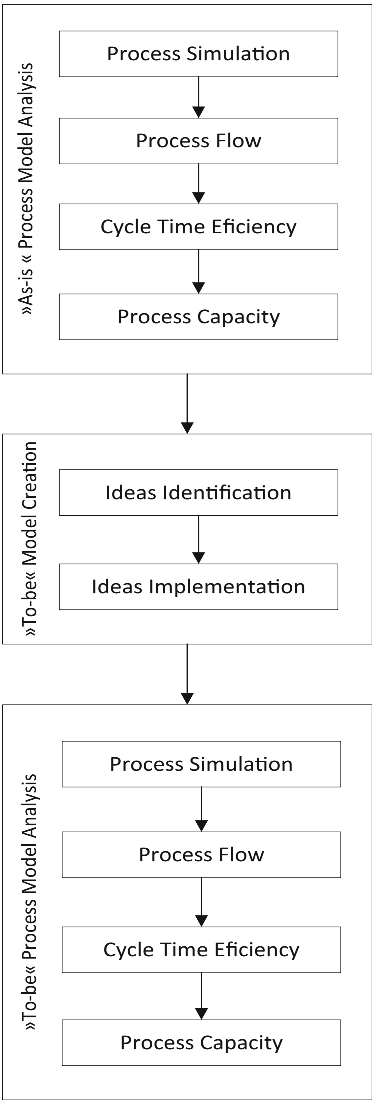
The relationship between the essence of business process modeling and overall business effectiveness and the efficiency of the organization depends on the consumer's satisfaction with the desired output. If the latter is everything the consumer required and aimed for, business processes are well-designed, efficient, as well as effective and will in time result in successful organizations (Al-Mashari and Zairi 2000).

On the other hand, if the consumer lacks appropriate satisfaction or the organization's growth and profit are decreasing, then business process management is the right solution that has to be planned and carefully carried out in the organization.

The third phase of TAD methodology deals with carrying out process improvement and innovation by identifying and implementing changes, searching for better solutions to existing problems, or considering developing new alternative solutions in order to improve the functioning of the enterprise.

To achieve that, we have to identify and understand the business processes as they are described by the company's documents and employees, as was discussed in the first two phases. In addition to that, the tacit knowledge accumulated by experienced people within the enterprise must be identified, captured and implemented.

Business process improvement and innovation is a complex and difficult interdisciplinary problem, whose solution requires the use of knowledge from different scientific disciplines, such as process analysis, knowledge management, and simulation. The current phase of TAD methodology consists of three sub-phases; these are "as-is" process model analysis, "to-be" process model creation, and "to-be" process model analysis.



Phase 3: Process improvement and innovation

11.1 "as-is" Process Model Analysis

In the first subphase of the process improvement and innovation phase, we try to identify existing problems within the "as-is" process model, developed in the second phase, and the possibilities available to solve these problems leading to improvement of the process (Damij and Damij 2005).

If improvement of the process selected is very difficult and questionable because the process needs radical changes, then process innovation is the right solution for creating a new process that replaces the existing one (Damij et al. 2008).

In order to achieve the organization's goal in making each of its processes more effective, we first have to analyze the "as-is" model of each selected process using the process performance measurements introduced in Chap. 5 in order to measure the process's performance.

Therefore, before starting process improvement, the state of the art of the process discussed is identified in order to provide a complete picture of process functioning, as described through process modeling in the second phase. Thus, the current subphase consists of four steps; these are simulation, process flow measures, cycle-time efficiency, and capacity utilization.

It is important to emphasize that the management of the organization should realize that process improvement is a dynamic process, which needs to be done continuously in order to keep the organization's processes effective and competitive. If the management of the organization stops the evaluation of the process after process improvement has been completed, the process will over time lose the value gained. So, process improvement should be planned to be done in determined and repeated periods of time.

11.1.1 Process Simulation

After developing the "as-is" process model, the process should be tested in a similar environment to the real one in order to discover its behavior and to analyze it using the process performance measurements. Simulation is a technique that enables us to create an environment that is similar to reality and therefore is the right technique for this purpose.

As was mentioned before, a business process is a horizontal process, which represents the connection between a set of work processes performed within the framework of one or more departments of an organization. A business process may be a complex process, which has to be partitioned into a number of subprocesses in order to understand it completely. Likewise, a work process consists of a group of activities that provide specific work, which together result in an expected output. Furthermore, an activity is simply a microprocess that is performed by one person and consists of a number of tasks. Finally, a task is a well-defined elementary work or job.

From the above given short description, it is understandable that we are dealing with a very complex and difficult concept, which can function effectively only when it is well organized and continuously improved in order to enable proper management.

We may observe that in reality a number of difficult problems develop over time within each process. Such problems lead to the ineffectiveness and inefficiency of the process that is shown by a number of obstacles and bottle necks that cause queues and other difficulties that consequently result in customer dissatisfaction.

In addition to this, resource unavailability represents another problem that plays an important role in creating queues and consequently in decreasing the effectiveness and the quality of the process, which sooner or later leads to an unsuccessful organization.

As was explained in the first section of Chap. 7, queues may be found in different kinds of processes, such as business, administrative, medical and other processes. Solving the problem of queues may be achieved by using the simulation technique, which is the subject of the current step of the third phase of TAD methodology, with the purpose of improving the functioning of the process by raising its effectiveness and quality.

A flow unit (document, patient, or product) enters a process from its environment, proceeds through various activities, and exits it as an output into the process's environment. A flow unit, job, or transaction on its way through the process may join other flow units at the end of queues waiting to be processed by process's activities.

Simulation is a technique that enables us to imitate the functioning of a certain real process by developing a process model whose attributes are the same as the attributes of the original one. For this purpose, real life input data is collected and used in conducting experimentation on the behavior overtime of the model developed, without disturbing the functioning of the original process.

In addition, the simulation technique provides the very important possibility of carrying out experimentation on the process discussed by generating various scenarios and testing different options of "what-if" questions that are based on an understanding of the process's functioning and an analysis of the simulation output results.

Let us recall some definitions of simulation and discrete systems given by Banks et al. (2001):

– A simulation is the imitation of the operation of a real-world process or system over time;
– A discrete system is one in which the state variable(s) change only at a discrete set of points in time.

Furthermore, the simulation of a business process is also a computer-based simulation, which means that such a simulation is done by running special software on the computer system. This kind of simulation plays an important role in shortening the execution time of activities within the process because discrete-event simulation regards time as the only element that is taken into consideration.

In this step, the improvement team uses the simulation technique to imitate the behavior of the "as-is" process model. Thus, the team prepares a scenario(s) to run the simulation of this process model. Such a simulation enables the improvement team to imitate the behavior of the process in an environment similar to reality in order to make necessary changes if needed. The results of this simulation are later compared with the results from the simulation of the "to-be" process.

Process simulation is an iterative approach, which may be repeated a number of times until the improvement team is satisfied with the solution achieved.

Surgery
Using simulation is important because it creates an environment to test the process's behavior similar to that existing in reality. Therefore, this technique enables us to experiment with the process behavior, for example, by generating such a number of transactions as the number of flow units that pass through the process in reality.

The iGrafx simulation software package was used to develop a simulation model of the healthcare process termed Surgery. This model was created on the basis of the "as-is" process model, shown in Figs. 10.1 and 10.2.

Simulation of the Surgery process was run taking into consideration the following assumptions:

– The capacity of the Clinic is 30 beds and is completely occupied;
– The number of patients hospitalized daily is equal to the number of patients that leave the hospital;
– 500 patients are scheduled for different kinds of surgery;
– The "as-is" process model presented by Fig. 10.1, Activity Table – part 1, was transferred into a simulation model (iGrafx process);
– The duration times of the activities of the simulation process were defined corresponding to the times listed in the column "Time" of the Activity Table – part 2, see Fig. 10.2;
– Seven resources are defined; these are 3 Nurses in the Clinic, 1 Nurse in Intensive Care, 1 Nurse in EKG, 1 Doctor in X-ray, 3 Surgeons, 1 Anesthetist, and 1 Technician in the Laboratory;
– 10 % of patients are placed in Intensive Care;
– Recovery in Intensive Care is defined by the function TriangleDist(0, 5, 1), which means that the minimum stay time is equal to 0, the maximum is equal to 5 days, and the most likely 1 day; and
– Recovery in Clinic is defined by function TriangleDist(5, 8, 5), which means the minimum stay is 5, the maximum 8, and the most likely 5 days.

Using the above given assumptions, the simulation model is shown in Fig. 11.1.

The results gained from running the simulation of the "as-is" process were used to calculate the process performance parameters in the next three steps of the current subphase.

11.1.2 Process Flow

As was stated in Chap. 5, process flow is a dynamic process that starts when a flow unit or job enters a process, continues processing throughout the process's activities, and ends when the flow unit leaves the process as its output.

To measure the process flow, three key measures are used; these are cycle time, flow rate, and inventory. These measures enable us to calculate:

– The average time that a flow unit needs to pass through the process (average cycle time);

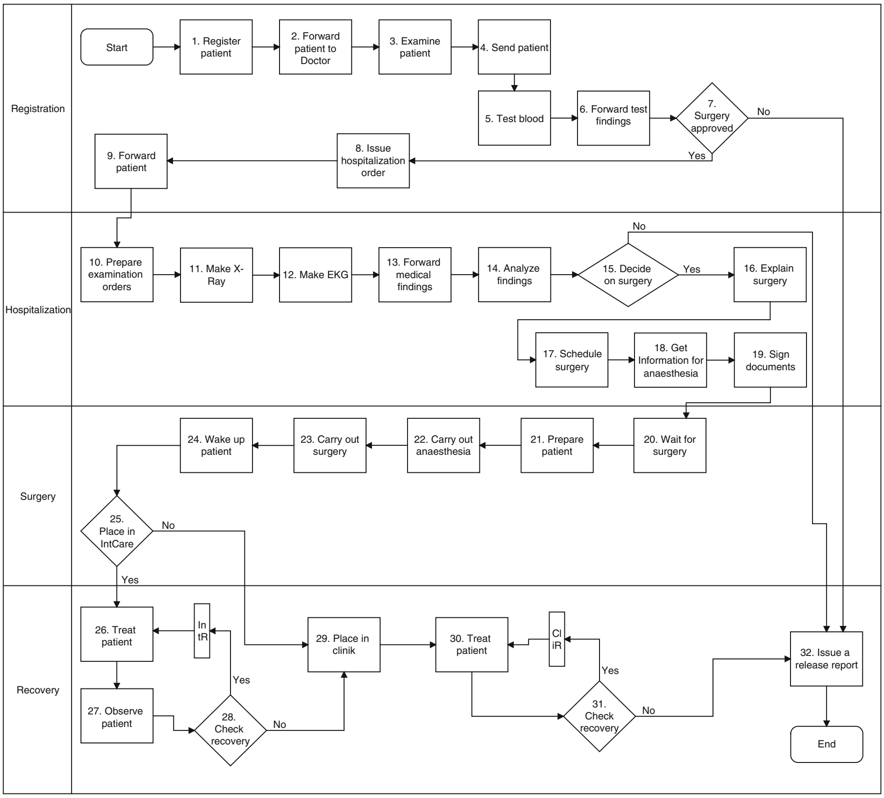


Fig. 11.1 Simulation model of "as-is" process surgery

– The average number of flow units that are inside the process boundaries at any point of time (average inventory); and
– The average number of flow units that pass through the process per unit of time (average flow rate).

Before using the process flow measures, let us remember their definitions given in Chap. 5:

– The average cycle time is the average of the cycle times of all flow units that exit the process during a specific period of time;
– The average inventory is the number of flow units within the process boundaries at any point in time; and
– The average flow rate is the average number of flow units that flow through the process per unit of time.

Process flow is defined by the listed variables, which are calculated using Little's law, which defines an important relationship between the average inventory, the average flow rate, and the average cycle time in a stable process. Little's law is:

$$I = R * T \tag{11.1}$$

where I is average inventory, R is average flow rate, and T is average cycle time.

The average cycle time of a process is gained from the results of a simulation run in the previous step. Information about the average inventory is usually obtained from the management during interviews, whereas the average flow rate is calculated using Little's law.

Surgery

The results of running a simulation of the "as-is" model of the Surgery healthcare process show that the average cycle time of the process is 14.6 days, the minimum cycle time is 9, and maximum cycle time is 20.86 days. Furthermore, the average inventory, as one the key measures of the process flow, was identified from information obtained from the management of the clinic. During the interviews conducted in the first phase, we learned that the maximum number of patients in the clinic is 30, the clinic is occupied completely and the waiting period is several months.

Therefore, the flow rate of the Surgery process was calculated using formula 11.1, as follows:

$$
\begin{aligned}
& \mathrm{I} = \mathrm{R} * \mathrm{T} \\
\text{Average} \quad & \mathrm{T} = 14.6 \text{ days} \\
\text{Average} \quad & \mathrm{I} = 30 \text{ patients} \\
\text{Average} \quad & \mathrm{R} = 30 \,/\, 14.6 = 2 \text{ patients per day}
\end{aligned}
$$

11.1.3 Cycle Time Efficiency

Usually a flow unit on its way from the start to the end of a process goes through a sequence of activities and buffers. Therefore, the cycle time of a flow unit within a process consists of the times spent within the process's activities and the waiting times spent in different buffers.

In order to discuss and calculate cycle time efficiency as an important process performance measurement, we need first to understand the meaning of important terms, such as theoretical cycle time, activity time, and waiting time.

The theoretical cycle time of a process could be defined as the sum of times of activities needed for processing a flow unit throughout the process.

The activity time is actually the time needed for an activity to complete the processing of a flow unit.

The waiting time is the time spent by a flow unit within a buffer waiting for an activity to start processing it.

The cycle-time efficiency is a percentage comparison between the theoretical cycle time and the average cycle time and, therefore, obtained by dividing the theoretical cycle time by the average cycle time of the process. The cycle-time efficiency is the ratio between the theoretical cycle time and the average cycle time. It is calculated using the following formula:

$$\text{Cycle Time Efficiency} = \text{Theoretical Cycle Time} \ / \ \text{Average Cycle Time} \tag{11.2}$$

Surgery
The theoretical cycle time is obtained from the results of the “as-is” process simulation. These results show that the theoretical cycle time in our example is equal to 2.47 days. Therefore, the cycle time efficiency of the Surgery process is calculated using formula 11.2, as follows:

$$\text{Cycle time efficiency} = 2.47 \ / \ 14.6 = 17\%$$

This result shows that the existing process is very inefficient and needs immediate action to improve it.

11.1.4 Process Capacity

It is obvious from the explanation introduced in Chap. 5 that the process capacity is an essential tool to measure process performance and represents an important indicator that helps management to make decisions concerning the improvement of their business processes. Thus, let us recall some of the definitions and explanations given in Chap. 5.

Anupindi et al. (2006) defined the process capacity as: “The maximum sustainable flow rate of a process”. And as we know, the average flow rate represents the average number of flow units that flow through the process per unit of time.

The capacity of a process depends on the process resources, which are needed for performing the activities of the process. In other words, the resources play a very important role in determining whether the process capacity is as it should be. Therefore, it is important to emphasize that the improvement team, in addition to the process activities, should also pay maximum attention to the process resources.

In order to understand the process capacity, let us recall a few terms, such as resource pool, unit load, theoretical capacity and capacity utilization.

As introduced before, a group of resources that perform similar kinds of activities forms a resource pool. Furthermore, each member of a resource pool represents a unit of this pool. A number of resources may be involved in performing an activity and it is also true that one resource may be involved in carrying out several activities.

The unit load of a resource is the sum of the times of activities performed by a certain resource in processing a flow unit throughout the process.

In reality, resources are not always available. In addition to working time, there are also times when resources are not available for performing activities. Therefore, the theoretical capacity of a resource unit was defined by Anupindi et. al. (2006), as: “the resource’s maximum sustainable flow rate if it were fully utilized”. And the theoretical capacity of a resource pool, as: "the sum of the theoretical capacities of all resource units in that pool".

Different resource pools may have different theoretical capacities and calculating their theoretical capacity leads to determining the pool with the minimum theoretical capacity, which represents the bottleneck resource pool of the process and defines the theoretical capacity of the whole process.

The theoretical capacity of the process is calculated using the following formula:

$$R_p = c_p / T_p * \text{ Load Batch } * \text{ Scheduled Availability} \tag{11.3}$$

where:

– R_p is the theoretical capacity of resource pool p,
– c_p is the number of resource units in resource pool p,
– T_p is the unit load of a resource unit in resource pool p,
– Load Batch is the ability of a resource unit to perform a number of flow units simultaneously, and
– Scheduled Availability is the working time in which a resource unit is scheduled.

Average flow rate and theoretical capacity are measures used to determine the number of flow units that pass through the process per unit of time. Considering both measures, we may find that it is rare in reality for the theoretical capacity to equal the throughput of the process. This is because of resource unavailability and idleness, a low outflow rate related to low demand, or a low inflow rate related to problems with supply rate.

In addition, capacity utilization measures the degree to which resources are effectively utilized by a process. Capacity utilization indicates the extent to which resources, which represent invested capital, are utilized to generate outputs (flow units and ultimately profits) (Anupindi et al. 2006).

Capacity utilization is defined for each resource pool. The capacity utilization of the process is defined as the capacity utilization of the bottleneck resource pool (Anupindi et al. 2006).

The capacity utilization of a resource pool can be calculated using the following formula:

$$\rho_p = R / R_p \tag{11.4}$$

where ρ_p is the capacity utilization of a resource pool, R is the average flow rate and R_p is the theoretical capacity of the resource pool.

Surgery

The capacity utilization of each resource pool is calculated and shown in the results of the "as-is" process simulation, as follows: Surgeon 38.11 %, Nurse in Clinic 31.05 %, Nurse in Intensive Care 14.01 %, Anesthetist 30.19 %, Doctor in X-ray 17.37 %, Nurse in EKG 17.40 % and Technician 25.87 %.

The theoretical capacity of each resource pool of the process could be calculated using formula 11.4; that is by dividing the flow rate of the process by the capacity utilization of each resource pool, as follows:

From the above results, the theoretical capacity and capacity utilization of the whole process are equal to 5.26 and 38.11 %, respectively, because these values are the theoretical capacity and capacity utilization of the bottleneck resource pool Surgeon.

11.2 "to-be" Model Creation

The previous subphase of the current phase provided a detailed analysis of process performance with the aim of gaining essential information about what kind of a process we are dealing with. The calculated process performance enables the management to make a decision about the necessity of process improvement or innovation. This information also enables the improvement team to determine which performance parameters are more problematic and must be tackled first in the improvement process.

The process performance measures obtained from the analysis of the previous subphase, such as flow rate, inventory, cycle time, cycle-time efficiency, theoretical capacity and capacity utilization, help the team to target those problems of the process that cause the ineffective functioning of the process.

The listed process performance parameters are interdependent. Therefore, for example, shortening the process cycle time may consequently lead to decreasing the inventory, increasing the flow rate, cycle time efficiency and theoretical capacity. In order to shorten the cycle time efficiency of the process, different possibilities should be studied carefully, such as:

- Removing work processes that fit better within other business processes,
- Removing or reducing waiting times,
- Removing unneeded activities,
- Shortening the duration of time-consuming activities, and
- Reducing the number of repetition loops.

Increasing the cycle time efficiency is done by removing or at least reducing waiting times. Furthermore, increasing the theoretical capacity of the process, results in a better capacity utilization of the bottleneck resource pool. To do this, the team should think about the following solutions:

- Removing or shortening the waiting times,
- Reducing the unit load of the resource pool,
- Adding new resource units to the resource pool, and
- Increasing the availability of the resource units of the pool.

In order to create an effective "to-be" process model, the improvement team should benefit from concepts of the knowledge management cycle, such as knowledge capture and/or creation, knowledge sharing and dissemination, and knowledge acquisition and application. These concepts may contribute a great deal in solving a complex and demanding problem such as process improvement and innovation.

Therefore, the current subphase consists of two steps: ideas identification and ideas implementation, which benefit from the first and second concepts of knowledge management. Meanwhile, the fourth phase of TAD methodology implements the identified and articulated knowledge, which is concurrent with the third concept.

11.2.1 Ideas Identification

In the previous subphase, performance measurements, such as average cycle time, average flow rate, cycle time efficiency, theoretical capacity and capacity utilization were made by running a simulation of the "as-is" process. This enabled the team to analyze the simulation results in order to decide which actions are necessary to improve the process.

Depending on the problems identified, the team decides to organize interviews with knowledgeable employees or to invite them to join the team. The reason for doing this is that we know that to elicit tacit knowledge accumulated in the heads of experienced workers represents the key to finding better ways of process improvement, in addition to new ideas and solutions provided by the innovative improvement team.

This means that business process improvement or innovation should be built on ideas elicited from knowledgeable and experienced people. For this reason, the improvement team should include such experienced employees from the organization that could provide such new knowledge.

Therefore, development of a new "to-be" process model that represents the effective behavior of the process discussed requires the improvement team to benefit from the knowledge capture and/or creation concept of the knowledge management cycle.

Knowledge capture and knowledge creation is done by searching for or inventing new approaches and for ways that enable us to identify, elicit, and articulate unused knowledge hidden in the minds of its owners. Such new knowledge is gained from professionals and from highly experienced individuals and groups of individuals.

Knowledge capture refers to the identification and subsequent codification of existing (usually previously unnoticed) internal knowledge and know-how within the organization and/or external knowledge from the environment. Knowledge creation is the development of new knowledge and know-how innovations that did not have a previous existence within the company (Dalkir 2005).

We know that knowledge can be explicit or tacit. Explicit knowledge concerns the carrying out of an organization's processes and is identified from the organization's documents, which describe in detail different working procedures and also from interviews with employees. This kind of knowledge is usually identified, captured and used during the first and second phases to develop the Process and Activity Tables, where the process is identified and modeled.

Tacit knowledge is developed by employees through years of experience in performing their daily work activities. Tacit knowledge refers to something that is very difficult to articulate, to put into words or images; typically highly internalized knowledge such as knowing how to do something or recognizing analogous situations (Dalkir 2005).

To capture tacit knowledge from its owners, TAD methodology has developed a simple technique that could make this difficult task easier and more productive. The technique is based on creating a table, called the Improvement Table, which is structured as follows: The first 3 columns of the table are the same as the first 3 columns of the activity table, first part. These columns are needed in order to keep track of the first part of the table. In addition to these columns, the table is extended by three new columns that represent the "Lessons Learned" columns group; these are the "Activity", "Work Process" and "Business Process" columns.

The aim of these special columns is to obtain and store the tacit knowledge elicited from professional and experienced employees. The knowledge and ideas are obtained first at the activity level about how to do things in more innovative ways in order to accelerate the processing of activities, raise the quality of their outputs, and minimize their cost.

The team's discussion is then continued at the work and business process level. For this purpose, operational and business managers could also be invited to contribute to the team. The purpose of this is to benefit from their knowledge and ideas.

The result of this effort is the identification and capture of important unused tacit knowledge about each activity, work process, and business process. Tacit knowledge is then stored in the "Lessons Learned" columns. This means new knowledge about the activities is stored in the column "Activity", about the work processes in the column "Work Process", and the business process in the column "Business Process".

Surgery

Analyzing the interesting results obtained from the detailed analysis carried out in the first subphase of the current phase lead us to the following conclusions about the process Surgery:

- A long average cycle time that lasts 14.6 days;
- A low flow rate of 2 patients/day;
- A low cycle time efficiency of 17 %;
- A low theoretical capacity of 5.26 patients/day;
- A high capacity utilization of 38.11 %.

It is clear from the first conclusion that the average cycle time is too long and represents the most serious problem. Therefore, the improvement team needs to find a solution and introduce necessary changes in order to improve it and make it more efficient and effective.

Business Process	Work Process	Activity	Lessons-Learned		
			Activity	Work Process	Business Process
Surgery	Registration	1. Register patient		Remove	Using the listed improvements enables us to shorten the average cycle time by several days.
		2. Forward patient to Dr			
		3. Examine patient			
		4. Send patient to Lab			
		5. Test blood			
		6. Forward blood findings			
		7. Approve surgery			
		8. Issue hospitalization order			
		9. Forward patient			
	Hospitalization	10. Prepare examination orders	Change	- Change activity 10 to Register patient. - Remove activities 11, 12, 13 because blood test, X-ray, EKG,etc. are done before hospitalization. - Remove activity 15 because the surgery is already decided. - Change activity 17 to reschedule surgery because it is used only In exceptional cases.	
		11. Make X-Ray	Remove		
		12. Make EKG	Remove		
		13. Forward medical findings	Remove		
		14. Analyze findings			
		15. Decide on surgery	Remove		
		16. Explain surgery			
		17. Schedule surgery	Change		
		18. Get information for anesthesia			
		19. Sign documents			
	Surgery	20. Wait for surgery	Remove	- Remove activity 20 - Activity 25 is performed only if is determined by the surgeon.	
		21. Prepare patient			
		22. Carry out anesthesia			
		23. Carry out surgery			
		24. Wake up patient			
		25. Place in intensive Care			
	Recovery	26. Treat patient		- Reduce the time of activity 32 to 30.	
		27. Observe patient			
		28. Check recovery			
		29. Place in clinic			
		30. Treat patient			
		31. Check recovery			
		32. Issue release report	Change		

Fig 11.2 Improvement table – surgery process

Concerning the second conclusion, we expect that the cycle time efficiency of the process will be improved as a consequence of shortening the cycle time of the process and removing or reducing the waiting times.

Furthermore, shortening the average cycle time increases the average flow rate of the process and may lead to raising the theoretical capacity, and better capacity utilization.

Thus, let us focus on solving the problem of shortening the cycle time of the process. Fig. 11.2 is created to enable the team to elicit and store tacit knowledge and new ideas from the improvement team, which may lead to shortening the cycle time of the Surgery process. The first 3 columns are copied from Fig. 10.1. In the columns "Lessons Learned", new knowledge is captured as results of interviews conducted with the main nurse and surgeon in the Clinic.

In the following, Fig 11.2 shows the Improvement Table of the "as-is" Surgery process. The table contains an analysis of the activities and work processes of the existing Surgery process, in addition to new ideas and suggestions to improve its functioning and make it more efficient.

Registration. This work process is actually used for urgent cases. The Clinic also uses it for planned operations. So, patients with planned operations also undergo it. For this reason, the team decided to remove this work process from the Surgery process because it is part of another healthcare process, which deals with urgent cases. Further, registration of patients should be done at the Clinic.

Hospitalization. In the Hospitalization work process several activities should be removed or changed, such as:

– Change activity 10 to activity "Register patient", which is then executed at the Clinic and becomes the first activity of the Hospitalization work process;
– Remove activities 11, 12, and 13 because the patient makes the required examinations, such as: blood test, X-Ray, EKG, etc. a few days before hospitalization;
– Remove activity 15 because a decision about surgery is usually already made and there is no need to make a new decision about it;
– Change activity 17 to "Reschedule surgery" because sometimes something exceptional happens that prevents performance of surgery as scheduled; and
– Remove activity 20 because usually there is no waiting for surgery, and it is carried out as scheduled on the day of hospitalization.

Surgery. In this work process, which includes activities (20–25), the 25th activity is carried out only if so determined by the surgeon.

Recovery. Activities (26–28) are performed only if the patient is placed in Intensive Care. We suppose that placing the patient in Intensive Care is rare, and is done only if so determined by the surgeon. Therefore, we suppose that the patient may spend (0–5) days in Intensive Care, and most likely only 1 day.

Activities (30–32) are performed on a daily basis and repeated for (5–10) days, most likely 5 days.

The last activity is changed by reducing its duration time. This is done by giving the patient a temporary release document. The real release report is mailed to the patient later.

11.2.2 Ideas Implementation

The result of the previous step of the current subphase is the creation of the Improvement Table, which stores tacit knowledge elicited from experienced employees, in addition to creative suggestions developed by the improvement team.

The current step implements this knowledge and suggestions stored in the Improvement Table to develop the “to-be” process model. Thus, this step is concurrent with the second concept of the knowledge management cycle, knowledge sharing and dissemination.

As we know, knowledge sharing and dissemination is done by codification of knowledge, which means translating tacit into explicit knowledge in order to share and disseminate it within the framework of the enterprise.

Knowledge codification is the process of producing knowledge or an intellectual artifact–anything that allows knowledge to be communicated independently of its holder (Dalkir 2005).

Knowledge sharing and dissemination could be done within an organization in different ways, such as:

– Interactions between members of a group or groups;
– Publishing and updating knowledge on special websites on the organization’s intranet or using other communication possibilities, such as documents; and
– Integrating the knowledge within the organization’s business process models and then implementing it by developing an information system to support the process model developed.

Therefore, knowledge stored in the Improvement Table should be shared and disseminated by using it for developing the “to-be” process model. Such a technique of implementing knowledge within the “to-be” process model means that the knowledge is organized in accordance with the context of the working activities performed, within different work processes of the business processes discussed. This guarantees the use of new knowledge by employees and is therefore, in our view, the best way of using this knowledge.

The development of the “to-be” process model is done by updating:

– The Process Table if the organization of the “to-be” process model differs from the organization of the “as-is” model, which means that the “to-be” process uses different work processes or passes through different functional areas;
– The Activity Table corresponding to the ideas and suggestions stored in the Improvement Table.

Surgery

To implement the ideas defined in Fig 11.2, both parts of the Activity Table were updated. Figs. 11.3 and 11.4 were developed from Figs. 10.1 and 10.2 by updating them with the suggestions given in Fig 11.2.

Fig. 11.3 and 11.4 represent the new “to-be” model of the Surgery process; this is the new Activity Table. This table shows that the “to-be” process model contains only three work processes because the “Registration” work process was removed. In addition, two activities were changed and six activities were removed from the “Hospitalization” work process. And the duration time of the last activity of the process was also changed.

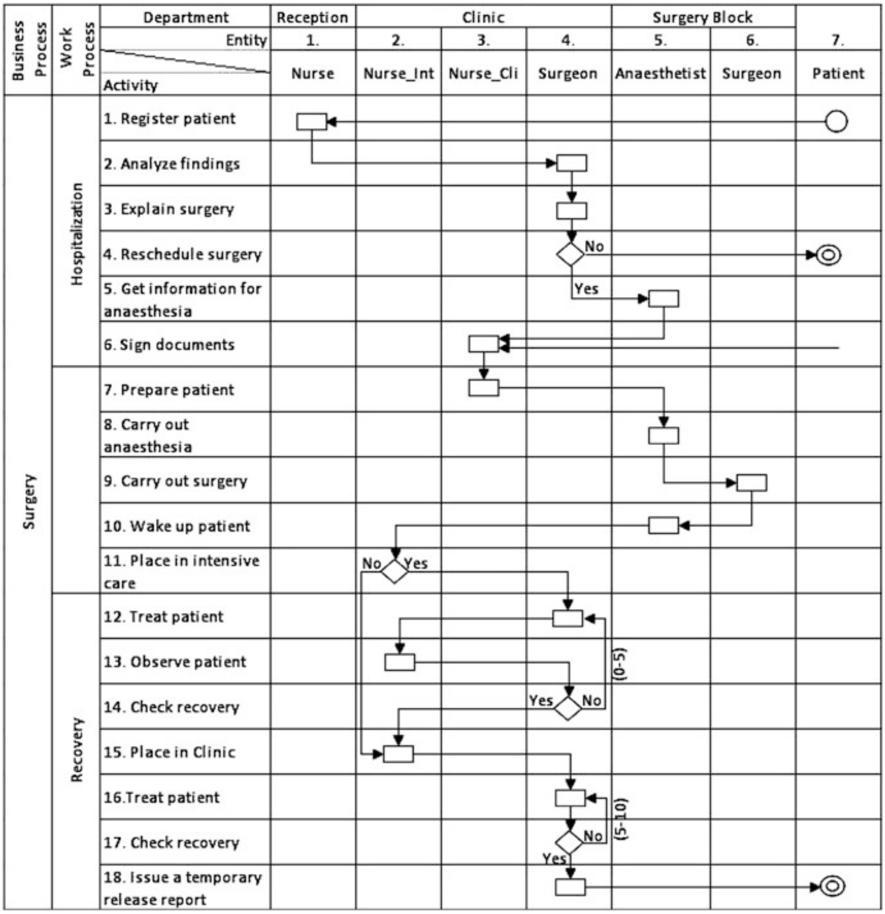


Fig 11.3 Activity table – Part 1 of “to-be” surgery process

11.3 “to-be” Process Model Analysis

In this subphase, the performance measurements of the “to-be” model of the Surgery healthcare process, developed in the previous subphase, are calculated. Such calculation enables us to estimate the improvements made in the process performance of the new “to-be” process compared to the performance of the existing “as-is” process, which was calculated in the first subphase of the current phase.

This subphase consists of the same four steps as the steps of the first subphase. Thus, it starts by running a simulation of the “to-be” process and continues by calculating the three process performance measures; namely process flow, time cycle efficiency, and process capacity.

Parameter / Activity	Description	Resource	Time	Rule	Input/ Output
1. Register patient	Nurse in Reception Office accepts patient's medical card, Doctor's order, registers her/him	Nurse-RO	20-30 min	Check medical card validity	Doctor's order, Medical card
2. Analyze Findings	The surgeon analyzes patient's findings	Surgeon	30 min	Check medical findings	Findings
3. Explain surgery	Surgeon provide a more detailed explanation of surgery to patient	Surgeon	30 min		
4. Reschedule surgery	Surgeon reschedules the surgery if something unpredictable happens	Surgeon	30 min		
5. Get information for anesthesia	Anesthetist gets information from patient about anesthesia	Anesthetist	30 min	Check previous problems with anesthesia	Anesthesia Report
6. Sign Documents	Patient signs anesthesia and surgery documents		60 min	Read documents carefully	Signed documents
7. Prepare Patient	Nurse-Cli prepares patient for surgery	Nurse-Cli	30 min		
8. Carry out Anesthesia	Anesthetist carries out anesthesia	Anesthetist	30 min	Check report of anesthesia	
9. Carry out Surgery	Surgeon carries out surgery	Surgeon	2-5 hours	Check medical findings	
10. Wake up Patient	Anesthetist wakes up patient	Anesthetist	10 min		
11. Place in intensive care	Nurse places patient in intensive care room. 5% of patients are placed in intensive care		20-30 min		
12. Treat patient	Nurse in intensive care provides patient with prescribed treatments 3 times per day, 0-5 days (most likely 1 day)	Nurse-Int	3* 10 min (0-5) days		Temperature form
13. Observe patient	Nurse in intensive care observes patient's state and provides what patient needs 6 times per day, 0-5 days (most likely 1 day)	Nurse-Int	6* 10 min (0-5) days		Temperature form
14. Check recovery	Surgeon checks patient recovery twice per day, 0-5 days (most likely 1 day)	Surgeon	2* 10 min (0-5) days		Temperature form
15. Place in clinic	Nurse in clinic places patient in patient's ward in clinic	Nurse-Cli	20-30		Temperature form
16. Treat patient	Nurse in clinic provides patient with prescribed treatments 3 times per, 5-10 days (most likely 6 days)	Nurse-Cli	3* 10 min (5-10) days		Temperature form
17. Check recovery	Surgeon checks patient's recovery daily twice per day, 5-10 days (most likely 1 day)	Surgeon	2* 10 min (5-10) days	Check temperature form	Temperature form
18. Issue temporary release document	Surgeon issues a temporary release document that enables patient to leave the hospital	Surgeon	20-40 min		Release report

Fig 11.4 Activity table – Part 2 of "to-be" surgery process

11.3.1 Simulation

A simulation model was developed on the basis of the contents of Figs. 11.3 and 11.4, which represent the "to-be" model of the Surgery healthcare process Surgery.

The simulation of the "to-be" Surgery process was run taking into consideration the following assumptions:

– The capacity of the Clinic is 30 beds and is completely occupied;
– The number of patients hospitalized daily is equal to the number of patients that leave the hospital;

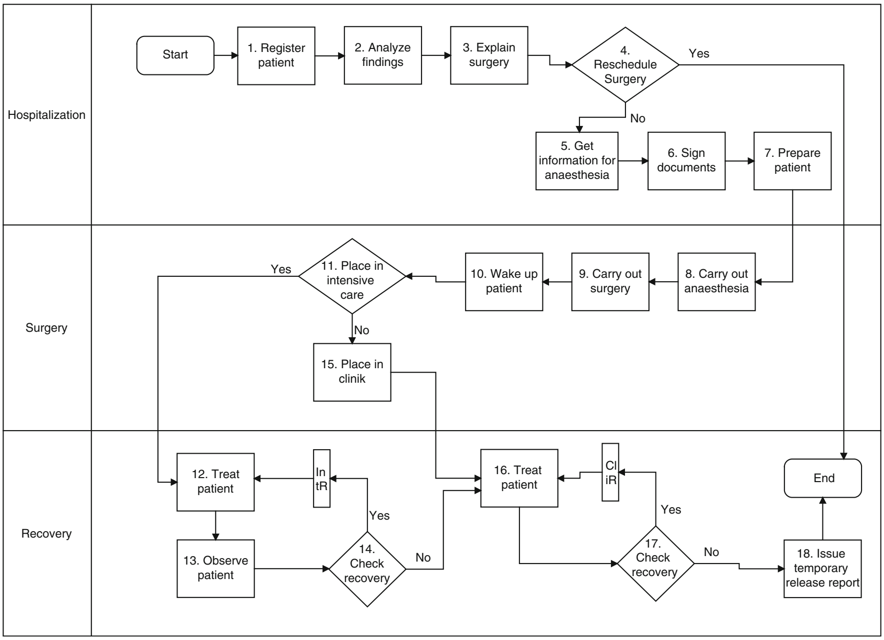


Fig. 11.5 Simulation model of "to-be" surgery process

– 500 patients are scheduled for different kinds of surgery;
– The "to-be" process model presented in Fig. 11.3, Activity Table – part 1, was transferred into a simulation model (iGrafx Process);
– Duration times and other characteristics of the activities of the simulation process are defined corresponding to the content of Fig. 11.4, the Activity Table – part 2;
– Four resources are defined; these are 2 Nurses in the Clinic, 1 Nurse in Intensive Care, 2 Surgeons, and 1 Anesthetist;
– 5 % of surgeries are re-scheduled;
– 5 % of patients are placed in Intensive Care;
– Recovery in Intensive Care is defined by the function TriangleDist(0, 5, 0), which means that the minimum stay is equal to 0, the maximum to 5 days, and the most likely 0 days; and
– Recovery in the Clinic is defined by function TriangleDist(5, 8, 5), which means the minimum stay is 5, the maximum 8, and most likely 5 days.

Figure 11.5 shows the simulation model of the "to-be" Surgery healthcare process in which the above listed assumptions were used.

The results gained from running the simulation of the "to-be" process are used in the next three steps of the current subphase to calculate the process performance measures.

11.3.2 Process Flow

Simulation of the "to-be" process Surgery showed that the average cycle time of the process is 8.4 days, the minimum cycle time 6.3 days, and the maximum 18 days. This means a major improvement was achieved in shortening the average cycle time compared to the "as-is" process.

As was mentioned before, the inventory is 30 patients. Therefore, to calculate the flow rate of the "to-be" process, Little's law was used, as follows:

$$
\begin{aligned}
& I = R * T \\
\text{Average} \quad & CT = 8.4 \text{ days} \\
\text{Average} \quad & I = 30 \text{ patients} \\
\text{Average} \quad & R = 30 / 8.4 = 3.57 \text{ patients per day}
\end{aligned}
$$

From the above given results, two important improvements were made compared to the "as-is" model; these are:

The average cycle time is shortned from 14.6 days (minimum 9 and maximum 20.86) to 8.4 days (minimum 6 and maximum of 18 days). This is an important improvement representing a decrease in the average cycle time of 6.2 days, i.e. by 42 %.

– The flow rate of the process is increased by 1.57 patient per day, i.e. by 78 %.

11.3.3 Cycle Time Efficiency

The theoretical cycle time is obtained from the results of the simulation of the "to-be" process model, and is equal to 1.78 days. The cycle time efficiency of healthcare process Surgery is calculated using formula 11.2, as follows:

$$\text{Cycle Time Efficiency} = \text{Theoretical Cycle Time} / \text{Average Cycle Time}$$

$$\text{Cycle Time Efficiency} = 1.78 / 8.4 = 21\%$$

This result also shows that an improvement in the cycle time efficiency is achieved merely by shortening the cycle time of the process.

11.3.4 Process Capacity

The capacity utilization of each resource pool of the "to-be" Surgery process is obtained as one of the simulation results of the process. These results show the capacity utilization of the resource pools to be: Surgeon 51.84 %, Nurse in Clinic 32.85 %, Anesthetist 16.33 % and Nurse in Intensive Care 11.99.

The theoretical capacity of each resource pool of the process is obtained using the formula given below in order to calculate the theoretical capacity, as follows:

$$R_p = R \ / \ \rho_p$$

Surgeon	$R_p = 3.57 \ / \ 0.52 = 6.86$ patient/day
Nurse in Clinic	$R_p = 3.57 \ / \ 0.33 = 10.8$ patient/day
Anesthetist	$R_p = 3.57 \ / \ 0.16 = 22.3$ patient/day
Nurse in Intensive Care	$R_p = 3.57 \ / \ 0.12 = 29.77$ patient/day

The theoretical capacity and capacity utilization of the whole process are 6.88 and 51.84 % because these are the theoretical capacity and capacity utilization of the Surgeon bottleneck resource pool.

These results show that further improvements are achieved; the capacity utilization of the process is increased from 38.11 to 51.84 % and the theoretical capacity of the process is also increased from 5.26 to 6.88 patient per day.

In addition to this, the capacity utilization of other resource pools within the Clinic is also improved. These are Nurse in Clinic from 31.05 to 32.85 % and Nurse in Intensive Care from 14.01 % (taking into the account the assumption that 10 % of patients are placed in the Intensive Care) to 11.99 % (taking into the account the assumption that only 5 % of patients are placed in the Intensive Care).

References

Al-Mashari, M., & Zairi, M. (2000). Revising BPR. A holistic review of practice and development. *Business Process Management Journal, 6*(1), 10–42.

Anupindi, R., Chopra, S., Deshmukh, D. S., Van Mieghem, A. J., & Zemel, E. (2006). *Management business process flows: Principles of operations management*. Upper Saddle River: Pearson Education.

Banks, J., Carson, S. J., Nelson, L. B., & Nicol, M. D. (2001). *Discrete-event system simulation*. Upper Saddle River: Prentice Hall.

Dalkir, K. (2005). *Knowledge management in theory and practice*. Amsterdam: Elsevier Butterworth-Heinmann.

Damij, N., & Damij, T. (2005). *Business process modelling and improvement using TAD methodology* (Lecture notes in computer science, pp. 380–385). Berlin: Springer.

Damij, N., Damij, T., Grad, J., & Jelenc, F. (2008). A methodology for business process improvement and IS development. *Information and Software Technology, 50*, 1127–1141.

Phase 4: System Development 12

Goals. In this chapter the following questions and themes are explored:
– Presenting the fundamentals of object-oriented modeling
– Introducing a class model development approach
– Explaining the meaning of user document analysis for object identification
– Exploring the meaning of functional dependence for class model creation
– Describing a process for building systems design
– Removing the gap between systems analysis and systems design
– Explaining a procedure for implementing the system
– Showing how to ensure quality of the system developed

This chapter discusses the fourth phase of TAD methodology, which deals with the development of a process management system that implements the functioning of the improved or innovated business process and in this way completes the work performed by the previous three phases.

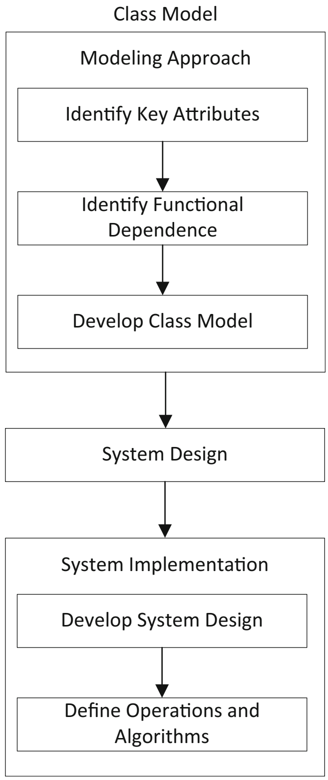
The current phase first develops the system's class model and system's design and then continues by implementation of the class model and design of the system. The result of this phase is a software package that at the end is deployed and used in the real environment of the organization.

The fourth phase is partitioned into three subphases: class model, system design, and system implementation. The first subphase starts by building a class model of the system using a simple approach that develops the class model on the basis of the concept of functional dependence explained in Chap. 8.

The second subphase continues by creating the system design, which is carried out on the basis of the "to-be" process model developed in the third phase, more precisely in accordance with the Activity Table – first part, see Chap. 11.

In the third subphase, the class model and design of the system are implemented by developing an application system that is then installed in the company or organization in order to execute the functioning of the business process discussed.

N. Damij and T. Damij, *Process Management*, Progress in IS,
DOI 10.1007/978-3-642-36639-0_12,



Phase 4: System development

12.1 Class Model

It is evident from the content of Chap. 8 that normalization is a necessary, applicable and useful step in data modeling. It is also clear that the normalization concept could be used and contributes a great deal in developing the object class model of the system. Sanders (1995) mentions the term object normalization to indicate the use of normalization in the field of object- oriented modeling.

12.1.1 Fundamental Object-Oriented Concepts

There are many well-known books that deal with the field of object-oriented modeling. Therefore, our aim in this section is to give a brief introduction to basic object-oriented concepts. This is done mainly by listing some important definitions given by well-known authors and short descriptions.

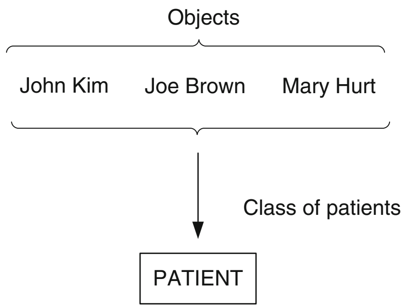


Fig. 12.1 Class of objects

12.1.1.1 Object Class

An object class could be understood as an abstraction for representing a number of objects that have similar attributes, behavior, and associations with objects of other classes.

An object class describes a group of objects with similar properties (attributes), common behavior (operations), common relationships to other objects, and common semantics (Rumbaugh et al. 1999).

An object is anything identified in the process of information systems development that is recognized by its properties and behavior.

An object is anything, real or abstract, about which we store data and those operations that manipulate the data (Martin and Odell 1992).

Figure 12.1, for example, shows that patients John Kim, Joe Brown and Mary Hurt are objects with similar properties, behavior and relationship with objects of other classes in the context of a healthcare system. Thus, this group of objects is represented by an object class called PATIENT, which describes what is common to all these objects.

Each object in a certain class is called an object instance in this class. For this reason, John Kim, Joe Brown and Mary Hurt are object instances in the class PATIENT.

An attribute is a data value held by the object in a class. Each attribute has a value for each object instance. Different object instances may have the same or different values for a given attribute. Each attribute name is unique in a class (Rumbough et al. 1991).

An identity attribute is a minimal set of attributes that uniquely identifies and represents an object instance (Rumbaugh et al. 1999).

Therefore, an attribute indicates a determined property of objects in an object class. For example, PatientID, Name, Address, Age, and so on are attributes of the class PATIENT, see Fig. 12.2.

The behavior of objects in a class is represented by operations. An operation is a function or transformation that may be applied to or by objects in a class (Rumbough et al. 1991)

Figure 12.2 shows that an object class consists of three parts: in the first part the class's name is indicated, the second part lists the attributes of the class, and the third part lists the operations of the objects of the class.

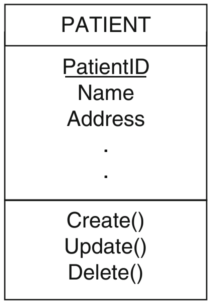
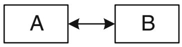


Fig. 12.2 Class PATIENT

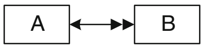
12.1.1.2 Association

An association is a relationship between two classes of the class model. There are different types of associations that exist between classes, such as one-to-one, one-to-many and many-to-many.

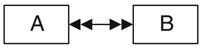
Assume that we have two classes A and B. A one-to-one association means that every object instance of class A is associated with only one object instance of class B and each object instance of class B is associated to only one object instance of class A.



A one-to-many association means that every object instance of class A is associated with none, one or more object instances of class B and each object instance of class B is associated with only one object instance of class A.



A many-to-many association means that every object instance of class A is associated with none, one or more object instances of class B and each object instance of class B is associated with none, one or more object instances of class A.



In order to implement a many-to-many association, such an association is usually replaced by a class called an association class, which is related to the original class by two one-to-many associations. For example, the above given many-to-many association is replaced by the following association class.

12.1.1.3 Inheritance

Inheritance is the most powerful feature of object-oriented modeling. Inheritance means defining a system of hierarchies between classes, where a subclass can inherit attributes and operations from a higher class.

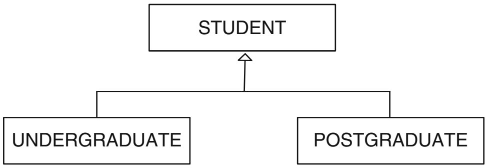


Fig. 12.3 An example of Inheritance

Inheritance can be added in two directions: by generalization of common aspects of existing classes into a superclass (bottom-up) or by refining existing classes into specialized subclasses (top-down) (Rumbough et al. 1991).

Generalization is bottom-up analysis of classes of a class model. It means creating a higher superclass for similar attributes and operations of two or more classes of the class model.

Generalization represents the best way for sharing similar characteristics (attribute and operations). This is achieved by putting these characteristics together in one class from which other classes inherit and use them. In addition to the inherited characteristics from the superclass, the classes may have other special characteristics of their own.

Specialization is top-down analysis of the classes of a class model. This means refining existing classes into specialized classes. This is done by creating subclasses that inherit the characteristics of the refined classes. In addition to the characteristics inherited from the existing classes, the created subclasses may have other special characteristics their own.

Figure 12.3 shows an example of inheritance between the class STUDENT and the classes POSTGRADUATE and UNDERGRADUATE.

12.1.2 Modeling Approach

Using the normalization concepts and particularly the concept of functional dependence described in Chap. 8 is very important for carrying out user document analysis, which enables us to identify the classes of the class model. It is also helpful for defining the relationships that exist between the classes of the class model.

As was shown in Chap. 8, the functional dependence concept is an excellent tool for analyzing the relationships existing between the key attribute of a relation on one hand and the non-key attributes of the same relation on the other. Functional dependence is very useful for analyzing the relationships existing between key attributes of different relations.

The purpose of this subphase is to introduce an approach that is based on the concept of functional dependence. The approach leads the analyst through a set of simple steps toward the creation of a class model of the improved process.

The idea of this approach is simplifying the normalization technique by using only functional dependence to analyze the relationships existing between attributes contained in user documents. Using this approach may lead us to develop a data

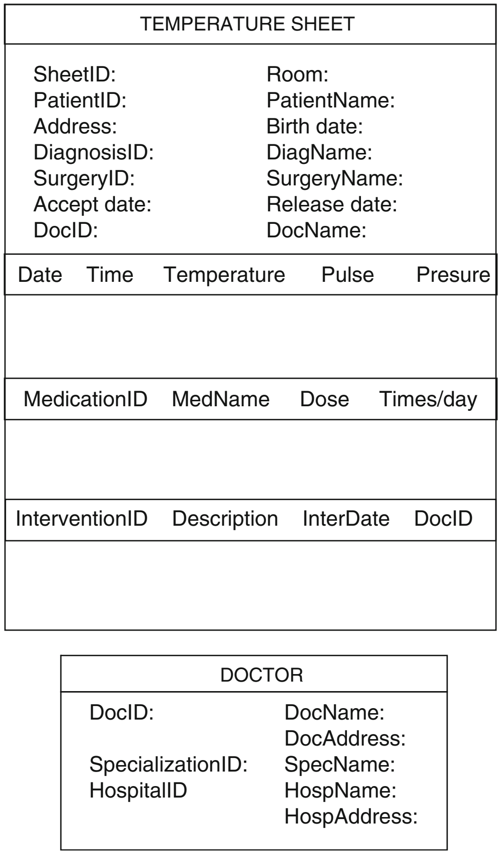


Fig. 12.4 Two documents of the surgery process

model whose relations are at least in the fourth normal form. This approach consists of three steps: identify key attribute, identify functional dependence, and develop a class model.

Surgery

Two simplified documents of the Surgery healthcare process are used to demonstrate the application of this approach. These documents are a doctor form (DOCTOR) and a temperature sheet (TEMPSHEET), as shown in Fig. 12.4.

12.1.2.1 Identify Key Attributes

It is understandable that the key attribute of an object is a unique property of the object in an object class that represents it and distinguishes it from other objects of the class.

The first step of the approach deals with analyzing the collected user documents one by one. The purpose of this analysis is to define the key attributes of all objects, which are identified in these documents.

Analysis 12.1 Key attributes – document TEMPSHEET

TempSheetID
PatientID
DiagnosisID
DocID
SurgeryID
MedicationID
InterventionID
TempSheetID,MedicationID
TempSheetID,InterventionID
TempSheetID,Date,Time

In our experience, it is better to start with a complex document and continue with others, which are less complex. Each document may contain simple key attributes and key attribute collections (Damij 2001).

Each document should be analyzed carefully in order to identify simple key attributes linked to non-key attributes and key attribute collections related to different repeating groups listed within the document discussed. Each simple key attribute represents an object class, while a key attribute collection represents an association class that connects two other classes together (Damij 2000).

Analyzing the document TEMPSHEET, see Analysis 12.1, enables us to identify the following two groups of key attributes. The first group contains seven simple key attributes that belong to object classes: TEMPSHEET, PATIENT, DIAGNOSIS, DOCTOR, SURGERY, MEDICATION, and INTERVENTION.

The second group shows the last three key attribute collections that belong to the association classes TEMPSHEET-MEDICATION, TEMPSHEET-INTERVENTION, and PARAMETERS.

12.1.2.2 Identify Functional Dependence

This approach discusses the possibility of developing a class model on the basis of analyzing documents instead of relations, as was used to develop a data model given in Chap. 8. Therefore, the definition of functional dependence in Chap. 8 could be adjusted to cover the associations existing between attributes of a user document.

An attribute B of a certain document is functionally dependent on a set of attributes A ($A_1,\ldots,A_n$) if every value of the attributes set A ($A_1,\ldots,A_n$) is associated with one and only one value of attribute B (Damij and Damij 2010).

The given definition of functional dependence simplifies the steps of normalization and covers the implementation of the functional, fully functional, and transitive data dependences explained previously in Chap. 8.

The current step of the approach uses the following algorithm to identify the functional dependences existing between the attributes of a document:

(a) For each key attribute defined in the first step, identify the functional dependences existing between the key attribute and non-key attributes; and
(b) Identify the functional dependences existing between the key attribute of the document and other key attributes.

Analysis 12.2 Functional dependence – document TEMPSHEET

TempSheetID	→	RoomNo AcceptDate ReleaseDate
PatientID	→	PatientName BirthDate Address
DiagnosisID	→	DiagName
SurgeryID	→	SurgName
DocID	→	DocName
TempSheetID,Date,Time	→	Temperature Pulse Pressure
MedicationID	→	MedName
InterventionID	→	Description
TempSheetID,MedicationID	→	Dose Times/Day

Surgery

Point (a) of the algorithm is implemented by identifying the functional dependences of the non-key attributes of the document TEMPSHEET on the key attributes listed in step 1, see Analysis 12.2.

Analysis 12.2 shows the following functional dependences:

- Non-key attributes RoomNo, AcceptDate, and ReleaseDate are functionally dependent on the attribute TempSheetID, because each TempSheetID value determines one value of the listed attributes.
- Non-key attributes PatientName, Address and BirthDate are functionally dependent on the attribute PatientID, because every PatientID value identifies one value of each of these attributes.
- Non-key attributes DiagName, SurgeryName and DocName, MedName and Description are functionally dependent on key attributes DiagnosisID, SurgeryID, DocID, MedicationID and InterventionID successively.
- Non-key attributes Temperature, Pulse and Presure are functionally dependent only on the attributes collection TempSheetID, Date, and Time, because every value of this attribute collection determines only one value of each of the non-key attributes.

For the same reason, attributes Dose and Times/Day are functionally dependent on the attribute collection TempSheetID,MedicationID, and attribute InterDate and DocID are functionally dependent on the attribute collection TempSheetID, InterventionID.

Point (b) of the algorithm is implemented by identifying the functional dependences existing between the key attribute of the document analyzed and other key attributes identified in the first step, as shown in Analysis 12.3.

Analysis 12.3 Functional dependence – document TEMPSHEET

TempSheetID	→	PatientID
	→	SurgeryID
	→	DiagnosisID
	→	DocID
TempSheetID,InterventionID	→	DocID

In our example, the following analysis shows the functional dependences of key attributes on the key attribute TempSheetID of the document TEMPSHEET and also on the key attribute collection TempSheetID,InterventionID.

These functional dependences between key attributes indicate associations that link the class that represents the document analyzed, TEMPSHEET in our example, to other identified classes and also other associations, as shown in the next step where the class model is developed.

12.1.2.3 Develop Class Model

The third step of the approach deals with building the class model by transferring the results of the analyses accomplished in the second step into a class model.

Surgery

Building the class model is done, as follow:

1. For each key attribute listed in Analysis 12.2 define a class, the class name and its attributes, which are the key attribute of the class and those non-key attributes that are functionally dependent on the key attribute corresponding to Analysis 12.2;
2. Create associations that connect the class, which represents the document to other classes in the model in accordance with Analysis 12.3;
3. Create an association between every class, whose key attribute is a key attribute collection, and those classes whose key attributes form the key attribute collection as shown in Analyses 12.2 and 12.3.

Implementing the above given procedure using Analyses and 12.3 enables us to create a part of the class model that contains ten classes, as shown in Fig. 12.5.

Point (1) is implemented by drawing boxes and defining the names of classes and listing their attributes. Point (2) is done by creating associations between class TEMPSHEET and classes PATIENT, SURGERY, DIAGNOSIS, DOCTOR and PARAMETERS.

Point (3) is accomplished by creating associations between class TEMP-MED and classes TEMPSHEET and MEDICATION, between class TEMP-INTERV classes TEMPSHEET and INTERVENTION, and also between classes TEMPSHEET and PARAMETERS.

After completing the analysis of document TEMPSHEET, the approach of developing the class model continues by starting a new iteration using the above presented steps of the approach to analyze the second document; this is DOCTOR.

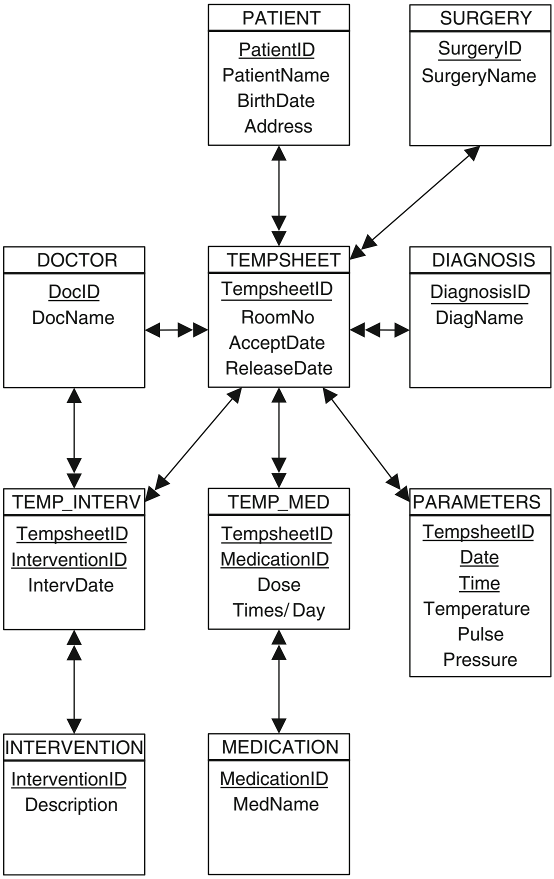


Fig. 12.5 Class model of surgery process

Analysis 12.4 Key attributes – document DOCTOR

DoctorID
SpecializationID
HospitalID

Step 1: Identify key attributes

Analysis 12.4 shows the following key attributes identified from the document DOCTOR.

These key attributes belong to the classes DOCTOR, SPECIALIZATION, and HOSPITAL.

Step 2: Identify functional dependence

Corresponding to point (a) of the algorithm presented in Step 2, the following functional dependences of the key attributes of the document DOCTOR on the non-key attributes are identified, see Analysis 12.5.

DocID	→	DocName
		DocAddress
SpecializationID	→	SpectName
HospitalID	→	HospName
		HospAddress

Analysis 12.5 Functional dependence – document DOCTOR

DocID	→	SpecializationID
	→	HospitalID

Analysis 12.6 Functional dependence – document DOCTOR

In accordance with point (b) of the algorithm, the following functional dependences existing between the key attribute of the document DOCTOR and other key attributes are found, see Analysis 12.6.

These functional dependences indicate the associations existing between the class DOCTOR and the classes SPECIALIZATION and HOSPITAL.

Step 3: Develop class model

To complete the class model of the process Surgery shown in Fig. 12.5, new classes and attributes are added to it as a result of implementing the algorithm in analyzing the document DOCTOR. Thus, the classes SPECIALIZATION and HOSPITAL identified in Analysis 12.4 are added to the class model and the class DOCTOR is extended by a new non-key attribute DocAddress corresponding to Analysis 12.5. In addition, associations are defined between the class DOCTOR and the classes SPECIALIZATION and HOSPITAL on the basis of Analysis 12.6 (Fig. 12.6).

12.2 System Design

The current subphase of the fourth phase continues the work accomplished in the third phase by developing the design of the system on the basis of the information collected in the Activity Table of the process.

This subphase consists of two steps. The first step deals with developing the design of the system that implements the process discussed. The second step completes the class model developed in the first subphase of the current phase. This is done by defining the operations of the object classes, writing the algorithms needed to implement these operations, and other algorithms related to the design of the system.

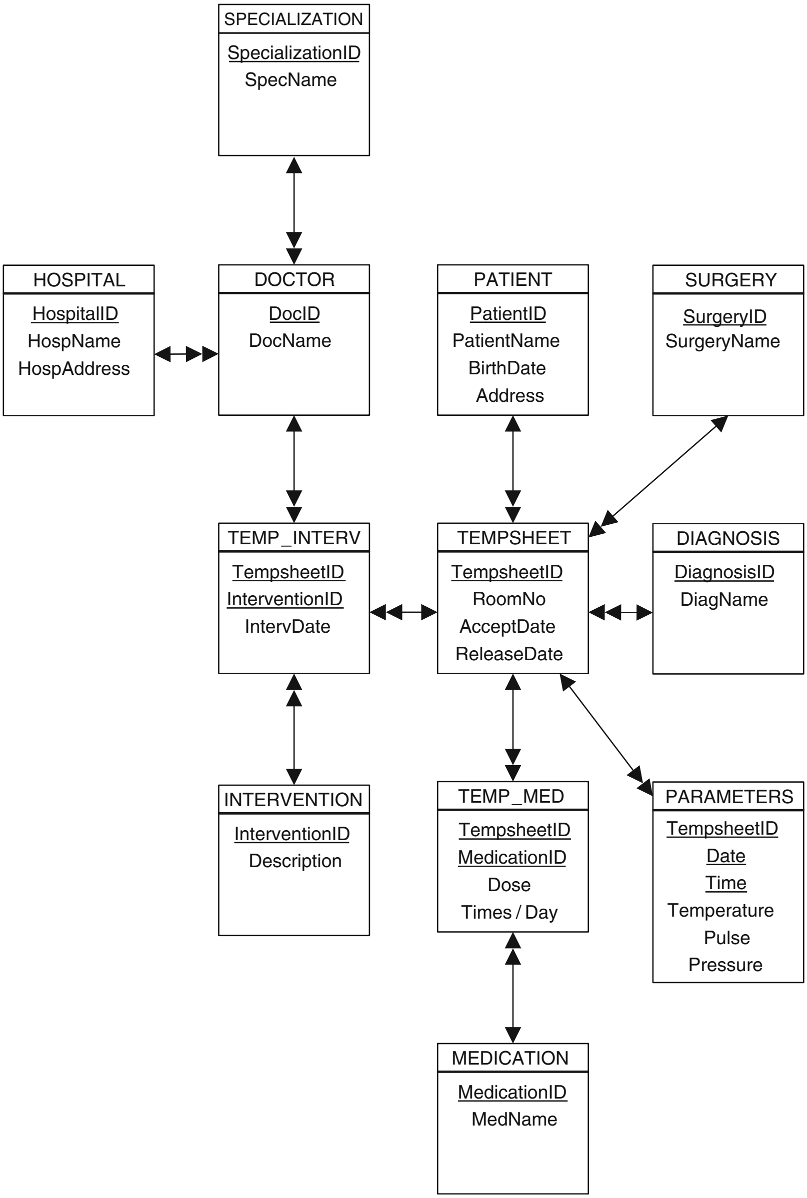


Fig. 12.6 Class model of process surgery

12.2.1 Develop System Design

The design of the system is derived from the "to-be" process model; this is from the Activity Table – First Part of the "to-be" model. More precisely, it is derived from the first three, four, or five columns of the table depending on the structure of the process model.

The design is actually represented by a table that shows the system's design as a hierarchical system, which is structured in accordance with the structural scheme of the improved business process. Therefore, the design consists of a number of levels corresponding to the structure of the process shown in the first few columns of the Activity Table – First Part.

Usually, a business process is partitioned into a number of work processes, each of these work processes consists of a set of activities, and each activity may be partitioned into tasks.

Therefore, the first level of the design model, called the business process level, is derived from the first column of the Activity Table. The second level, called the work process level, is created according to the content of the Work Process column. The third level, called the activity level, is developed from the information comprised in the Activity column of the table.

In the case of a large business process, such a process is usually partitioned into a number of subprocesses, which are defined in the second column of the Activity Table. In such cases, the second level of the design model is created from the content of the second column of the table and called the Subprocess level. Other levels, Work Process and Activity, are moved to lower levels and represent the third in fourth levels of the design.

In cases where a number of activities are partitioned into tasks, the lowest level of the design is represented by the Task level. This design level is structured in accordance with the content of the Task column in the Activity Table.

Organizing the design of the system in the way described above enables us to create a system design that represents a true reflection of the reality of the business process discussed. Developing a system design in such a manner means transferring the information collected in the Activity Table into the design model of the system.

This fact means that TAD methodology enables the modeler to create a design of the system that is tightly related to the result of the process modeling and improvement, and contributes a great deal to removing and minimizing the gap existing between the systems analysis and systems design.

Surgery

Figure 12.7 shows the design of the system of the healthcare process termed Surgery. As is evident from this figure, the model represents a three level hierarchical system. The first level is the process Surgery level, the second is the work process level, which shows four work processes, and the last level is the activity level, which shows all activities performed within the presented work processes of the process.

12.2.1.1 Define Operations and Algorithms

The class model developed in the first subphase of the fourth phase consists of a number of object classes. Each of these classes is related to some other classes by a number of associations and contains a set of attributes.

Fig. 12.7 Design of surgery process

Surgery	Hospitalization	Register patient
		Analyze findings
		Explain surgery
		Reschedule surgery
		Get information for Anesthesia
		Sign documents
		Wait for surgery
	Carrying out Surgery	Prepare patient
		Carry out anesthesia
		Carry out surgery
		Wake up patient
		Place in intensive care
	Recovery	Treat patient
		Observe patient
		Check recovery
		Place in Clinic
		Treat patient
		Check recovery
		Issue a temporary release Report

Fig. 12.8 An example of a class

ORDER
OrderId Date . .
CreateOrder() Cancel Order() . .

The current step deals with completing class model development by identifying and defining operations within the framework of each object class of the class model.

Rambaugh et al. (1991) defined an operation as follows: An operation is a function or transformation that may be applied to or by objects in a class.

These operations actually determine the behavior of the objects of the system, which indicates the behavior of the whole system.

Surgery

Thus, in addition to the attributes, each object class of the class model contains a number of operations that represent the behavior of the objects of this class. For example, Fig. 12.8 shows that the class Order, in addition to attributes, also contains operations to create and cancel an Order.

Identification of the operations is derived from the “to-be” process model, more precisely from the Activity Table – Second Part, where each activity or task is described in detail.

The input to identify and define operations within the object classes is the Activity Table – Second Part. From each activity or task description within the activity table, a number of operations is derived and defined within an object class.

In this step, in addition to the operations indicated within the object classes of the class model, algorithms are also written that show how these operations should be implemented.

Furthermore, algorithms should be written to connect the lowest level of the design of the system, this is the task or activity level, with object classes of the class model in order to trigger the execution of different operations defined within these classes.

Figure 12.9 shows a completed class model of the healthcare process termed Surgery.

12.3 System Implementation

The results of the previous two subphases of the fourth phase are essential inputs on the basis of which the development of the information system is carried out. The purpose of the development of such an information system is to support the functioning of the improved business process, and is therefore called the process management system.

The inputs to develop such a system are the class model, system design and the algorithms written. These inputs are used in the current subphase to implement the process improved or innovated by creating the system database and developing various programs.

In addition, at the end the system development team takes care of analyzing and implementing the integration of the system developed within the information system of the organization.

Developing an information system to support the process discussed requires choosing a proper platform for the system, selecting a database system, and deciding on a programming language.

The current subphase could be partitioned into three steps; these are Programming, Testing, and Deployment.

12.3.1 Programming

This step of the system implementation subphase includes creating a database system, developing a menu system, and developing a number of programs corresponding to the system design.

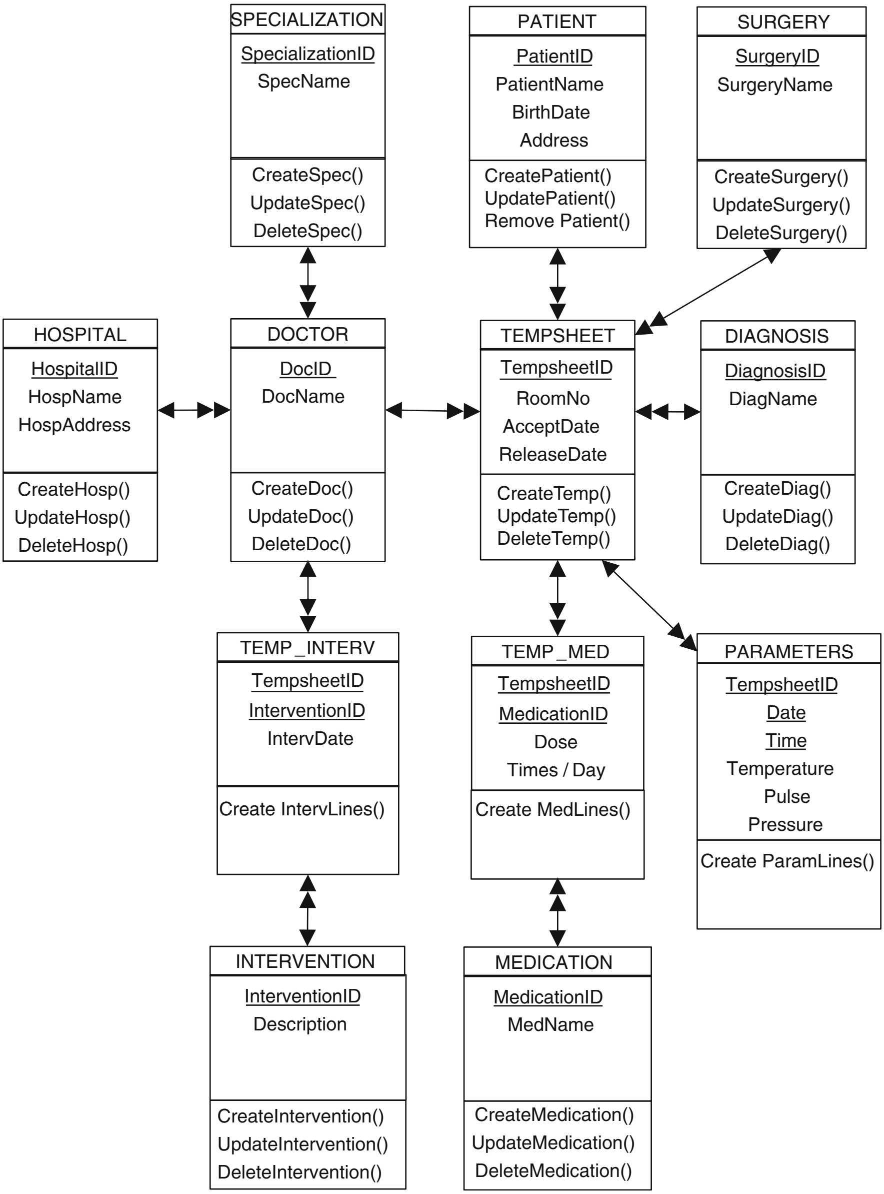


Fig. 12.9 Completed class model of healthcare process surgery

In order to develop a menu system, the system design developed in the second subphase is transferred into a hierarchical menu system that is structured in accordance with the structural scheme of the system design.

Usually this step is started by creating a database system and transferring the design model into a hierarchical menu system according to the design structural scheme.

The lowest level of the menu system, which is the activity or task level, is connected to different programs. These programs are developed corresponding to the algorithms written in the previous subphase, which exactly define the steps needed to execute each activity or task listed in the menu system.

Furthermore, the algorithms written that describe the step by step execution of each operation defined within the object classes of the class model are transferred into programming code. This work means that the operations are transferred into methods.

Methods specify the way in which operations are encoded in software (Martin 1993). Therefore, a method is an implementation of an operation defined within a class of the class model.

12.3.2 Testing

To ensure the quality of the software system developed, the system development team has to provide careful testing of the system during the process of development.

To do this, a testing procedure should be used at different phases of the programming and system's development process, such as at program, group of programs, and system levels:

– Each program usually implements a certain task of an activity or an activity at the lowest level of the menu system. Therefore a number of tests should be done in to order to assure that the program is free of mistakes and works properly.
– A set of tasks may form an activity and a number of activities represent a determined work process. A group of programs that implements tasks and activities of a certain work process should be tested together carefully and precisely to ensure that the work process concerned is performed as it should be.
– A major test or tests should be carried out on the whole software system developed, first in the laboratory and then in reality.

12.3.3 Deployment

The final result of the current phase is a software package, called the process management system, which is deployed by installing it on the computer systems of the organization.

The role of the process management system is to ensure proper implementation the improved or innovated business process. In addition to this, the system should provide a monitoring possibility in order to trace business process instances at any time.

For this reason, the process management system must be rigorously tested using real business process instances. Such testing enables the system development team to follow the process functioning step by step and discover if there are still problems or mistakes that should be dealt with.

Furthermore, the development team has to organize presentations and learning courses in order to teach the employees of the organization about the new operation of the process and how to use the new information system deployed.

References

Damij, T. (2000). A procedure for object model development. *Journal of Object-Oriented Programming, 13*(8), 16–20.

Damij, T. (2001). *Tabular application development for information systems*. New York: Springer.

Damij, N., & Damij, T. (2010). An approach for class model development. HEALTHINF 2010: *Proceedings of the third international conference on health informatics, institute for systems and technologies of informatics, control and communication* (pp. 414–421), Valencia.

Martin, J. (1993). *Principles of object-oriented analysis and design*. Englewood Cliffs: Prentice-Hall.

Martin, J., & Odell, J. (1992). *Object-oriented analysis and design*. Englewood Cliffs: Prentice-Hall.

Rumbough, J., Blaha, M., Permelani, W., Eddy, F., & Lorensen, W. (1991). *Object-oriented modeling and design*. Englewood Cliffs: Prentice-Hall.

Rumbaugh, J., Jacobson, I., & Booch, G. (1999). *The unified software development process*. Massachusetts: Addison-Wisley.

Sanders, L. G. (1995). *Data modeling*. Danvers: Boyd & Fraser.

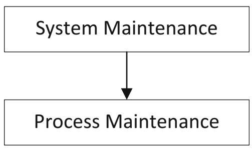
Phase 5: Maintenance 13

Goals. In this chapter the following questions and themes are explored:

– Introducing the meaning of the monitoring function
– Discussing how to carry out system maintenance
– Explaining the important role of generating a log file and visualization of the process
– Exploring the necessity for continuous process improvement
– Discussing how to implement process maintenance
– Determining the role of the process owner

The final phase of TAD methodology deals with controlling the functioning and behavior of the outputs of the third and fourth phases. The maintenance phase is an essential stage in the business process management life cycle.

The role of the current phase is to execute the control function at the process management system and business process levels. Therefore, this phase consists of two steps, system maintenance and process maintenance.



Phase 5: System maintenance

N. Damij and T. Damij, *Process Management*, Progress in IS,
DOI 10.1007/978-3-642-36639-0_13, © Springer-Verlag Berlin Heidelberg 2014

13.1 System Maintenance

This step is concerned with using the monitoring function in order to check the daily operation of the process management system. The monitoring function enables the process management team and employees involved in performing activities within the system to discover problems and deficiencies in the system.

This procedure gives the impetus to the process management team to provide the necessary changes, improvements and solutions for the problems and deficiencies indicated so as to optimize the functioning of the process management system. On the other hand, it also stimulates the management of the organization to make the decision to take appropriate actions.

As was mentioned before, the monitoring function should be provided by the process management system, which was developed and installed in the fourth phase. This means that the system should enable responsible employees to monitor the status of each business process instance at any time and be able to follow it on its way from the beginning to the end of the business process.

To implement the monitoring feature in the process management system, the system should generate a log file that records detailed data about all events happening in each business process instance during its route through the business process activities. In such a way the software system provides the system developers with all the data needed for its maintenance.

In addition to this, the process management system should provide the possibility of visualization of the process (Khan 2004). This means that the current state of any process instance flowing through the business process should be capable of visualization at any moment. In other words, processing any flow unit that goes through different process activities can be visualized. The visualization feature is very important and enables the employees responsible to provide customers with accurate information about their inquiries, in addition to discovering obstacles and bottlenecks existing within the process management system.

If any kind of problem is detected in the functioning of the process management system, then the process management team should analyze the problem identified carefully in order to find a convenient solution.

In such a situation, a new iteration of the fourth phase should be repeated in order to update the process management system with the corrections and solutions suggested.

It is obvious that the System Maintenance step is actually an iterative approach, which may be repeated as many times as needed for the purpose of updating the process management system with new suggestion and changes.

13.2 Process Maintenance

It must be emphasized that after carrying out the improvement or innovation of a certain business process and developing and implementing its process management system, the company may expect the process concerned to gain a number of needed advantages concerning its performance, cost and quality in comparison with other competitive business processes.

Nevertheless, these advantages start to decrease over time until reaching the point of their complete disappearance. This happens mainly because the competition is also working to improve their business processes. On the other hand, the management of the organization often does not implement a continuous improvement plan and consequently does not follow the dynamic changes that occur continuously in the reality of the organization's environment.

To solve this problem, the company should follow and apply a continuous business process improvement plan to ensure that the organization is always a step ahead of its competitors, or at least not behind them.

In the Process Maintenance step, the process owner who is responsible for management of the process improved has to carefully follow all the dynamic changes that happen in the environment of the organization. In addition to this, she/he should analyze and register any new innovative idea that may appear during the daily use of the process management system.

The process owner should lead the way in updating the business process with new ideas and changes through implementation of a continuous business process improvement plan. Continuous process improvement should be organized dynamically in accordance with the changes occurring in the process and the organization's environment.

The Process Maintenance step is also an iterative approach, which may be repeated many times; that is whenever new ideas or necessary changes are identified concerning improvement of the business process functioning.

Each new iteration starts with the second subphase of the third phase in order to update the "to-be" process model with the changes required and solutions found. It then continues with the fourth phase, where the new features are implemented within the process management system.

Reference

Khan, N. R. (2004). *Business process management: A practical guide*. Tampa: Meghan-Kiffer Press.

Case Study 2 — 14

Goals. In this chapter the following questions and themes are explored:
– Introduction to the practical use of TAD methodology
– The methodology as a step by step guide
– Management of an interesting Sales_Claim business process
– Proof that TAD is the right tool to implement process management

The final Chapter focuses on practical implementation of the whole algorithm of TAD methodology using an interesting business process called "Sales_Claim". This business process introduces the problem of claim applications in a large trading company. For different reasons, customers are unsatisfied with the services of the company. Mainly, customers are unhappy with the existing way of solving their claims because the process is ineffective, time consuming, and above all, the process does not provide customers with information about their claims during their processing.

Therefore, the Sales_Claim process needs to be analyzed and improved in order to satisfy customer requirements. To do so, TAD methodology is used in order to improve the process discussed.

14.1 Phase 1: Process Identification

14.1.1 Process List Creation

In order to implement the first phase, interviews were organized with the management of the Sales Department. Three goals were specified in order to improve the Sales_Claim process and solve problems connected with it. These goals are:
– Minimizing the number of sales claims,
– Minimizing the time of sales claim processing,

N. Damij and T. Damij, *Process Management*, Progress in IS,
DOI 10.1007/978-3-642-36639-0_14, © Springer-Verlag Berlin Heidelberg 2014

Fig. 14.1 The process table of Sales_Claim process

		Business Process
Functional Area	**Work Process**	**Sales_Claim**
Sales	Reception of Sales_Claim	*
	Under-received products	*
	Over-received products	*
Warehouse	Changing products	*

– Providing customers with up to date information about their claims,

The process is performed in two departments; these are Sales and Warehouse. In these departments four work processes were identified that are performed in the process of Sales_Claim. These work processes are:
– Reception of Sales_Claim,
– Under-received products,
– Over-received products,
– Product changing.

14.1.2 Process Flow Identification

Figure 14.1 represents the Process Table of the Sales_Claim business process. The table shows the flow of the process as it passes through different functional areas (departments) of the company. In addition, the table also lists the process's work processes, grouped by the functional areas where they are performed.

14.2 Phase 2: Process Modeling

14.2.1 Activity Table Development: Part 1

Figure 14.2 shows the first part of the Activity Table of the business process Sales_Claim. In the first and second columns of the table, the business process and its four work processes are shown. Figure 14.2 contains 23 activities and 3 resources, belonging to the Sales and Warehouse departments. This table is actually a simplified version of the original Activity Table of Sales_Claim, which contains 192 activities and 18 resources involved in performing them.

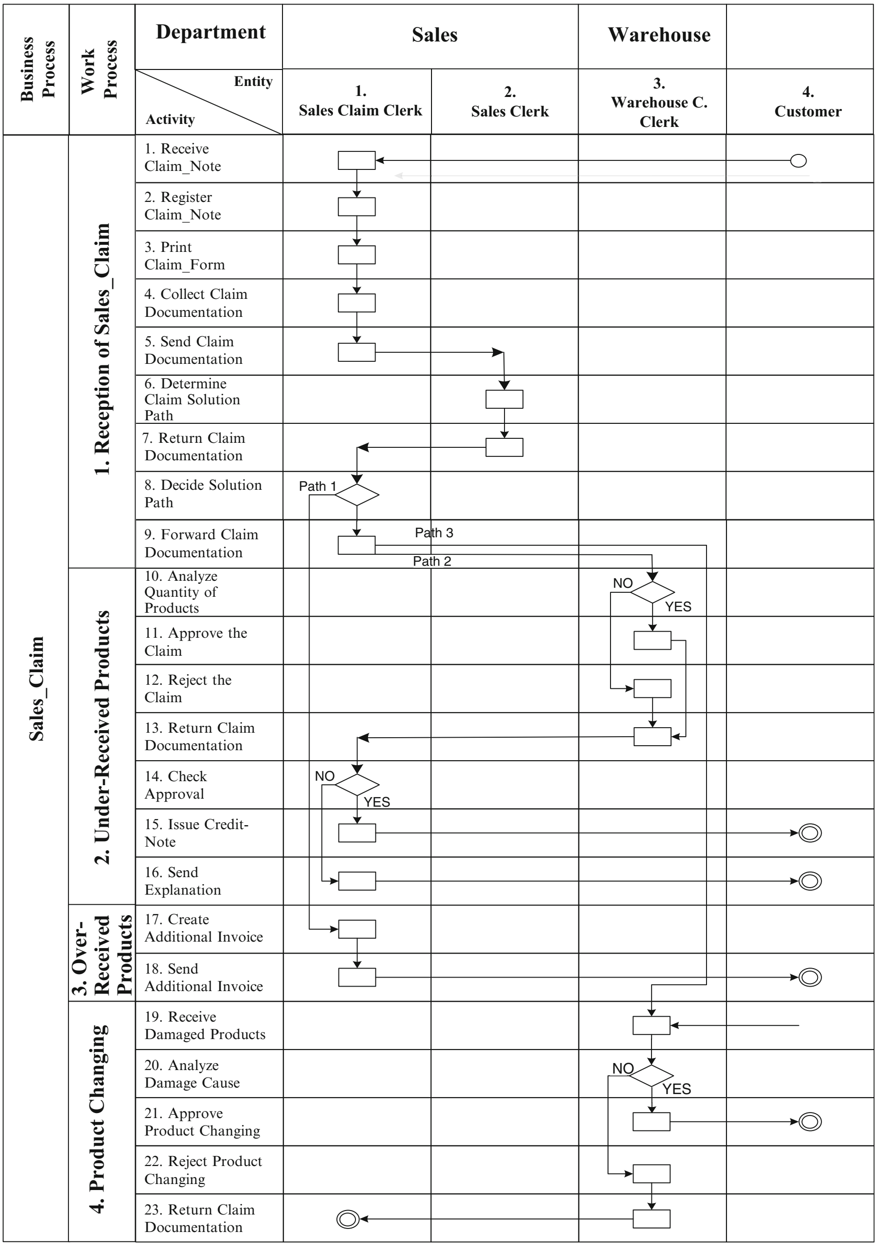


Fig. 14.2 The activity table of "as-is" Sales_Claim process

14.2.2 Activity Table Development: Part 2

Figure 14.3 shows the second part of the Activity Table of the "as-is" Sales_Claim business process. Both tables (Figures 14.2 and 14.3) together represent the "as-is" model of the Sales_Claim business process.

14.3 Phase 3: Process Improvement and Innovation

14.3.1 "as-is" Process Model Analysis

14.3.1.1 Process Simulation

A simulation model of the Sales_Claim business process was created on the basis of the "as-is" process model given in Figs. 14.2 and 14.3.

Simulation of the Sales_Claim business process was run taking into consideration the following assumptions:

- The number of sales claims generated is 3,000;
- Fifty sales claims are usually in different stages of the process;
- A standard calendar was used, this is 8 h/day, 5 days/week and 22 days/month;
- A new claim is generated every hour;
- The following resources were defined: five Sales Claim Clerks, one Sales Clerk, and two Warehouse Claim Clerks.

Figure 14.4 shows the simulation model of the "as-is" Sales_Claim business process.

14.3.1.2 Process Flow

The simulation results of the "as-is" Sales_Claim business process show that the average cycle time of the process is 12.94 days; this is 2.59 weeks. The average inventory is 50 claims, as was identified during interviews with the management of the Sales department.

To calculate the average flow rate of the process, Little's law was used, as shown in formula 1. This is done by dividing the average cycle time by the average inventory, as follows:

$$\text{Average CT} = 12.94 \text{ days}$$
$$\text{Average I} = 50 \text{ claims}$$
$$\text{Average R} = 50\ /\ 12.94 = 3.86 \text{ claims/day}$$

14.3.1.3 Cycle Time Efficiency

From the results of the process simulation we found that the theoretical cycle time of the "as-is" Sales_Claim business process is 0.95 day; this is 7.61 h. Therefore, the cycle time efficiency of the cby dividing the theoretical cycle time by the average cycle time, as follows:

Activity \ Parameter	Description	Resource	Time	Rule	Input/ Output
1. Receive Claim_Note	Sales claim clerk receives a claim note from the customer	Sales Claim Clerk	30 min	Check customer's Order and Shipment	Claim_Note Order, Shipment
2. Register Claim_Note	Sales claim clerk registers customer's Claim_Note	Sales Claim Clerk	10-20 min		Claim_Note
3. Print Claim_Form	Sales claim clerk prints a Claim_Form to open a claim application	Sales Claim Clerk	10 min		Claim_Form
4. Collect Claim Documentation	Sales claim clerk collects the rest of the claim documentation	Sales Claim Clerk	1-2 hour		Dispatch Order, Invoice
5. Send Claim Documentation	Sales claim clerk sends claim documentation to Sales clerk	Sales Claim Clerk	30 Min		Claim Document
6. Determine Claim Solution Path	Sales clerk analyzes the cause of the claim and writes its solution on the claim documentation.	Sales Clerk	30-60 min	Check the cause of the claim	Claim Document
7. Return Claim Documentation	Sales clerk returns claim documentation to Sales claim clerk	Sales Clerk	10-20 min		
8. Decide Solution Path	Sales claim clerk starts claim solution path: under-received, over-received product, or product-changing	Sales Claim Clerk	60 min	If under-received products then go to Analyze Quantity of Products Else if over-received products is then go to Create Additional Invoice Else if product damaged then go to Receive Damaged Product	Claim Document
9. Forward Claim Documentation	Sales claim clerk forwards claim docum. to Warehouse claim clerk	Sales Claim Clerk	15-30 Min	Check under-received products	Claim Document
10. Analyze Quantity of Products	Warehouse claim clerk analyzes the quantity of the order and shipped products	Warehouse Claim Clerk	60 min	If the qty shipped < qty paid then go to Approve the Claim Else If the qty shipped = qty paid then go to Reject the Claim	Order, Shipment, Invoice, Payment, Claim_Note
11. Approve the Claim	Warehouse claim clerk approves the claim	Warehouse Claim Clerk	30-60 min		
12. Reject the Claim	Warehouse claim clerk rejects the claim	Warehouse Claim Clerk	30-60 min		
13. Return Claim Documentation	Warehouse claim clerk returns claim documentation to Sales claim clerk	Warehouse Claim Clerk	10-20 min		Claim Document
14. Check Approval	Sales claim clerk checks whether the Warehouse claim clerk has approved or rejected the claim	Sales Claim Clerk	30-60 min	If the claim is approved then go to Issue Credit-Note else If the claim is rejected then go to Send Explanation	Claim Document
15. Issue Credit-Note	Sales claim clerk issues a credit-note and sends it to the customer	Sales Claim Clerk	60 Min		Credit-Note
16. Send Explanation	Sales claim clerk sends an explanation to the customer about the claim rejection	Sales Claim Clerk	60 min		Explanation
17. Create Additional Invoice	Sales claim clerk creates an additional invoice for additional products received by the customer	Sales Claim Clerk	60 Min		Additional Invoice

Fig. 14.3 (continued)

Parameter / Activity	Description	Resource	Time	Rule	Input/ Output
18. Send Additional Invoice	Sales claim clerk sends an additional invoice to the customer	Sales Claim Clerk	15-30 min		Additional Invoice
19. Receive Damaged Products	Warehouse claim clerk receives the damaged product from the customer	Stock Keeper	15-30 Min		Claim Document
20. Analyze Damage Cause	Warehouse claim clerk analyzes whether transport is the damage cause	Warehouse Claim Clerk	1-2 h	If the cause is transport then go to Approve Product Changing Else If the cause is not transport then go to Reject Product Changing	
21. Approve Product Changing	Warehouse claim clerk approves changing the damaged product	Warehouse Claim Clerk	30-60 min		
22. Reject Product Changing	Warehouse claim clerk rejects changing the damaged product	Warehouse Claim Clerk	30-60 min		
23. Return Claim Documentation	Warehouse claim clerk returns claim documentation to Sales claim clerk	Warehouse Claim Clerk	10-20 Min		Claim Document

Fig. 14.3 Activity table – part 2 of "as-is" Sales_Claim process

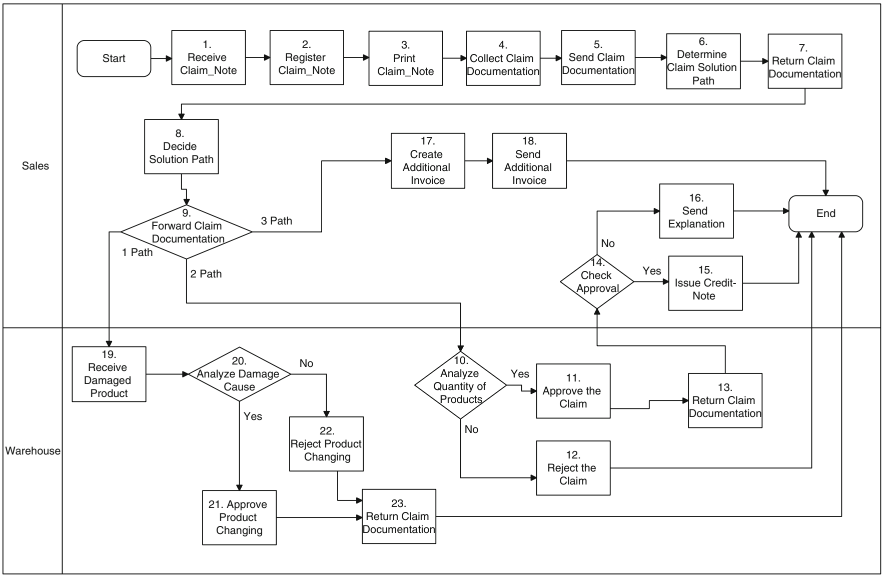


Fig. 14.4 Simulation model of "as-is" Sales_Claim process

$$\text{Cycle time efficiency} = 0.95/12.94 = 7\%$$

This result shows that the process is inefficient and needs to be analyzed and improved.

14.3.1.4 Process Capacity

The capacity utilization of each resource pool is calculated and is shown in the results of the process simulation. These results show the capacity utilization of the resource pools are Sales Claim Clerk 99.39 %, Sales Clerk 98.53 %, and Warehouse Claim Clerk 77.05 %.

The theoretical capacity of the resource pools could be calculated by dividing the average flow rate by the capacity utilization of each resource pool, as shown below:

$$R_p = R/\rho_p$$

$$\text{Sales Claim Clerk } R_p = 3.86/0.99 = 3.89 \text{ claim/day}$$
$$\text{Sales Clerk } R_p = 3.86/0.98 = 3.9 \text{ claim/day}$$
$$\text{Warehouse Clerk Claim } R_p = 3.86/0.77 = 5 \text{ claim/day}$$

These calculations show that the theoretical capacity of the process is 3.89 claims per day because that is the theoretical capacity of the bottleneck resource pool Sales Claim Clerk.

14.3.2 "to-be" Process Model Creation

14.3.2.1 Ideas Identification

The results of the "as-is" process analysis performed in the previous subphase show several important findings, such as:

– The average cycle time of the Sales_Claim process is long and lasts 12.94 business days,
– The process cycle time efficiency is only 7 %.
– The capacity utilization of the resource pools shows that they are very busy; namely Sales Claim Clerk 99.97 %, Sales Clerk 97.85 %, and Warehouse Claim Clerk 77.05 % utilized.

From the above listed facts, we may conclude that the main problem of this process is the long average cycle time, which makes it inefficient and causes the resource pools to be overloaded.

In order to improve the existing process, interviews were organized with experienced employees, which resulted in creating Fig. 14.5. This is the Improvement Table of the Sales_Claim business process, which stores elicited tacit knowledge and other ideas suggested by the team.

From the ideas stored in Fig. 14.5, the business process could be improved by implementing the following measures:

– Making the resource pool Sales Claim Clerk responsible for solving the sales claims problem within the Sales department,
– Removing the resource Sales Clerk,
– Increasing the number of units in the Sales Claim Clerk resource pool,
– Removing activities 5 and 7, and
– Decreasing the number of units in the Warehouse Sales Clerk resource pool.

Business Process	Work Process	Activity	Lessons-Learned		
			Activity	Work Process	Business Process
Sales_Claim	1. Reception of Sales Claims	1. Receive Claim_Note		- Unite solving the sales claim within the Sales department by the Sales Claim Clerk. - Increase the number of Sales Claim Clerks. - Remove the resource Sales Clerk. - Remove activities 5 and 7. - Decrease the Number of Warehouse Sales Clerks.	These ideas should reduce the passing of the claim documents between employees and create a united team of claim clerks that focuses on doing their job effectively. This suggestion should lead to a decrease bthe average cycle time and create an efficient business process.
		2. Register Claim_Note			
		3. Print Claim_Form			
		4. Collect Claim Documentation			
		5. Send Claim Documentation	Remove		
		6. Determine Claim Solution Path			
		7. Return Claim Documentation	Remove		
		8. Decide solution path			
		9. Forward Claim Documentation			
	2. Under-Received Products	10. Analyze Quantity of Products			
		11. Approve the Claim			
		12. Reject the Claim			
		13. Return Claim Documentation			
		14. Check Approval			
		15. Issue Credit-Note			
		16. Send Explanation			
	3. Over-Received Products	17. Create Additional Invoice			
		18. Send Additional Invoice			
	4. Product Changing	19. Receive Damaged Products			
		20. Analyze Damage Cause			
		21. Approve Product Changing			
		22. Reject Product Changing			
		23. Return Claim Documentation			

Fig. 14.5 Improvement table of Sales_Claim business process

14.3.2.2 Ideas Implementation

To implement the process improvement ideas given in Fig. 14.5, new Figs. 14.6 and 14.7 are created. These tables are developed on the basis of Figs. 14.2 and 14.3 updated by the improvement ideas given in the improvement Fig. 14.5.

Figures 14.6 and 14.7 together form the new Activity Table that represents the "to-be" model of the Sales_Claim business process. Figure 14.6 shows the first part of the Activity Table, which contains 21 activities and 2 resources; these are Sales

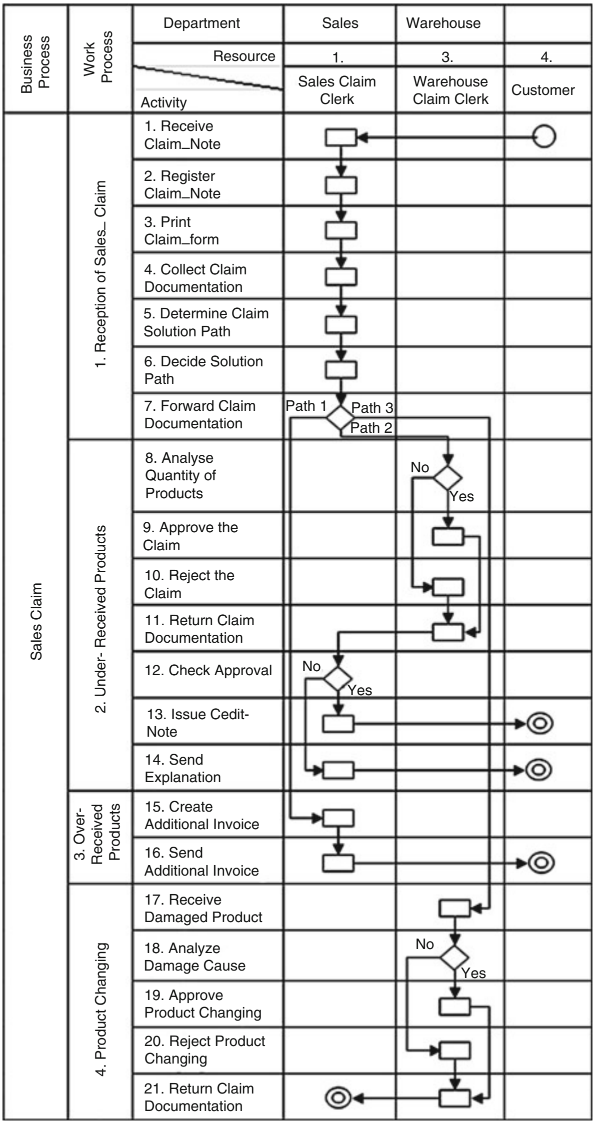


Fig. 14.6 Activity table – part 1 of "to-be" Sales_Claim process

Claim Clerk and Warehouse Claim Clerk. Meanwhile, Fig. 14.7 shows the second part of the Activity Table.

14.3.3 "to-be" Process Model Analysis

14.3.3.1 Process Simulation

The "to-be" Sales_Claim process model represented by both parts of the Activity Table, Figs. 14.6 and 14.7, was transferred to a simulation model of the process.

Parameter / Activity	Description	Resource	Time	Rule	Input/ Output
1. Receive Claim_Note	Sales claim clerk receives a claim note from the customer	Sales Claim Clerk	30 min	Check customer's Order and Shipment	Claim_Note Order, Shipment
2. Register Claim_Note	Sales claim clerk registers customer's Claim_Note	Sales Claim Clerk	10-20 min		Claim_Note
3. Print Claim_Form	Sales claim clerk prints a Claim_Form to open a claim application	Sales Claim Clerk	10 min		Claim_Form
4. Collect Claim Documentation	Sales claim clerk collects the rest of the claim documentation	Sales Claim Clerk	1-2 hour		Dispatch Order, Invoice
5. Determine Claim Solution Path	Sales clerk analyzes the cause of the claim and writes its solution on the claim documentation.	Sales Clerk	30-60 min	Check the cause of the claim	Claim Document
6. Decide Solution path	Sales claim clerk starts claim solving path: under-received, over-received product, or product-changing	Sales Claim Clerk	60 min	If under-received products then go to Analyze Quantity of Products Else if over-received products then go to Create Additional Invoice Else if product damaged then go to Receive Damaged Product	Claim Document
7. Forward Claim Documentation	Sales claim clerk forwards claim docum. to Warehouse claim clerk	Sales Claim Clerk	15-30 Min	Check under-received products	Claim Document
8. Analyze Quantity of Products	Warehouse claim clerk analyzes the quantity of the order and shipped products	Warehouse Claim Clerk	60 min	If the qty shipped < qty paid then go to Approve the Claim Else If the qty shipped = qty paid then go to Reject the Claim	Order, Shipment, Invoice, Payment, Claim_Note
9. Approve the Claim	Warehouse claim clerk approves the claim	Warehouse Claim Clerk	30-60 min		
10. Reject the Claim	Warehouse claim clerk rejects the claim	Warehouse Claim Clerk	30-60 min		
11. Return Claim Documentation	Warehouse claim clerk return claim documentation to Sales claim clerk	Warehouse Claim Clerk	10-20 min		Claim Document
12. Check Approval	Sales claim clerk checks whether the Warehouse claim clerk has approved or rejected the claim	Sales Claim Clerk	30-60 min	If the claim is approved then go to Issue Credit-Note else If the claim is rejected then go to Send Explanation	Claim Document
13. Issue Credit-Note	Sales claim clerk issues a credit-note and sends it to the customer	Sales Claim Clerk	60 Min		Credit-Note
14. Send Explanation	Sales claim clerk sends an explanation to the customer about the claim rejection	Sales Claim Clerk	60 min		Explanation
15. Create Additional Invoice	Sales claim clerk creates an additional invoice for additional products received by the customer	Sales Claim Clerk	60 Min		Additional Invoice
16. Send Additional Invoice	Sales claim clerk sends an additional invoice to the customer	Sales Claim Clerk	15-30 min		Additional Invoice
17. Receive Damaged Products	Warehouse claim clerk receives the damaged product from the customer	Stock Keeper	15-30 Min		Claim Document
18. Analyze Damage Cause	Warehouse claim clerk analyzes whether transport is the damage cause	Warehouse Claim Clerk	1-2 h	If the cause is transport then go to Approve Product Changing Else If the cause is not transport then go to Reject Product Changing	
19. Approve Product Changing	Warehouse claim clerk approves changing the damaged product	Warehouse Claim Clerk	30-60 min		
20. Reject Product Changing	Warehouse claim clerk rejects changing the damaged product	Warehouse Claim Clerk	30-60 min		
21. Return Claim Documentation	Warehouse claim clerk returns claim documentation to Sales claim clerk	Warehouse Claim Clerk	10-20 Min		Claim Document

Fig. 14.7 Activity table – part 2 of "to-be" Sales_Claim process

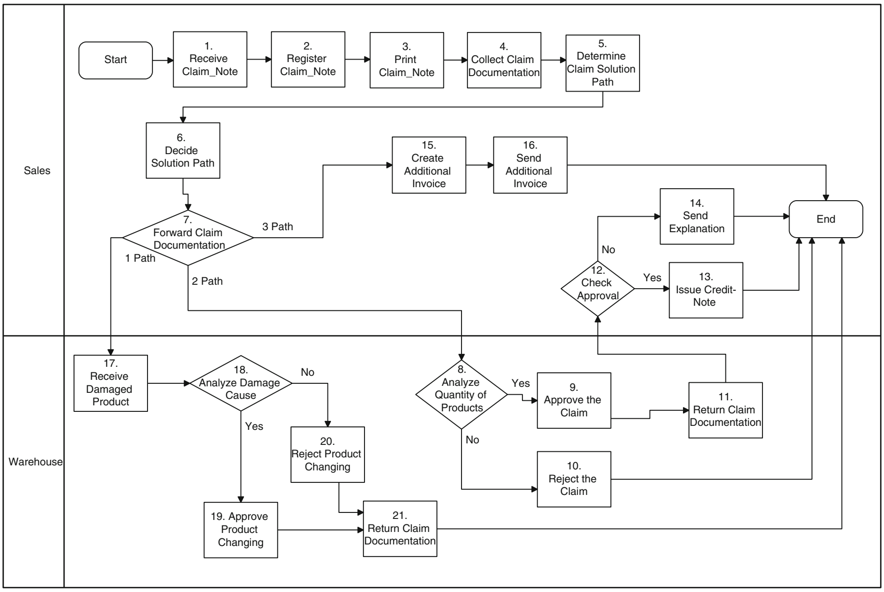


Fig. 14.8 Simulation model of "to-be" Sales_Claim process

The simulation of the "to-be" process model was then run taking into account the same assumptions as those defined for simulation of the "as-is" process, except the last one. These assumptions are:

– The number of sales claims generated is 3,000;
– Fifty sales claims are usually in different stages of processing;
– A standard calendar was used, this is 8 h/day, 5 days/week and 22 days/month;
– A new claim is generated every 1 h;
– The following resources were defined: six Sales Claim Clerks and two Warehouse Claim Clerks.

The following Fig. 14.8 shows the simulation model of the "to-be" model of the Sales_Claim business process.

14.3.3.2 Process Flow

The simulation results showed that the average cycle time of the "to-be" Sales_Claim business process is 3.18 days. From previous discussion, we know that the average inventory of the process is 50 claims.

To calculate the average flow rate of the process, formula 1 is used, as follows:

$$\text{Average CT} = 3.18 \text{ days}$$
$$\text{Average I} = 50 \text{ claims}$$
$$\text{Average R} = 50/3.18 = 15.72 \text{ claim/day}$$

This result shows that using the "to-be" model of Sales_Claim business process enabled shortening the average cycle time from 12.94 to 3.18 days, which consequently lead to increasing the average flow rate of the process from 3.86 to 15.72 claims per day.

14.3.3.3 Cycle Time Efficiency

To calculate the cycle time efficiency of the “to-be” Sales_Claim business process, formula 2 is used, as shown below. The values of both the theoretical cycle time and the average cycle time of the process were obtained from the results of the process simulation.

$$\text{Cycle time efficiency} = 0.86/3.18 = 27\%$$

In comparison to the cycle time efficiency of the “as-is” process, this result shows a major improvement in process cycle time efficiency.

14.3.3.4 Process Capacity

The theoretical capacity of each resource pool of the “to-be” Sales_Claim business process is calculated by dividing the average flow rate by the capacity utilization of each resource pools.

The simulation results show the resource pool utilization of the Sales Claim Clerk is 91.17 % and of the Warehouse Claim Clerk 80.67 %. In addition, the average flow rate was calculated before as 15.72 claims per day.

Therefore, the theoretical capacity is calculated using formula $R_p = R/\rho_p$, as follows:

$$\begin{aligned} &\text{Sales Claim Clerk} && R_p = 15.72/0.91 = 17.27 \text{ claim/day} \\ &\text{Warehouse Clerk Claim} && R_p = 15.72/0.81 = 19.4 \text{ claim/day} \end{aligned}$$

Comparing the theoretical capacity and the capacity utilization of the “to-be” Sales_Claim process with those of the “as-is” process shows that a major improvement has been achieved in the functionality of the process.

14.4 Phase 4: Systems Development

14.4.1 Class Model

The modeling approach, introduced in Chap. 12, is used to develop the class model of the Sales_Claim business process by analyzing two simplified documents These documents are Claim Form and Product, as shown in Fig. 14.9.

14.4.1.1 Modeling Approach

Step 1: Identify Key Attributes

Analysis 14.1 shows that the document Claim Form contains three simple key attributes that belong to the object classes namely CLAIM, CUSTOMER, and

Fig. 14.9 Two documents of Sales_Claim process

CLAIM FORM			
ClaimID:		Date:	
CustomerID:			
Name:		Address:	
ProductID	Name	Date of Purchase	Claim Cause

PRODUCT
ProductID:
Name:
Cost:
Description:

Analysis 14.1 Key attributes – document claim form

ClaimID
CustomerID
ProductID
ClaimID,ProductID

Analysis 14.2 Functional dependence – document claim form

ClaimID	→	Date
CustomerID	→	Name
	→	Address
ProductID	→	ProductName
	→	Cost
ClaimID,ProductID	→	ClaimCause

PRODUCT. In addition, one key attribute collection is identified, which belong to the object class CLAIMPRODUCT.

Step 2: Identify Functional Dependence

In this step, the functional dependences existing between attributes are identified. This is done in accordance with the algorithm introduced in Sect. 12.1, firstly, between the key and non-key attributes and secondly, between the key and foreign key attributes.

Analysis 14.2 shows that the Non-key attribute Date is functionally dependent on key attribute ClaimID, non-key attributes Name and Address are functionally

Analysis 14.3 Functional dependence – document claim form

ClaimID	→	CustomerID

dependent on key attribute CustomerID, and non-key attributes ProductName and Cost are functionally dependent on attribute ProductID. In addition, non-key attribute ClaimCause is functionally dependent on key attribute collection ClaimID,ProductID.

Analysis 14.3 shows that the foreign key attribute CustomerID is functionally dependent on the key attribute ClaimID. This is because any value of attribute ClaimID identifies one value of CustomerID attribute, while each value of the attribute CustomerID may be related to one or more values of the attribute ClaimID.

This functional dependence indicates an association between the classes CLAIM and CUSTOMER.

Step 3: Develop Class Model

We start building the class model of the Sales_Claim business process by defining four classes; this means an object class for each key attribute identified in Analysis 14.1. These classes are CLAIM, CUSTOMER, CLAIMPRODUCT, AND PRODUCT.

Analysis 14.2 enables us to define the classes' attributes. Each defined class contains, in addition to the key attribute of the class, those non-key attributes that are functionally dependent on the key attribute of the class, as is shown in Analysis 14.2.

Analysis 14.3 is used to create associations existing between classes of the class model. An association is defined between two classes if the key attribute of a certain class is functionally dependent on the key attribute of another class, as shown in Analysis 14.3. Such an association is created between the classes CLAIM and CUSTOMER because CustomerID is functionally dependent on ClaimID.

Furthermore, an association is defined between any class whose key attribute is an attribute collection, and those classes whose key attributes form the key attribute collection. Therefore, such an association is created between the classes CLAIM and CLAIMPRODUCT.

See Fig. 14.10, which shows the class model of the Sales_Claim business process.

After completing analysis of the first document, a new iteration using the same approach is started to analyze the document Product.

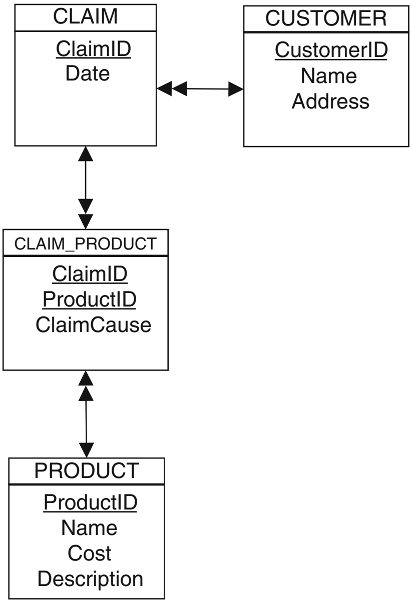
Step 1: Identify Key Attributes

Considering the document Product shows that it contains one key attribute; this is ProductID.

Step 2: Identify functional dependence

Analysis 14.4 shows that the following functional dependence exists between the key attribute ProductID and other non-key attributes of the document.

Fig. 14.10 Class model of Sales_Claim process



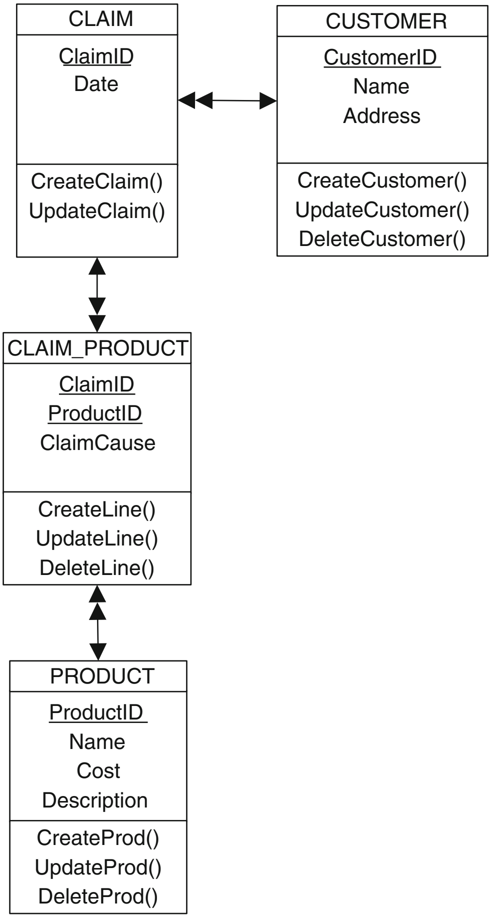
Analysis 14.4 Functional dependence – document PRODUCT

ProductID	→	ProductName
	→	Description

Fig. 14.11 System design of Sales_Claim process

Sales Claim	Reception of Sales Claims	Receive Claim_Note
		Register Claim_Note
		Print Claim_Form
		Collect Claim Documentation
		Determine Claim Solution Path
		Decide Solution Path
		Forward Claim Documentation
		Analyze Quantity of Products
		Approve the Claim
	Under-Received Products	Reject the Claim
		Return Claim Documentation
		Check Approval
		Issue Credit-Note
		Send Explanation
		Create Additional Invoice
		Send Additional Invoice
	Over-Received Products	Receive Damaged Products
		Analyze Damage Cause
	Product Changing	Approve Product Changing
		Reject Product Changing
		Return Claim Documentation

Fig. 14.12 The complete class model of sales_claim process



Step 3: Develop Class Model

From Analysis 14.4, it is easy to conclude that a new attribute, that is Description, should be added to the class PRODUCT; see Fig. 14.11.

14.4.2 System Design

14.4.2.1 Develop Systems Design

The system design of the business Sales_Claim is shown in Fig. 14.11. As is evident from this figure, the model represents a three level hierarchical system. The first level is the business process level, the second is the work process level that shows four work processes, and the third and last level is the activity level, which shows all the activities of the process.

14.4.2.2 Define Operations and Algorithms

The current step deals with identifying and defining the operations of each object class of the class model. Figure 14.12 shows the complete class model of the Sales_Claim business process.

In addition, the necessary algorithms should be developed to implement the design model shown in Fig. 14.11.

Appendix

The current Appendix introduces a step-by-step guide for creating the Activity Table using MS Excel.

Step 1:

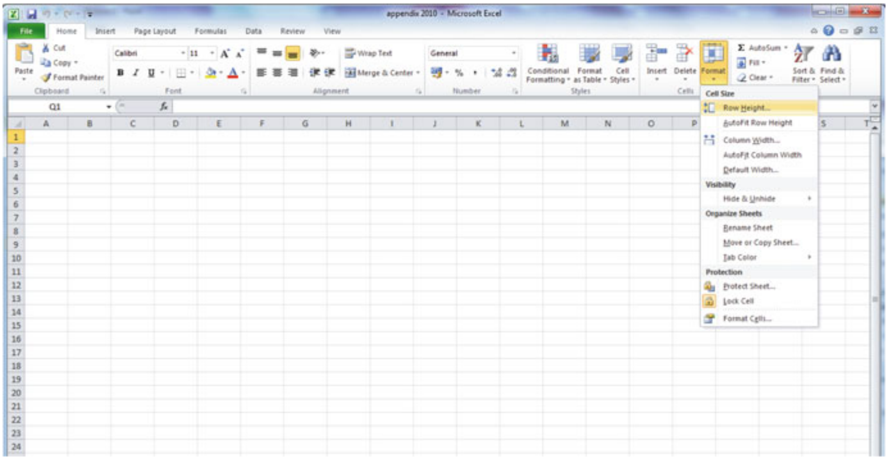
- Insert the name of the business process in the first column;
- Insert the names of the work processes in the second column;
- Insert the names of the activities in the rows of the third column;
- Merge the cells of the first column;
- For each work process merge cells depending on the number of its activities;
- Insert the words “Business Process”, “Work Process” and “Department” in the first three cells of the first row;
- Insert the names of the departments in the following cells of the first row;
- Insert the names of the resources in the second row from the fourth cell on;
- For each department merge cells depending on the number of its resources.

Step 2:

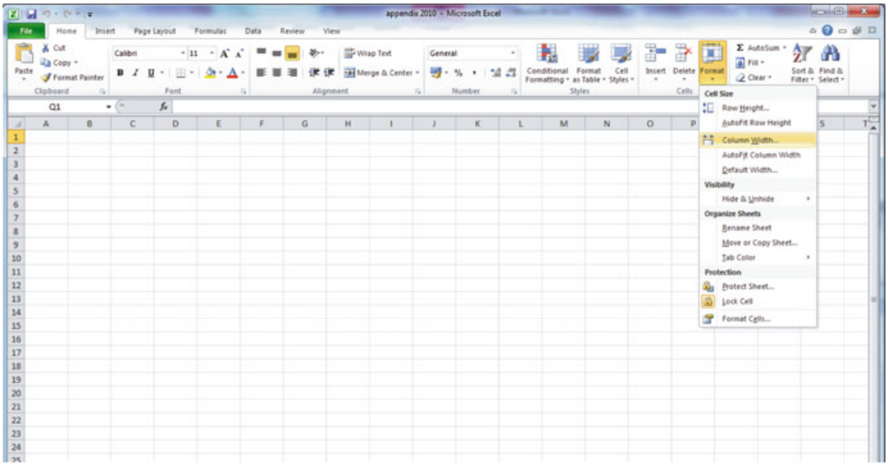
- Define row height and column width for all rows and all columns

  It is important that text within the cells is fully visible and enables the modeler to define a network by inserting different symbols;
- To define row height and column width, go to Home menu, select Cells, Format, and then either Row Height or Column Width; see Pictures 1 and 2.

N. Damij and T. Damij, *Process Management*, Progress in IS,
DOI 10.1007/978-3-642-36639-0,



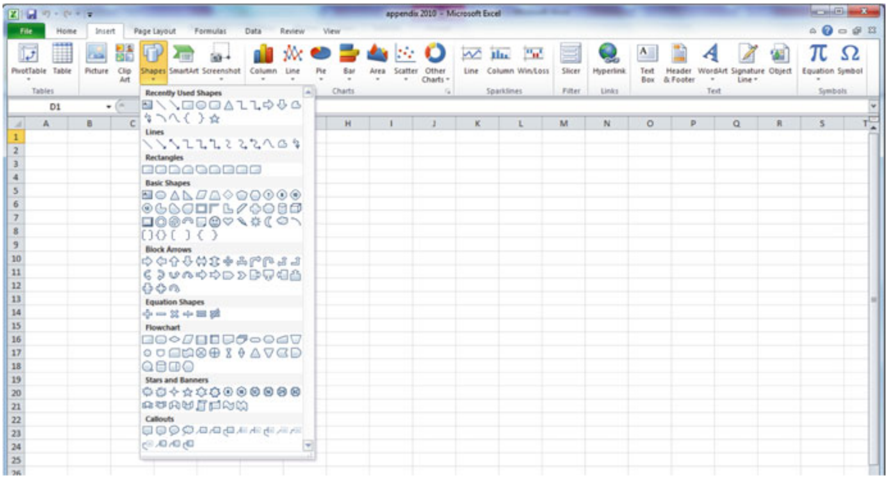
Picture 1



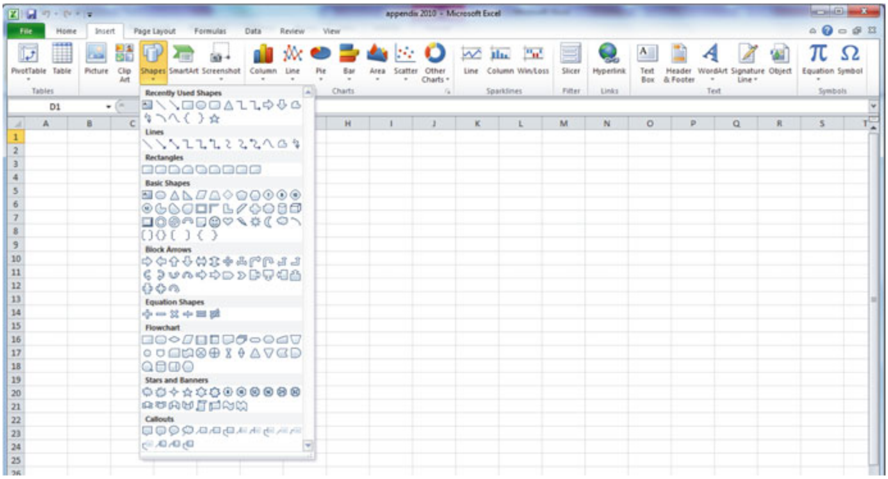
Picture 2

Step 3:

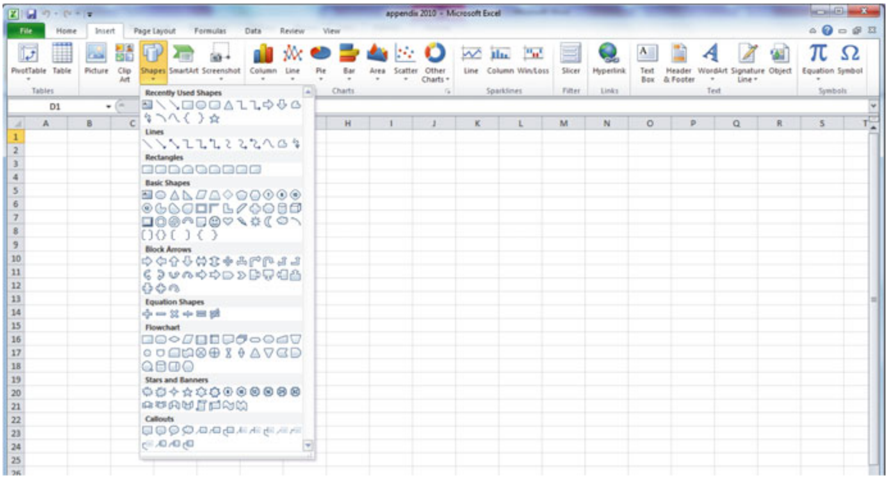
- Activate the Drawing Toolbar by selecting from the Insert menu Illuminations and Shapes as shown in Pictures 3 to 9;
- Define all five symbols on the right side of the table: ▭, ○, ◇ and ◎ as well as $\longrightarrow$It is important that all symbols have the same size;
- Insert the appropriate symbol in the appropriate cell and repeat this throughout the whole table;
- Use the Drawing tool to characterize each shape as shown in Pictures 6 and 9.



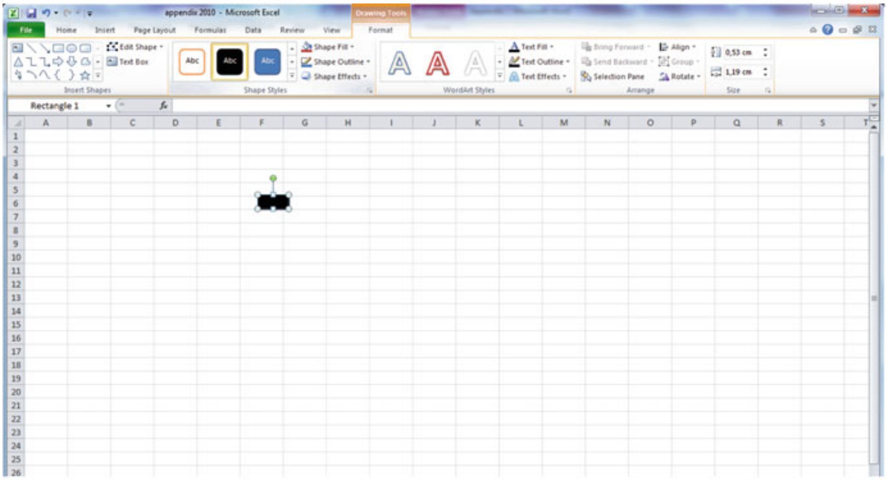
Picture 3



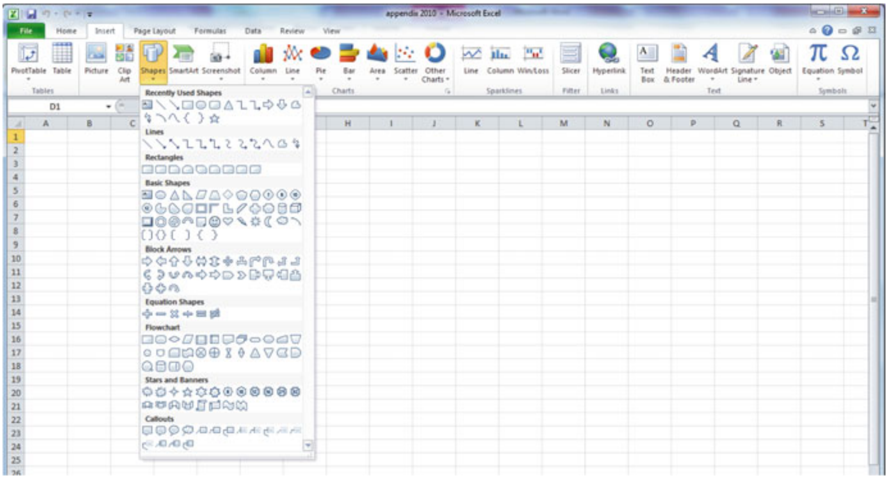
Picture 4



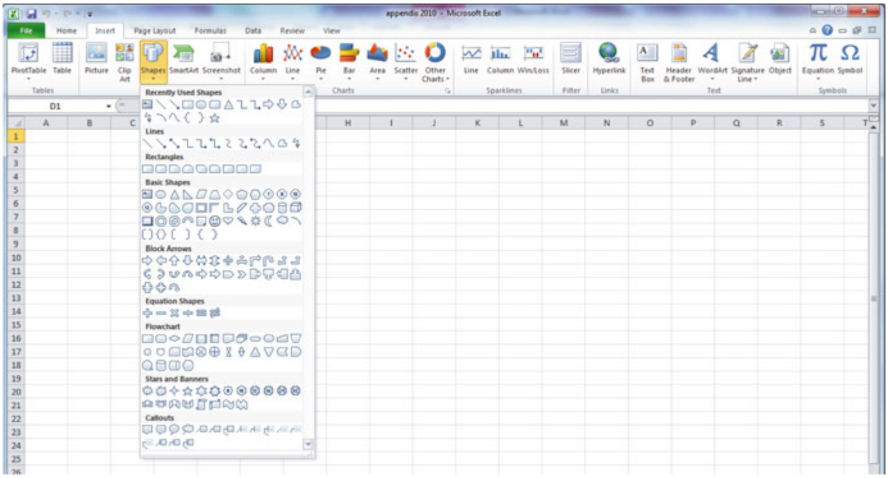
Picture 5



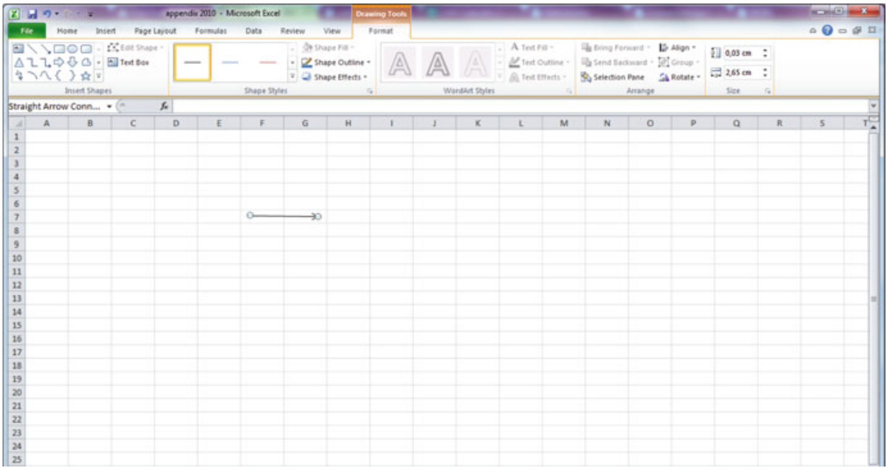
Picture 6



Picture 7



Picture 8



Picture 9

Step 4:
If necessary, centre the symbols in the cell and use an arrow to connect them.

Index

N. Damij and T. Damij, *Process Management*, Progress in IS,
DOI 10.1007/978-3-642-36639-0,