Business Engineering and Service Design

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1 author:

Oscar Barros
University of Chile

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Óscar Barros

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Abstract

This work presents an innovative approach to business design, known as Business Engineering, and its application to service offerings design in general. Such an approach is characterized by:

- Integrating many disciplines—Ontology, Strategy, Business Models, Modularization, Platform Design, Case Management, Business Processes, Business Intelligence, Information Systems, and Information Technology (IT)—in generating detailed Enterprise Architecture designs for services, which are aligned with and make operational stakeholders' interests.
- Providing a hierarchical design methodology that allows managing the complexity of full enterprise design by starting with overall aggregated designs, which are then detailed by hierarchical decomposition.
- Basing designs on Business, Architecture, and Process Patterns that abstract and formalize the knowledge and experience generated from hundreds of business design cases in which the approach has been applied.
- Introducing advanced Analytics—for example, predictive and prescriptive data-based models, optimization techniques, and simulation—to support business development, by using models to generate new or improved service designs, and management by embedding models in operating process design; this allows generating truly Business Intelligence that optimizes service performance.
- Using formal constructs to model patterns and designs based on the Business Process Management Notation (BPMN), allowing simulation and eventual execution of the designs using Business Process Management Suite (BPMS) and Service-Oriented Architecture (SOA) technology.

The book provides the foundations of Business Engineering, reviews the several disciplines integrated within its methodology, and presents plentiful evidence of its power by giving detailed real application cases, including very impressive results in private and public situations.

Keywords

Analytics, BPMN, BPMS, Business Design, Business Design Patterns, Business Engineering, Business Intelligence, Enterprise Architecture Design, Service Design, Service Engineering, Service Processes Design

Contents

Acknowledgments

I want to recognize the continuous support I have received during my academic career at the Department of Industrial Engineering of the University of Chile. I have found a very good environment for my creative efforts in this academic unit, including the ideas of Business Engineering, theme of this book, and the Master in Business Engineering that I designed and implemented here.

I also want to deeply thank the hundreds of students that have worked in my academic projects, in trying to put to test my ideas in the real world, which is what any engineering discipline should do. They have had a very positive disposition to test innovative proposals, providing the laboratory I needed to prove that they work. This testing would have not been possible without the collaboration of many private and public organizations that have been willing to act as research subjects. Many thanks to all of them.

Prolog

For more than 15 years, I have been working on the development of the foundations of what I call Business Engineering, with the aim of providing tools, as other engineering disciplines have, for the design of businesses. This effort has been directed to show that enterprises can be formally designed and that their architectures, including processes, personnel organization, information systems, information technology (IT) infrastructure, and interactions with customers and suppliers should be considered in a systemic way in such design. This Enterprise design is not a one-time effort, but in the dynamic environment we face, organizations need to have the capability to continuously evaluate opportunities to improve their designs. Other researchers have recognized this need, as the ones who have worked under the idea of Enterprise Architecture, but they have mostly concentrated on the technological architecture and just touched on the business design issues. Our work resulted, in 2003, in a graduate program of study, the Master in Business Engineering at the University of Chile,[1] which has been taken up by several hundreds of professionals. Such Master has been the laboratory where many of the ideas we propose have been tested and many new ones generated as generalization of the knowledge and experience generated by hundreds of projects developed in the theses required by this program.

I have published books (in Spanish and English) and papers (in English), all detailed in the references, that touch on different topics of my proposal. In this work, I give a compact summary with two new additions: The adaptation of our ideas to services, based on the work we have been doing in this domain for at least 10 years, where we have carried out research and development efforts by adapting our approach to provide working solutions for a large number of Chilean firms. These solutions are already implemented, and showing that large increases in quality of service and efficiency in the use of resources can be attained.

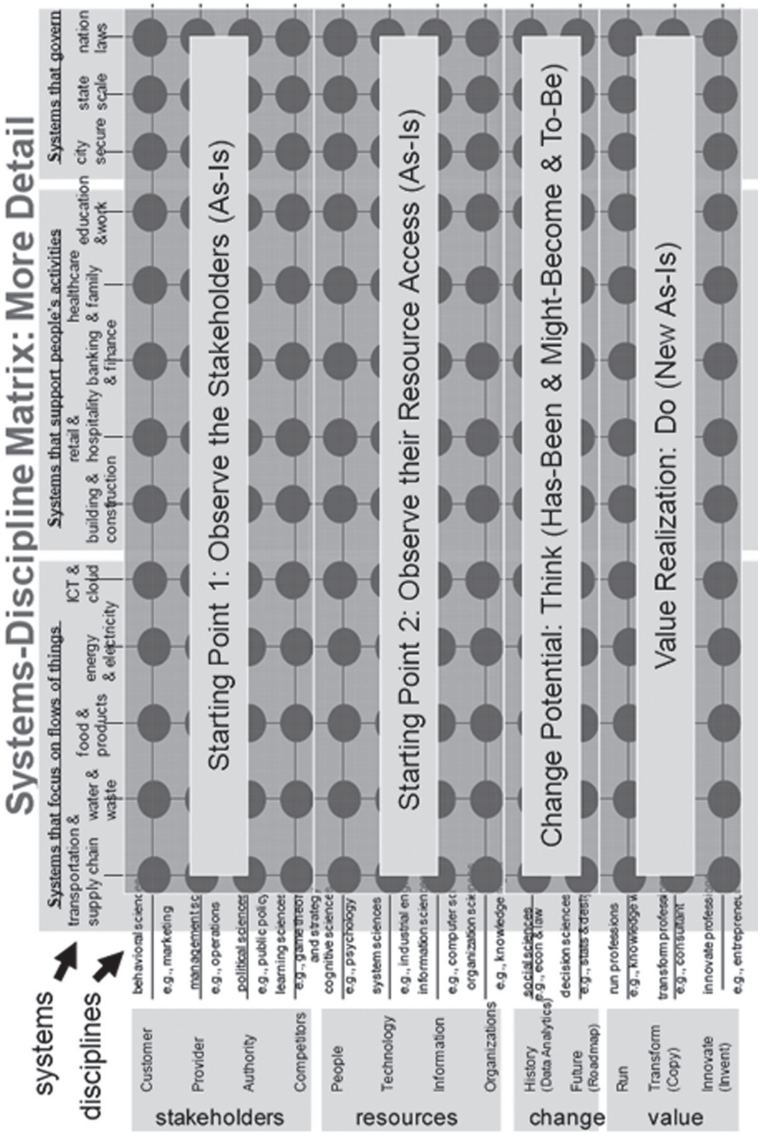
Our approach includes the integrated design of a business, its service configuration (architectures), capacity planning, the resource management processes, and the operating processes. Such an approach is based on general patterns that define service design options and analytical methods that make possible resource optimization to meet the demand. This is complemented with technology that allows process execution with Business Process Management Notation (BPMN) and Business Process Management Suits (BPMS) tools and web services over Service-Oriented Architecture (SOA). In summary, we integrate a business design with Analytics and supporting Information Technology (IT) tools in giving a sound basis for a service design.

General patterns provide reference models and general process structures, in given domains, as a starting point to design the processes for a particular case. The key idea is to formalize successful design knowledge and experience in these models, reuse such knowledge when designing, and avoid reinventing the wheel. Patterns are normative, in that they include what it is recommended as best practices and the ones we have found that work in practice in hundreds of projects, as it has been remarked before. So, they contain specific guidelines on how a process should be designed, allowing reuse of such patterns, thus avoiding to start from very expensive "as is" process documentation, proposed by methodologies such as Business Process Management (BPM).[2] It is our experience that "as is" documentation is very expensive, running into the millions of dollars for large organizations, and there is a low to medium probability that the effort ends in failure, because of killing of the project without any result whatsoever. This has been the case of two large government agencies in Chile, which spent more than one million dollars each on "as is" studies and eventually decided to terminate the projects because of lack of results, and two large banks and one of the leading holdings companies of the country, which have had similar experiences.

There are two key concepts that characterize our proposal for Business Engineering: Ingenuity and Form. We posit that good engineering requires Ingenuity to design the innovative solutions businesses require in the extreme competitive environment that organizations currently face. Thus, our emphasis is on systemic, integrated, and innovative business design, explicitly oriented to make an organization more competitive in the private case and more effective and efficient in the public case. On the other hand, the design has to materialize in a Form, in the traditional architecture sense proposed by Alexander,[3] which can follow certain patterns based on the existent knowledge that provides a starting point for such design. Software engineers took their pattern ideas[4] from Alexander, and this is also the inspiration for our pattern's proposal.

One particular characteristics of this book is that it illustrates all its ideas and proposals with many real cases, coming from projects that have been implemented in practice and provided very impressive results, which are detailed in the chapters. The cases show how the same design guidelines, we will present, successfully provide good results in very different situations and environments.

As Spohrer and Demirkan propose in the presentation of the series in "Service Systems and Innovation in Business and Society," of which this book is part, I embrace the idea of integrating scientific, engineering, and management disciplines to innovate in the services that organizations perform to create value for customers and shareholders that could not be achieved through disciplines in isolation. The integration developed in this book can be located in the Spohrer and Demirkan's System-Discipline Matrix, included as follows, as centered on "Systems that support people's activities" that are designed with the participation of most of the disciplines defined in the matrix. Thus, for example, as it will be presented in this book, quantitative marketing—with the tools of Data Mining—is used to model customers' needs and options; Management Science allows characterizing providers' logistic; the Economics theory permits to model competitors' behavior; knowledge management and change management define people roles in service change; Industrial Engineering and Information Sciences provide the tools for information analysis and supporting tools definition; and all these disciplines plus Strategic Planning, other Analytics—as Optimization Models and Business Analytics—process modeling and design, project management, and others serve as a basis to generate ideas to produce and implement a design that realizes the value for the customers and stakeholders.


Systems-Discipline Matrix: More Detail
systems
disciplines
Systems that focus on flows of things
transportation & supply chain
water & waste
food & products
energy & electricity
ICT & cloud
Systems that support people's activities
building & construction
retail & hospitality
banking & finance
healthcare & family
education & work
Systems that govern
city secure
state scale
nation laws
stakeholders
Customer
Provider
Authority
Competitors
resources
People
Technology
Information
Organizations
change
History (Data Analytics)
Future (Roadmap)
value
Run
Transform (Copy)
Innovate (Invent)
e.g., marketing
e.g., operations
political sciences
e.g., public policy
learning sciences
cognitive sciences
e.g., psychology
system sciences
e.g., knowledge
social sciences
e.g., econ & law
decision sciences
run professions
Starting Point 1: Observe the Stakeholders (As-Is)
Starting Point 2: Observe their Resource Access (As-Is)
Change Potential: Think (Has-Been & Might-Become & To-Be)
Value Realization: Do (New As-Is)

Hence, this book is completely aligned with the purpose of this series and its contribution is to provide an original Business Engineering approach that emphasizes service design and derives an integral and systemic solution that starts with Strategy and Business Model definition, follows with business design, processes design, and information system design, and finished with well-planned implementation.

This is a revision of a previous book with Business Expert Press, *Business Engineering and Service Design with Applications for Health Care Institutions*, which will be edited in two volumes: the one we are presenting now and a follow up volume that will cover applications in Health Care under the name *Service Design with Applications for Health Care Institutions.*

In this revision we restructure the original chapters, creating two new ones: one with revisions and updating of the design ideas we propose, which is Chapter 4, *Design Framework for Intelligent Enterprise Architectures*, and another one that makes a review of the relevant disciplines that are integrated in our approach, which is Chapter 3; this chapter, among other things, reviews Modularity, a somewhat new development, and shows how it can be incorporated in our proposal; deepens the presentation of Analytics and shows it as the foundation for intelligent architectures; and reviews formal Economics theory and concepts that permit rigorous design evaluation. Finally, new cases are presented in Chapter 5, which emphasize the idea of structural business design as a mean to obtain competitive advantage.

CHAPTER 1

Introduction

Ever since the idea of Service Science was proposed,[1] several lines of work in what is now called Service Science, Management, and Engineering (SSME) have been put forward.[2] In the Prolog, we linked our work to a framework related to SSME, developed by Spohrer and Demirkan, for "Service Systems and Innovation in Business and Society," and concluded that our proposed approach is congruent with their ideas.

This book reports our research and development work in the engineering part of SSME, and in particular, the design of the components of service systems. As stated in the Prolog, our main source of inspiration is Business Engineering, which not only shares the ideas and principles of SSME, but also tries to cover a larger domain, including any type of business. The value we add, as compared to SSME, is the emphasis on making operative the disciplines' integration it proposes, by introducing Strategy and Business Models as the starting point to define the design scope in a precise way; services Enterprise Architectures (EA) and processes, including the ones that "produce" the service, as the object of design; general patterns as a mean to facilitate the designs; Analytics embedded into EA and processes to make them truly intelligent in trying to optimize design performance; evaluation criteria to decide on designs; and a well-founded and defined methodology to perform the design.

Our approach is based on the following ideas that have not been fully exploited yet in service design.

First, we want to assure that service design is explicitly aligned with Strategy[3] and Business Model;[4] to accomplish this, we propose the methodology of Business Engineering in performing such design.[5]

Then, in making service design explicit at a high and systemic level, we use a service EA based on Architecture Patterns;[6] this approach has been extensively tested in many real cases in health service design and other business sectors.[7]

Finally, in doing detail service design, starting from an EA, we use general process patterns that provide predefined solutions for such design;[8] these patterns also consider the introduction of intelligence embedded into their components as Analytics-based business logic. Here, we are aligned with the proposals of Davenport and Harris[9] of using Analytics (e.g., Business Intelligence, optimization, and Machine Learning) in making enterprises more competitive. As a tool to define how intelligence can be integrated into the design, particularly at the level of EA, several structures are presented in Chapter 4, which show alternative ways to do this.

These ideas and the experience generated by applying them across various domains, such as manufacturing, distribution, bank services, retail, and hospitals,[10] have enabled us to propose the conceptual model (Ontology) in Figure 1.1, which formalizes such ideas. According to this model, designs are based on the *Strategy* and the *Business Model* that an organization wants to put into practice. But no Strategy or Business Model specifies *how* the positioning and the value will be actually delivered in operational terms. This is what a *Business Design* will detail, starting with *Business Capabilities* necessary according to the Strategy and Business Model. This must be complemented with the design of processes, systems, organizational and information technology (IT) support that make the Business Capabilities fully operational, giving rise to the other architectures included in Figure 1.1

1. *Process Architecture*, which establishes the processes necessary to implement the Capabilities and Business Design, the relationships that coordinate the processes, the business logic—algorithms, heuristics, rules, and in general, procedures—that automate or guide such processes and their connection to IT support.
2. *Organization Architecture*, which is related to the common organizational charts and defines how work will be structured—who will do what—and the relationships among them—who will respond and relates to whom. Such architecture is much related to the Process Architecture, since, as we will detail and exemplify in Chapter 5, process design determines, in many cases, peoples' roles.
3. *Systems Architecture*, which defines the Information Systems that exists in an organization, their relationships, and the support they

give to processes. Again there is a close relationship between this architecture and Process Architecture, since the system support should be, according to our proposal, explicitly defined in the process design, which can be given with current, modified, or new systems that change the architecture.

4. *Information Architecture*, which shows the structure of the Information Systems' data, and for the same reasons as in (3), is also related to processes.

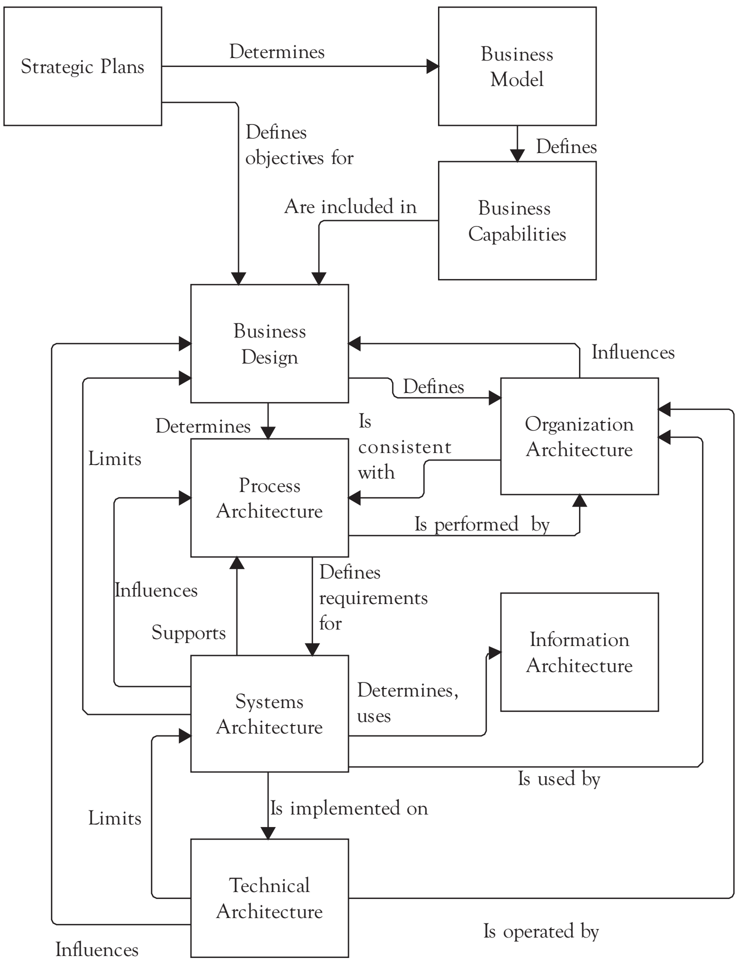


Figure 1.1 Ontology for a Business Design

5. *Technical Architecture*, or the contents and structure or the hardware and nonapplication software on which data resides and systems are run, which are obviously related to all the aforementioned architectures.

Notice that the conceptual model suggests a design methodology, to be detailed in Chapter 5, which we now apply to a much-simplified real-life example of a private hospital that has defined a Strategy of providing the most advanced services in its market in terms of medical practices and supporting technology. The Business Model then is to provide high-value services to patients, which increases the probability of patients' well-being, and for which they are willing to pay premium prices. Then, the hospital needs Capabilities and a Business Design that are able to generate such services. The Capabilities are, in this case, the abilities necessary to innovate in medical practices and the knowledge of new technology that supports such practices, which implies the redesign of the medical services to be provided; the Business Design is a structure of components that delivers the Capabilities. In this case, a new component that performs a new service development, another that is able to put the new services into practice and one that can do associated marketing and selling. Since the hospital does not have these components, new processes that enhance the current architecture to make such components operational should be designed. Among others, a process for a new service development should include the definition of actors' role in the process, which can be a new group created for this purpose or a group comprising the existing people in hospital operations that, with adequate support, form an innovation team that produces new medical services. Clearly, there are different organizational structures for the aforementioned alternatives, and this shows the relationship between a process and organization design. Then process design will determine system support, for example, for new service development planning and tracking, and data, software, and hardware needs related to the other architectures, as illustrated in Figure 1.1.

These general ideas of Business Engineering are applicable to service design in any domain, as we show in Chapter 5, and in particular, to health services, which is dealt with in a follow-up volume: *Service Design with Applications to Health Care Institutions.*

The Business Engineering methodology for service design to exploit the previous ideas, applied to hundreds of real-life cases, has allowed us to propose a hierarchy of *design levels*, detailed in the following sections, which allows performing the complex, systemic problem of overall business (service) design in a sequence of related, coherent, and smaller pieces. We outline such levels as follows and exemplify them with various cases:

1. *Business Design* delivers the structure of components—production, management, supporting, and others—and their relationships, together with the interaction with the environment that generates a Business Capability, which provides a service with value for customers in accordance with the Strategy and Business Model. It represents *what a business should do* and does not map to an organizational unit, area, or product. A case of this type is the private hospital we just presented, which shows that the Business Model of leading on medical treatments and technology requires new Capabilities in the form of new activities that discover and manage innovations of this type to provide value for customers. Another case is a financial credit card data-processing organization that gives services to several banks, which is using Analytics applied to customer data, both internal and external big data, to develop new services; it has used such data to model customer behavior and discover new business opportunities for the banks it serves, such as campaigns for credit card use and to avoid churn; this case will be detailed in Chapter 5. This level includes designing the service in itself (product) and its production; for example, in the case of the private hospital, new medical practices with renovated equipment to perform medical services is the final result sought with this type of design.
2. *Business configuration and capacity design* includes the determination of the Process Architecture that should be present to assure that the service defined in (1) is provided in an effective and efficient way. In addition, what capacity should each process provide to be able to meet the demand according to the desired Service Level Agreement. For example, hospitals' emergency services may have different configurations in terms of its processes, among others: (a) use of a Triage (patient routing), (b) a fast-track line, and (c) several different

lines of service. Once the components are defined, capacity must be determined in order to have a desired patient average waiting time. This problem is relevant only when the demand behavior changes or there are possible innovations in service technology, and it is usually related to strategic investment issues.

3. *Resource management process design* is the management of people, equipment, and supplies that are necessary to provide the capacity established in (2). For example, in the credit card transaction case in (1), the structure of the group that will generate and execute campaigns for banks and the number of people necessary in each part of the process. Such processes are executed with regular frequency depending on demand dynamics.
4. *Operating management processes design* provides processes necessary for day-to-day scheduling of demand over the resources in order to assure the required level of service and optimize their use. For example, production scheduling processes in a paper plan to assign order to machines in such a way that customer's orders are processed on time and production is maximized.

Design levels are applied according to the situation under study; thus, new businesses or new variants over an existing one imply performing all the levels; for example, in the case of the financial credit card data-processing organization outlined earlier, the new service to banks implies starting with a Business Design as defined earlier, including design of the new service (product) and its production, and then applying all the other levels to define how such design will be operationally implemented. When more marginal innovations are performed, only lower levels may apply; for example, changing the scheduling method for patients over surgical facilities to improve waiting time for surgeries and better using the resources means application of only design level 4. We will present several real-life cases in Chapter 5, which show how the different levels apply in particular cases.

The innovative design approach we propose to solve the aforementioned problems in an integrated way is based on explicit and formal general business, architecture and process models, called Business Patterns (BPs) and Business Architecture and Process Patterns, which enable the definition of service design options and analytical methods that allow customer characterization and resource optimization in designing and operating the service. This is complemented with modeling of the processes with Business Process Management Notation[11] and a technology that facilitates the process execution with Business Process Management Suites tools and web services over service-oriented architecture.[12] In summary, we integrate a business and process design approach with analytics and supporting IT tools, as shown in the following chapters.

We have applied the design approach to many types of services, and we will present cases from many industries. Further, in a follow-up volume, *Service Design with applications to Health Care Institutions*, we will present the results of a large-scale project we are developing for the health system in Chile.

The next chapter reviews the relevant literature, emphasizing the related work in SSME, Systems Science, and EA. The following chapter presents a summary of the relevant concepts in the disciplines of Strategy and Business Model, Modularity and Platform Design, Evaluation Theories and Methods, and Business and Process Intelligence that will be integrated in our approach. Then, we will present the framework behind our service design proposal, including the constructs that support the methodology used: Intelligent Design Structures, BPs, Process Architecture Patterns and Process Patterns. Finally, the design methodology is presented and applied to several cases validating our proposal, including the results generated; also, final conclusions are summarized.

CHAPTER 2

Review of Relevant Work

In this chapter, we review proposals that have a similar purpose to the design approach outlined in the previous chapter.

Service Science, Management, and Engineering

This work is related to the proposals on Service Science, Management, and Engineering (SSME),[1] with which we share the same design objective, but propose a different approach and other tools. In particular, our emphasis is on the design of the different types of processes that are needed to make a service operational. A proposal in the spirit of this work is the one by Tien and Berg[2] on service engineering. They propose a systems approach and show how different disciplines can contribute to it. They mention, among others, design and analytics (Operations Research and Management Sciences), but do not give methodological details on how to proceed; this book focuses on providing such details based on the process design ideas. Other papers that further delve into service design are those by Bullinger, Fähnrich, and Meiren,[3] which concentrate on product design, and by Johansson and Olhager,[4] which proposes service profiling, but neither of the papers consider process design. With regard to publications that explicitly consider services and processes, we have the one by Reijers,[5] which concentrates on the technical details of service workflow, but does not offer any service design methodology, and a paper by Hill et al.[6] which only identifies research opportunities in a service process design. Another proposal for the design of service-oriented systems, in the idea of Service-Oriented Architecture (SOA)-based on business process modeling, is made by Gasevic and Hatala,[7] but it does not go into real business design issues, except for technical ones related to Information Systems design.

Other relevant work is the application of the theory of constraints (TOC) to the design of services, including processes, which is reviewed by Groop,[8] including adaptations of this technique, coming from manufacture. In particular, the contributions of Ricketts[9] to the redefinition of TOC concepts, for example, inventory buffers and replenishment for services are presented. Applications to banks, engineering and product design, court systems, food services, education, government sector services, and several others are reviewed as well. In health services applications of the TOC, Groop found that the literature is sparse and applications are few. But since there seems to be a considerable interest in the use of the TOC in services, we will relate this technique with our proposal in later chapters.

We now review approaches, with the same purpose of SSME, which privilege the design of the service (product) in itself and its production, as opposed to, as we will discuss in the following chapter, the design of the management activities and associate processes that make the service operational; for example, the case of a bank that wants to innovate on its loan services by moving from traditional face-to-face selling to Internet-mediated self-service. In doing this, a detail design of the user experience is needed, specifying the sequence of interactions between the customer and a web application backed with the bank's systems;[10] this a configuration design, according to the definitions of the previous chapter, since a new way of performing the service is being designed, which must be complemented with other design levels, as we will show with several cases in Chapter 5. For this type of design, there are several lines of independent work for different types of services as follows:

1. One is a line on services oriented to the needs that have a significant personal, social, and emotional value, such as magazines, sports, tourism, restaurants, insurance, and the like. For these services, the design approaches emphasize the user experience and graphic methods for its mapping or representation, as proposed by Kalbach and others.[11] These approaches consider behavioral, cognitive, cultural, context, ecological, and other factors in analyzing and designing the user experience.

2. There are methods that take ideas from a physical product design, including mixing such products and associated services. In particular, Baines et al. provide a good survey of these types of methods[12] for what they call product services systems. Being physical product-based, they have engineering content in their design, so more formal service design methods are required. Examples of such services are the services integrated in lighting system solutions; lubricant services packages that reduce consumption; energy management, consumption, and process monitoring from energy providers; and monitored efficient washing machines paid per wash and serviced by the manufacturer. Another name used for this type of design is servitization of products, and it emphasis is on customization, higher quality, removing administrative and monitoring tasks away from the customer, and the reduction of environmental impact.
3. Another line of work is Modularity and Platform Design, which emphasizes the design of services that have a complex delivery with many components that are used according to customers' needs, which are not known in advance, such as health, logistics, welfare, investment banking, consulting, and the like. We will review in more detail this line in the next chapter, since their design methods are formal and close to the Business Engineering methods we propose.

We will use some of these methods, in particular Modularity, in our design proposal, but taking a more systemic viewpoint, considering the design of the business structure needed to produce a service designed by any of the methods mentioned. In particular, we will show their position in our design hierarchy. The cases in (2) and (3) are more related to our proposal. In fact, we have produced designs related to the ones in (2), such as full predictive maintenance services for trucks sold by a company in Chile and maintenance services for industrial customers of an electrical distributor in Peru, which will be summarized in Chapter 5.

Now, we consider various methods complementary to SSME, which propose specific tools in doing service design at the various levels defined in Chapter 1.

On the use of Analytics in service design, there is a line of demand forecasts focused on services. Here, the variable to predict is the number of clients who will demand the service to design the capacity needed to provide a given level of service, which is a design problem of the second level of the hierarchy presented in Chapter 1. In one case, joint demand and capacity design have been proposed for services in a restaurant,[13] where the main focus lies on optimizing the revenue for a given dynamic demand without considering, however, demand forecasting explicitly. A similar study has been proposed for scheduling elective surgery under uncertainty,[14] but again, without considering demand forecasting.

There have been several attempts to formal design in health services, such as the one by Marmor et al.[15] where a simulation approach is used to design an emergency service, but without introducing a process view. Other works using a simulation approach to capacity planning in hospitals are those by Samaha, Armel, and Stark;[16] Rojas and Garabito;[17] and Khurma and Bacioiu.[18]

Maglio, Cefkin, Haas, and Selinger[19] have proposed an approach for a high-level, systemic health system modeling, and simulation for policy decision making.

Complementary to such idea, our proposal to manage the health system is oriented toward the design of the components that are needed to implement the given policies.

Systems Engineering

Another related line of work is Systems Engineering, which also emphasizes the integration of disciplines for systems modeling with emphasis on Industrial Engineering, Operations Research, and several others. It is technique oriented, and provides no overall detailed methodology for services design. It is defined as an interdisciplinary approach to analyze, design, manage, and measure a complex system with efforts to improve its efficiency, productivity, quality, safety, and other factors, including the full suite of tools and methods that can analyze a system, its elements, and connections between elements; assist with the design of policies and processes; and help manage operations to provide better quality and outcomes at lower cost.

Systems Engineering can be applied in multiple ways depending on the specific challenges and the type of system, with the following possible general steps: defining the problem, modeling the system, analyzing alternatives, implementing options, and assessing what worked.[20]

The possible methods and tools include Industrial Engineering, production-system methods, Lean and broader process-improvement techniques, operations management, queuing theory, high-reliability approaches, human-factors engineering, complexity science, statistical process control, modeling and simulation, supply chain management, systematic management techniques, total quality management, root-cause analysis, checklists, failure modes, and effect analyses.

Areas in which Systems Engineering has been successfully applied include complex physical systems, such as business transformation, design for maintainability, Hubble space telescope design, complex adaptive operation, taxi scheduling, and various others.[21] But, it also has been applied in service design, particularly, public systems such as transportation, justice, crime prevention, and health. In this last line, a group of advisors on science and technology to the U.S. President has made a proposal to better health and lower costs by using Systems Engineering.[22] Again, in connection with the ideas of this approach in general and such proposal, our contribution is to make operational ideas by means of explicit service design methods.

Enterprise Architecture and Design Frameworks

For more than 30 years, many authors have attempted to synthesize the knowledge on how an enterprise should structure its business processes, the people who execute them, the information systems that support both of these, and the information technology (IT) layer on which such systems operate, in such a way that they are aligned with the business strategy. This is the challenge of Enterprise Architecture (EA) design, which is one of the themes of this book. We will provide a brief review of the literature on this subject with an emphasis on more recent proposals and methods that have been applied in practice. We also select approaches that propose some sort of framework, which provides a general EA in a given domain that can be reused as a basis for specific designs in such domain. In Chapter 4, we present our proposal for an EA design, which is based on the general domain models that we call EA patterns.[23]

The literature on EA can be classified into professional, produced by people for direct practical use in businesses, and academic, developed by people in universities and other organizations, without concern for immediate application.

In the professional literature, we have selected the following works:

1. Supply Chain Operations Reference (SCOR), which was originally centered on the supply chain, and subsequently, generalized to the whole enterprise.[24] This method has been developed by an association of companies and basically provides a structured classification or general architecture of all the processes an enterprise of the type in the SCOR domain (enterprises with supply chain) should have. The method also provides, at the lowest level of processes definition, metrics to measure performance and some information about links that connect processes.
2. American Productivity & Quality Center (APQC),[25] which is also a consortium of companies, including IBM, involved in the development of generic process architectures for companies of different domains, such as telecommunications, banks, automotive, and electric utilities. These firms created the APQC process classification framework by benchmarking their processes, which is constantly updated as new companies join the group.
3. Federal Enterprise Architecture (FEA),[26] which is an initiative of the U.S. government for the development of an EA for the whole of the public sector.
4. Component business modeling (CBM) of IBM,[27] which is not labeled as an EA, but as the structure of business components an enterprise should contain. They have a general version and different versions for several industries. These business components can be assimilated to a process structure.
5. The Open Group Architecture Framework (TOGAF), which is a framework for the development of an EA, proposed by The Open Group and based on an initiative of the U.S. Department of Defense.[28] From this perspective, TOGAF is more a methodology

than a general EA proposal. The EA is composed of four different architectures: business, applications, data, and technical, for which an Architecture Development Method (ADM) is proposed.

We subsequently review an academic approach developed by the Massachusetts Institute of Technology (MIT), which links EA with strategy and provides a conceptualization of different operating models that determine the architecture of the enterprise.[29] Four types of enterprise structures are proposed on the basis of the degree of business process integration and business process standardization: (a) diversification, (b) unification, (c) coordination, and (d) replication. Diversification focuses on decentralized organizational design with high local autonomy, as opposed to the unification model, which pursues low costs and standardization of business processes through centralization. The coordination model focuses highly on integration, without forcing specific process standards, whereas the replication model pursues standardization with low integration among the different units. Then, depending on the operating model one chooses, a corresponding architecture is selected.

Most of the aforementioned approaches attempt to describe an enterprise in terms of the structure of the process components needed to run a business. They emphasize components' classifications and do not explicitly consider relationships among them. Our experience in EA and process design is that the most important variable to be considered is the design of the relationships that coordinate all the components of the architecture and make them perform as a system. For such a design, it is very useful to have a general architecture model that explicitly provides the relationships among processes and other elements. The approach described in Chapter 4 provides such a structure based on relationships.

Other studies that reinforce the previous ideas have been made by Gartner, which investigated the world and Chilean experience of organizations in the field of EA. Their version of EA is an advanced expression of the idea of linking a Strategy and Business Model with the detailed design of the business, its processes, systems, and supporting technology, which is very consistent with our ideas of Business Engineering. The empirical evidence reported by Gartner says that although EA's initial efforts were focused on the IT architecture, with methodologies as proposed by

Zachman,[30] there are several companies currently leading the use of methods that emphasize the explicit design of the business and its processes with a strategic vision; examples of companies that have made progress in this direction include P&G, Whirlpool, GE, U.S. Army, and Kaiser Permanent. In addition, surveys show the interest and priority that this subject garners; for example, according to a survey of Gartner, 68 percent of the companies considered in a world-wide research expected an EA alignment with business in 2011.[31] In Chile, Gartner's survey established that the top priority of the companies that have an EA was to align it with the business strategy during 2012 and 2013.[32]

There are several proposals in the literature for general process models similar to what we call Business Architecture and Process Patterns (BAPPs); the SCOR model, Enhanced Telecom Operations Map (eTOM), APQC, CBM, and FEA, described earlier, basically propose hierarchies of processes that should be present in the domain to which they apply. Our BAPPs, which were proposed before these reference models or frameworks, besides process hierarchies, explicitly consider the relationships among processes at any hierarchical level.[33] BAPPs provide a better representation of the service design problem, where relationships are a key issue. Other patterns such as IBM's e-business patterns[34] and Fowler's patterns[35] are mostly technological.

CHAPTER 3

Disciplines Integrated in the Design Approach

There are several disciplines that provide lines of conceptual work and technical development used in this book, and which are integrated into the proposed design methods. The approach outlined in the Prolog and Chapter 1, which will be detailed in Chapter 4 and used in several cases in Chapter 5, integrate the conceptual models and analytical techniques that are reviewed later to provide support for executing each of the components of Figure 1.1. This is done with a systemic and hierarchical methodology, where upper-level designs, supported by some of the conceptual models and analytical techniques, are progressively detailed using other ideas and tools of the same type. So, many different conceptual models and analytical techniques, which are usually applied independently, are integrated in a coordinated way in a methodology that takes the best of them in some of its steps. Of course, this solves the problem of unilateral and seemingly opposed views of the same design problem—symbolized by several blind persons perceiving different parts of an elephant and arriving at very different conclusions—and provides a way to have an overall picture. But, to avoid the inherent difficulty of using multiple high-cost mental models and detail business logic simultaneously, they are graduated by hierarchical decomposition of the design. Hence, the isolated use of conceptual models and analytical techniques is avoided, eliminating the use of partial views, and the complexity of simultaneous multiple views is graduated by coordinated partial views ordered by the hierarchical design approach based on Figure 1.1.

A brief summary of the most important ideas and techniques is given in the next sections in order to make this book more self-contained.

Strategy

The work of Porter[1] and Hax and Wilde[2] on Strategy provides the starting point for a Business Design, as shown in Figure 1.1. The key ideas adopted are:

1. Porter's concept of *Competitive Advantage* as the key for obtaining a position that differentiates a business. He proposes to choose—in our terminology, design—a set, or architecture, of different activities—in our terminology, processes—that gives a unique mixture of value to the client. It relates to a business design to perform its activities in a different form or to develop different activities other than the competitors'. For example, the way in which eBay offered auctions over the Internet differentiated it from its competitors.
2. Hax and Wilde's proposal, which defines three basic positioning strategies for a business to generate customer bonding, and hence Competitive Advantage:
   a) *Best product* means developing unique attributes for a business' products that attract clients' preferences, such as the unique features Apple intends to provide for them, or good quality at a low price as Walmart does for theirs; another good example of this strategy is by Zara, the second world-level manufacturer and distributor of fashionable clothes, which bases its positioning on novel products at reasonable cost and their fast renovation, together with one of the best logistics in the industry that allows the fast launching to the market and replenishment of products.[3]
   b) *Integral solution to clients* implies understanding their needs in such a way that customized solutions can be offered; its final aim is for the offering organization to get placed into the *Value Chain* of the client, taking activities from such a chain for which it has top competences, as FedEx does for the complete delivery logistics for some of its clients,[4] and Amazon that provides full Internet-selling solutions for their business clients.
   c) *Systemic lock-in* is based on the economic theory of switching costs and network externalities,[5] which will be summarized in another

section of this chapter. It attempts to create conditions that make it very expensive and almost impossible for a client to make do without the services of an offering organization (lock-in), by creating an extended company that includes all the clients and the complementors, who develop value-added products and a portfolio of services they offer to the clients. The emblematic case of systemic lock-in is Microsoft, which has positioned Windows as a *de facto* standard, incorporating a great number of complementors into the system that produces a large offering of software that run only on this operating system. Candidates of the same status are Google and Apple iTunes.

After choosing a strategic positioning, among the options presented, we propose that an organization should design its Business Model, processes, and supporting Information Technology (IT) applications in such a way that they materialize and make operational the Strategy. Without a disciplined design, like the one we propose in Business Engineering, it is difficult to be able to guarantee the success of a Strategy, which means a significant change in the way a business is performed.

As a complement to the ideas of Strategy presented, we have found it useful to specify the metrics that allows determining the success of selected lines of action. This can be done using *Key Process Indicators* (KPIs) associated with different objectives one can pursue. One way of doing this is to use the ideas of a Balanced Scorecard (BSC),[6] which defines perspectives for KPI definition. The basic idea is to start with a vision—where the organization wants to be in the future—and a defined Strategy, and then develop the objectives and the KPIs for several perspectives: financial, clients, internal processes, and learning and growth.

Business Models

Also relevant are the ideas of Business Models proposed by several authors,[7] which provide key inputs for a business design. The basic concept of having a good strategy is not sufficient; it is necessary to design a Business Model, as stated earlier, which puts strategy into practice and the processes that make it operative. This is how FedEx changed its positioning strategy from package mover to supplier of logistic solutions, which meant a substantial change in its Business Model, offering to its clients the possibility of handling an important part of their distribution logistics, using its own processes and IT applications.[8]

To make the concept of Business Model more precise, the ideas of Johnson et al.[9] are adopted, which define it as a logical history that explains who the clients of an organization are, what they value, and how a positive economic result will be generated through providing such value.

The idea is to materialize a strategic approach in a plausible Business Model. Such a model should include solid foundation assumptions with respect to the customers and what they value, resulting in economic outcomes provided with an adequate justification. These should be reflected in a rigorous economic evaluation.

An example of a good Business Model is eBay, a company that started with the assumption that there were numerous customers who wanted to obtain goods by means of auctions, but did not have access to them or it was inefficient for them to resort to such type of service offering. Such clients would prefer to be users of a simple system at low cost, running fully on the Internet, which would allow them to bid for goods of any type, following the auction model. These clients would value, in addition to the transaction possibilities, avoiding to physically moving, assuring the payment to the seller, simple procedures of participation, and a low cost. They would be willing to pay a percentage of the value of the transaction, generating the income that makes the business viable. In addition, the costs would be low, since the business model of eBay did not imply getting directly involved neither in the physical handling of the goods nor in the associated financial handling, which could be handled by a courier and available means of payments. Therefore, the Business Model not only seemed attractive, but also economically sustainable; this has been actually demonstrated with the great success of this company. Notice that the Business Model determines the required processes and structure.

A case similar to eBay is Google, which discovered a value associated with the searches on the Internet and a great mass of clients who required it. Google assumed correctly that the users, in this case, were not willing to pay for the service, and that the key was to create a great community from which this company could extract value with other products. One of these products was advertising, which, in varied forms, provides income to Google, which has turned it into one of the most successful companies in the world, besides generating a lock-in effect.

Another interesting example of a Business Model is Grupo Multiasistencia, which operates in Spain, France, and Portugal. This organization offers services that allow coordinating repairs of houses, including the ones that occur from events covered with insurance policies. Multiasistencia allows that several companies, in particular, insurance organizations, and individuals who need this type of service, sign-up by means of the Internet to its network. Subsequently, the demand for services of repair work is processed and assigned to a set of outsourced professionals that execute the repairs. Furthermore, their services coordinate the successful execution and the invoicing of the repairs, payment collection, and the fees to the professionals.[10]

One impressive Business Model at the moment is of Apple, that, for example, made the downloading of music by means of the Internet easy and convenient; it combines hardware, software, and a 24-hour service that are implemented with the collaboration with the music suppliers. With the iPad, the model has become generalized to provide all types of applications developed by complementors. This has made Apple one of the companies of highest market value in the world and put it on the road to systemic lock-in.

A Business Model, according to Johnson et al.[11] besides specifying value for clients, should establish other factors as shown in Figure 3.1.

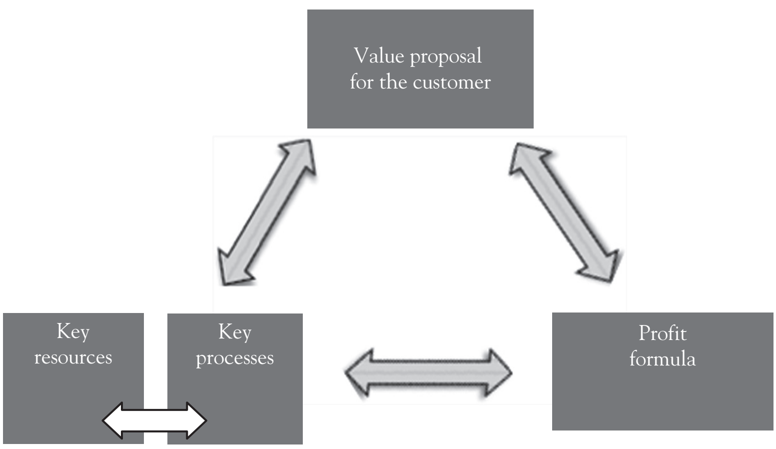


Figure 3.1 Factors to be considered in Business Models

Value proposal to the objective clients is related to the work needed to solve an important problem or to satisfy a key necessity of such clients; this determines a supply that solves the problem or satisfies the necessity. This is determined not only for what it is sold, but also for how it is sold.

Profit formula relates to: (a) the model of income, that is, how much money can be earned, which is determined by the size of market, frequency of purchase, and others; (b) the cost structure that is determined by how costs are assigned, including the costs of key assets, direct costs, indirect costs, and economies of scale; (c) the margin model or the difference between income and cost of each transaction, so as to arrive at the desired level of profits; and (d) the rate of use of resources, or how rapidly the resources are used to obtain the desired volume, which includes times of delivery, speed of production, rotation of inventory, use of assets, and similar.

Key Resources are the ones necessary to profitably give the client the value proposal; they may include human resources, technology, equipment, information, channels, partnerships, alliances brands, and licenses.

Key Processes include metrics, rules, and norms that make the delivery of the value proposal profitable and, also, repeatable and scalable. It may include: (a) processes, such as product design, development, supplying, manufacture, marketing, hiring and training, and IT; (b) rules and metrics, such as requirements for return for investments, credit rules, times of delivery, and conditions for suppliers; and (c) norms, that is, policies for the channels and clients.

Osterwalder and Pigneur proposed another methodology for Business Model development,[12] which shares many characteristics with the Johnson et al. proposal. The main difference is that it provides a canvas or table that summarizes all the variables that define a Business Model. It can be used as a design tool by systematically assigning characteristics to the variables in the canvas, thus defining the way a Business Model is to be structured. Osterwalder and Pigneur and Johnson et al. concur on most of the variables that define a Business Model and only differ on how to structure and present them. We conclude that they are equivalent and, in what follows, we opt for the proposal of Johnson et al. as it is more easy to use.

Modularity and Platform Design

We now review the ideas of *Modularity and Platform Design*, which have originated in designing physical products and manufacturing processes. When adapted to services, they partially cover the service design problem we defined in Chapter 1, which includes the four design levels and the Business Engineering methodology.

In order to give a context in defining the service design scope of Modularity and Platform Design, we present our view of the general components involved in such design. The model in Figure 3.2 shows such general components of a business design, using a simple flow representation,[13] which is inspired by the regulation model documented in several publications.[14] The main component behind the design problem related to Figure 3.2 is "Product or service production," which generates a product or service or both that is demanded by certain customers. The design of this component includes the design of *the physical product or service or both* that is provided to the customer and of the *production processes*—manufacturing and others—that are required to produce it. These two designs are, in many cases, related, since an adequate physical product or service design may simplify the production processes design and allow for more flexibility in the offerings. In fact, one of the key ideas of Modularity is to design physical products or services by assembling components—using predefined interfaces—that are common to many of them. Clearly, this type of design determines the production processes necessary to provide product or service or both. We will give examples of these ideas later in this section. In traditional manufacturing and production—such as consumer products, machinery, energy, chemical, and communications—the physical product and the production processes are relatively stable and, in many cases, are not design variables when designing an Enterprise Architecture (EA). In services, these designs are always present, as we will see in this section and cases in Chapter 5, and this makes an EA design more challenging.

The model in Figure 3.2 makes it clear that we also have to design the "Management activities," which cover all the design levels we outlined in Chapter 1, from the business overall architecture and management processes designs to Information System design; these will be detailed

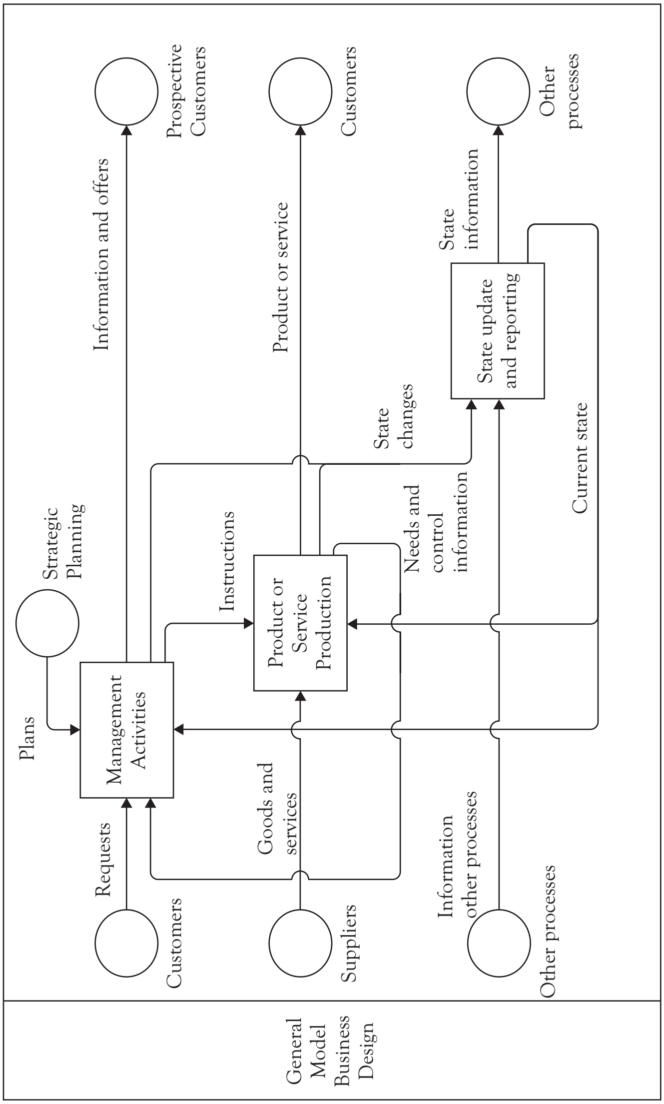


Figure 3.2 General model for a Business Design

in later sections and should be consistent with the "Product or service production" just presented. The Business Engineering methodology we propose assures such consistency, as we will explain in Chapter 5. The last component of the model in Figure 3.2 is "State update and reporting," which receives information about the transactions occurring in other components, determines their current situation, and feeds it back to the interested parties. It corresponds to the Information Systems' databases and reporting of any business, and is obviously an object of design. However, as we will argue later, it is a consequence of the other components' design.

The ideas of Modularity and Platform Design we will review clearly concentrate on a partial business design—physical product or service or both and production processes—but, such ideas are more useful if integrated with other more systemic approaches. The presentation will be oriented to services where there is parallel production and consumption, as it is the case of healthcare, airlines, banks, cruise services, logistics, and department stores, among others. In some of these cases, the idea of *coproduction* is also present, in the sense that the customer actively participates in the production of the service. In this context, Modularity "is the degree to which components of a system can be separated and recombined to create a variety of configurations without losing functionality."[15] For example, in hospital services, the usual design is to have modules for emergency care, ambulatory outpatient care, and hospitalization inpatient care[16] services. Then, a particular physical service is established dynamically, according to the need, for a patient, which define the sequence of actions that will be performed over him or her by the different modules. For example, a patient enters by emergency care and is sent, once stabilized, to hospitalization inpatient care, where he or she will have further treatments until he or she is discharged. This is further complicated by the fact that there are other modules—beds, surgical facilities, exams performing, procedures, and so on—that provide very specialized services that are activated according to the need. So, the flow of a patient can get very messy, and good protocols are needed to coordinate the different modules involved, so that what the patient needs is provided on time and with the required quality. This is a very difficult problem, and most hospitals do not have a good design to define, manage, and control the flow.

So, an approach called *case management* has been specialized to hospitals to provide such Capability;[17] we will review this approach in the next section in relation to Business and Process Intelligence. In this hospital example, the *design of the physical service* involves the medical practices that are defined for each health problem, which the case management approach tries to explicitly design by using Modularity ideas. The production process design has to do with managing the patient flow by means of good practices and IT supporting systems. For example, monitoring the state of each patient, in time and space and also the medical variables relevant to his or her illness, to be able to timely act when necessary; this may include, as we will see later in our patterns, the use of intelligent tools that, for instance, predict a possible patient's crisis based on his or her state and Business Intelligence (BI) models developed from historical data. In most hospitals, this process is very ill-defined and executed based only on the experience of medical professionals. So, here is an opportunity to improve many services by a good production process design, which has been severely overlooked in practice.

We can observe that to the two related design problems just described, one can add a third design element, which is organization design, that can also be modular,[18] and also present as functional components;[19] for example, specialty departments in a hospital: neurosurgery, pediatric, geriatric, heart disease, and the like.

The three design elements just presented are well-exemplified in a real case developed for municipal services in Denmark, whose structure is as follows:[20]

- Services provided:
  - Support unemployed with jobs and education
  - Support sick with help to return to the job market
- Level 1 service components (partial):
  - Receive client in job center
  - Have a job interview
  - Evaluate preparedness
  - Develop a job plan
  - Offer job training
  - Evaluate readiness
  - Evaluate the working ability

- Level 2 components (partial):
  - Create a case file
  - Evaluate information
  - Make a decision
  - Publish a decision
  - Calculate benefits
  - Pay out benefits
  - Order service
  - Make judgment
- Level 3 components (partial):
  - Scan a document
  - Apply for consent
  - Send information
  - Receive message
  - Place responsibility

Here, the design of the physical service is expressed as Level 1, which defines activities (modules) that may be needed to perform any of the services provided; the processes used in their production are the ones in Levels 2 and 3, that are combined in different configurations to execute several service variations; and the organization is implicit in the fact that the services provided and Level 1 components are in charge of different municipal units, as can also be some of the Levels 2 and 3 components.

Other interesting case that exemplifies the use of Modularity is the one of mental healthcare in Holland.[21] One relevant detail of this case is the definition of bundles for services of this type. We give a summary of one bundle for this in Table 3.1.

Table 3.1 Modularity health case

Bundle	Module	Component	Description
Health-related care	Psychiatric care	*Monitoring* Done by Care Person (CP)	This is a part of care everyone gets.
		Scaling up *Intensify care* *Crisis intervention*	When a patient (might) become(s)unstable, higher level CPs are involved.

(*Continued*)

Table 3.1 Modularity health case (Continued)

Bundle	Module	Component	Description
		Education of thirds	Concerns educating and supporting the patient's family and friends, to create understanding of the patient's situation.
	Medication care	*Long-lasting medication* Collected at preset times	Called "depot," this medication (usually) lasts several weeks.
		Regular medication *Directly from pharmacy* *From CP in weekly doses* *From CP in daily doses* *Collected at preset times* *Distributed at preset times*	Only people living off the terrain receive the medication from the pharmacy. Daily and weekly doses are always collected at the CP's office at preset times. Collecting and distributing happens at three preset times during a day.
		If-needed medication Controlled by patient Collected at preset times	Medication for when a patient feels anxious or otherwise thinks some more medication is needed.

Another interesting case where the design of the physical service, processes, and organization has been simultaneously performed is a large global logistics company.[22] This company has two business lines: Subcase A that moves physical goods in large shipments for the fashion and healthcare industries by using outsourcing and partnerships and Subcase B that moves physical goods in small shipments for manufacturing—for example, paper, metal, and retailing—industries by using its own fleet. Their main customers are global companies in the United States, Europe, Asia, and Latin America. In Subcase A, the services need to be customized for different industries, since the logistics needs for fashion and healthcare are different, to build cost-efficient solutions by utilizing similarities in customer needs; for example, offerings in order management, supply chain management, and vendor inventory management designs are the same for all industries. Subcase B offers highly standardized services with over 50 modules, but complemented with personalized value-added services that provide some customization. This type of design is done over all the services and can be summarized, considering the different aspects of modularity, as follows:

- Subcase A:
  - Service modularity: Developing the existing services
  - Process modularity: Standardization of IT processes
  - Organizational modularity: Focus on subcontracting
- Subcase B:
  - Service modularity: Developing new services
  - Process modularity: Standardization of IT and transport processes
  - Organizational modularity: Focus on internal work arrangements

As examples of the different process modules that the design contains, we can mention: goods pick up, loading, transporting, unloading, and delivery; information processes of sending and receiving orders, documentation, storing and transferring information, and tracking shipments; and control and monitoring processes. The definition of these modules in the service, process, and organizational dimension allows the creation of a Platform Design that structures the way in which particular services are created for different clients, as explained in the following paragraphs.

One of the consequences of very flexible modular arrangements, as presented and exemplified earlier, is the possibility of generating new services in a very dynamic way in the idea of mass customization, which are able to meet an heterogeneous demand.[23] Such an idea has been made feasible by a *Platform Design*, which has been defined, in the case of services, by Meyer, Jekowsky, and Crane,[24] as an "specific set of service functionality-delivered in human or computer form, or more typical, some combination thereof—that is used across multiple services or the procedural connections that bridge and link specific sets of service functionality." These authors have applied the aforementioned ideas to health services using case management to structure such service in two types: inpatient care and outpatient care. Then, for each type, they have designed the subsystems, composed of processes, human actors, and computer systems support, necessary to manage cases, by defining the actions to be performed over patients (personalized service) and coordinating his workflow by transferring information, by means of IT systems, along the line.

Despite the consideration of processes and organization modular designs proposed by Pekkaninen and Ulkuniemi,[25] the idea of Modularity is related to the lower physical levels of the whole design problem defined in Figure 3.1, and is far from a systemic Enterprise Architecture. But, other authors have tried to widen the scope. In particular, Voss and Hsuan[26] have defined a service architecture with the following levels:

i. An industry structure that may be integral in which all actors do mostly the same, for example, retail, or with a more modular setup, where different firms cover different parts of the market and possibly interact with certain interfaces, for example, public health, where there is a hierarchy of levels of different service complexities.
ii. A service company or supply chain, where different companies participate in a value chain, with outsourcing as a possible interface; for example, the Internet sales where some firms produce goods, others offer them through the Internet; another may provide payment services, and, finally, there is one that distributes such goods to the final client. Another structure variation in this level is the distribution of facilities, where many companies, such as banks, retail, and department stores have replicated facilities in different locations to cover a market.
iii. A service bundle, which is the service offering of a company, similar to the cases presented when discussing Modularity.
iv. A service package or component that defines the more basic subcomponents by means of which a service is delivered.

This is an attempt to define the full scope of a service architecture design, as we did in the design levels defined in Chapter 1, but authors do not go into any detail for (i) and (ii) and concentrate on (iii) and (iv). In Chapter 4, we will provide a way to do a systemic top-down service architecture design, covering all the aforementioned levels, and more, as opposed to what we have described in this section, which is mostly bottom-up. However, Voss and Hsuan propose an interesting way to perform designs (iii) and (iv) and give examples for cruise services' design and banks. In a mortgage bank, for example, they propose going from a bundle of independent services for different types of investments—stocks, fixed rent, mutual funds, and the like—to a customized service from which a client can chose from several saving options, which are modular and can be mixed at will.

Customization of services by using configurations of predefined components, as the Danish municipal services, mental health, and logistics examples, as given in earlier show, is a way to provide a service dynamically adapted to the customer. This is different from generating the service by means of people interacting with the customer that perform personalization interpreting his needs; for example, professional services, such as legal, engineering, and some consulting, which are specifically generated to attend a very specific and particular request.

Another interesting way to define bundles of modularized services is the one proposed by de Blok et al.[27] They define basic modules that are common to all services, modules that can reconfigured for different segments, and modules that can be customized at the individual level, as differentiated earlier. They apply their ideas to the provision of services for the elderly in a real case in Holland, giving details about the design; for example, a basic service is a living form; a configurable service is personal care with many variants and alternatives from which to select; and a customizable service is health-related care.

Another possibility associated with Modularity is replicating a service among different sites. The most popular opportunity for this is replicating similar services in companies that have the same offer in many locations. An obvious case of this type is McDonalds, but other more complex cases are banks, retail, hotels, and the like. A more difficult variation of this is replicating a service among different distribution channels; for example, what the New York Met Opera has done, by extending the traditional service of attending opera in at theater to on-demand access to some of its recorded performances through the Web, then, to live transmissions by satellite of some of its performances in thousands of theaters all over the world and deferred transmissions of the same material; and finally offering some of the performances on DVD and CD.

An interesting proposal for architecture definition and modeling oriented to replication is servitization as defined by Sheng, Wang, and Sun,[28] which cover the problem of extending an existing service to other customers in a dynamic way. For this, they propose the formalization of a service using an Ontology approach, which is a description of all the components of the service and their relationships. The Ontology can cover what we have defined as the physical service, production processes, and organizational descriptions; so it describes architecture, at least partially. Then, the Ontology can be extended and customized to define particular services to be provided for a particular client. They give a detailed example for services related to building maintenance, including installed equipment therein, that shows the advantage of designing based on previous knowledge. This is the same idea of the patterns presented in a previous section, which will be revisited when we present our business, architecture, and process patterns in the following section.

The expected benefits of using Modularity on the design of business are as follows:

- Unique modules that encapsulate advanced practices and are replicated along different business lines provide a competitive advantage that it is difficult to copy; for example, in the logistic case, reported by Pekkaninen and Ulkuniemi earlier, some of the modular components with advance practices can be ships' loading and routing mathematical models that optimize their use, which can be used for all the fleets in all locations, similar to what FedEx and Walmart have for their fleets of plains and trucks, respectively.
- Modularity allows dynamic customization and facilitates new product development, as shown in the building maintenance, mortgage bank, health services, and municipal services as described earlier.
- Modularity favors standardization oriented to improving efficiency, as shown in the municipal services case.
- Modularity favors, in some cases, the centralization of services shared by several business lines, thus generating economies of scale and scope; an example is the goods' centralized purchasing and logistics for government requirements, which

allows buying cheaper because of volume and standardization of products and services bought.[29] Modularity also favors outsourcing, since the formal definitions of components and their interfaces facilitate the selection of what can be outsourced and the definition of how it is to be implemented.[30] These ideas are included in the Shared Services Architecture Pattern presented in Chapter 4 and cases included in Chapter 5.

As described, Modularity concentrates on the physical product or service design or both, which is included in the second level of design, defined in Chapter 1. In Chapter 5, several real cases of service design along with the ideas of Modularity will be presented, which will also show how such design is integrated with other design levels.

Business and Process Intelligence

Business Intelligence (BI) is, in our approach, the application of Analytics, which is defined as follows, to business design and management. Davenport is the champion of the idea of using Analytics in better managing businesses: as early as 2005, he and others[31] proposed:

> New form of competition based on the extensive use of Analytics, data, and fact-based decision making. The Analytics—quantitative or statistical models to analyze business problems—may be applied to a variety of situations, including customer management, supply chains, and financial performance.

In a follow-up paper in *Harvard Business Review* and a book,[32] he elaborated on the subject; in summary, he stated that well-known companies base their success on the use of Analytics, and this is a good practice to be followed. He distinguishes the following types of Analytics in order from moderately complex to very complex:

1. Statistical analysis, such as regression and factorial analysis.
2. Forecasting and Extrapolation, such as time-series models and neural networks.

3. Predictive models, such as Data and Web Mining models.
4. Optimization models, such as Discrete Linear Programming (LP) and Stochastic models.

These analytical techniques are to be clearly distinguished from the more basic, the so-called BI tools, which essentially consist of facilities for access and reporting from data by means of information dashboards.[33] Advanced Analytics provide truly BI that generates insights on the state of the business and predictive or prescriptive capabilities to support optimal or close-to-optimal actions. For example, Walmart uses online data from all the sales points to feed predictive models that forecast demand for each of such points, which are used by optimization models that determine actions over the supply chain logistics to assure product availability at minimum distribution cost; currently, they are also using social media data to predict shoppers' purchases and act on that basis to plan logistics.

In this work, we consider Analytics of two types: *data-based*, oriented to predictive models, which includes traditional Statistics and Econometrics, Data Mining, Web Mining, and Process Mining,[34] and *Operations Research and Management Science*, which make possible prescriptive models, with techniques such as optimization models, both linear and discrete, heuristics, probabilistic models, simulation models, knowledge extraction and characterization models, and many others. These types of Analytics can be further classified as follows:[35]

- *Analytics 1.0* based on assembling internal data oriented to reporting, which can be enhanced by visualization tools. Emphasis in this level is on integrating, structuring, and using the data to generate information on the state of the processes to allow fact-based, improved, and fast decision making. Frontend tools, such as visualization software, based on dashboard reporting are used; also, integration tools that allow data preparation, built-in querying on an analytical database, and descriptive Analytics—complex graphical analysis—are options.
- *Analytics 2.0* adds, in relation to the previous level, big data—fast moving, external, large, and unstructured data

coming from external sources, including social media—which is stored and processed rapidly using new technology like parallel servers and Hadoop. Visual Analytics, a form of descriptive Analytics, is introduced. Emphasis is on real-time operations analytic solutions to make organizations more agile and proactive. The main idea is that there is a wealth of data that, when adequately used, can generate great value for them. For example, McKinsey[36] has calculated 60 percent potential increase in the retailers' operating margin by better using big data; and in $300 thousand millions the potential value for the U.S. healthcare by the right use of patients' data. Also, McAffe and Brynjollfson[37] have found that companies in the top-third of their industries in the use of data-driven decision making are, on the average, 5 percent more productive and 6 percent more profitable than their competitors. As an example of these possibilities, we have the case of Ommeo, a division of Siemens that delivers millions of electronic devices and other products throughout the world, which has developed a solution for supply chain product data management, including data from suppliers, equipment, field service, and repair operations.[38] With this solution, they provide suppliers, Ommeo operations, and customers with an end-to-end, fast, holistic view of supply chain data; such as one customer who has been able to use the solution to search 1.5 thousands million records in less than 3 seconds.

- *Analytics 3.0* complements the previous levels by incorporating predictive and prescriptive models in routine service production and management processes, which are based and operated on the internal and external big data. The aim is not only to drive operational and strategic decisions, but also the creation of new products and services. Here, true BI, as defined earlier, is performed to advise, recommend and, in some cases, automate decisions or actions using the full range of analytical tools: Data Mining, optimization, Machine Learning, and the like. The example of Walmart we gave before is a good instance of this idea. Other real case examples are to use diabetes patients' data, available in the whole health system, to develop predictive models to allow detecting probable crisis for an specific patient, before it occurs, to prevent serious health problems for him or her and high emergency treatment costs; and monitoring and collecting data online for mining trucks, using available sensors, by a service company that sells them and also offers maintenance services, in order to develop models that predict failures just in time, allowing to take corrective actions that minimize the downtime and maintenance costs.[39] Also, dynamic predictive models that use common company data and big data can help discovering new business possibilities with improved or new services and also allow designing and operating them as shown in the following.

These types of Analytics will be included in different BI architectures that will be presented in the following section. The use of Analytics in our design proposal relates to providing business logic that supports *intelligent* business decision making and operations and also business development using well-founded designs. The central idea is that, in executing services delivery and related processes, business logic is necessary to formalize certain routines that use models to assure that certain objectives are attained. For example, one may want to assure that the right services are offered to clients in order to maximize sales, for which a customer behavior's predictive model is needed. Or, one may need to assure satisfaction of a certain service level to clients, but trying to minimize costs, where a mathematical prescriptive model is required to optimally assign requests to facilities that process them. In both examples, the analytical tool—predictive model or prescriptive model—will be embedded in a business logic that specifies in a formal way how the process should be executed. In some cases, this logic will be fully automated as Amazon does for the logic that makes recommendations for clients, or the logic that Walmart uses to optimize its logistics. In others, the logic will make recommendations to the person who operates the process and he or she will have the authority to follow them or not. Also, business development, improving current services, and designing new ones are possible by the right use of Analytics. A case we have developed, mentioned in Chapter 1 and to be further developed in Chapter 5, which exemplifies this possibility, is a financial data-processing organization that, based on an analysis of credit card transactions it processes for banks, has been able to discover characteristic behaviors, for example, of card use and card closing. This allows to dynamically define proactive campaigns to be executed through a new business Value Stream to offer deals to groups of card clients, on behalf of the banks, according to their behavior. Another case is a distributor of heavy machinery to the mining industry, aforementioned, which, besides the current business of just selling equipment, wants to be able to offer value-added services for equipment maintenance by means of a new Value Stream. These are based on online equipment monitoring, by means of remote sensors mounted in them, which feed state data to the service company systems that allows to generate corrective actions just in time, by means of predictive maintenance models; this case is similar to the General Electric business that offers similar services for the equipment it sells.[40] These new Value Streams, when they execute externalized customers' processes, produce a lock-in effect that makes it difficult for them to terminate the service. Different streams may execute different Business Models. For example, the financial processing organization case has one Value Stream that executes a traditional model of mechanical transaction processing for banks, with low added value, and another Value Stream that makes proactive offers to banks' customers, which generates a high value for them.

We summarize some of the relevant Analytics for this book, which will be specifically used in some of the cases in Chapter 5 and in the follow-up volume dedicated to health applications, for the more technical reader who wants to get a feeling on how Analytics gets implemented. If one does not want to get into technical details, he or she can skip the rest of this section without loss of understanding of the cases.

Data-Based Analytics

The first type of model, which corresponds to some of the examples we gave previously in this section, is based on the *model for Knowledge Discovery and Data Mining*. A recent version of this model is Cross-Industry Standard Process for Data Mining , which is presented in Figure 3.3.[41]

The most relevant step in this proposal is "Modeling," for which we present a specific technique; the other steps will be illustrated with cases in Chapter 5.

One particular Data Mining modeling tool that will be used in some cases in Chapter 5 is the clustering algorithm *k-Means*, which works as given in Figure 3.3.

A clustering or S*egmentation* algorithm consists of finding groups between a set of individuals. The segmentation technique *k-Means*, which is a well-known algorithm for clustering and a simple and effective application, follows a procedure of classification of a set of objects in a certain given number of *k* clusters. It represents each one of the clusters by the average (or weighted average) of its points or centroid. The representation by means of centroids has the advantage that it has an immediate graphical and statistical meaning. According to Lloyd, it is simple, efficient, and often results in the optimal solution.[42]

The mathematical formulation of the clustering problem is as follows.[43] Given a set of observations $(x_1, x_2, \ldots, x_n)$ where each observation is a *d*-dimensional real vector, *k*-Means clustering aims to partition the

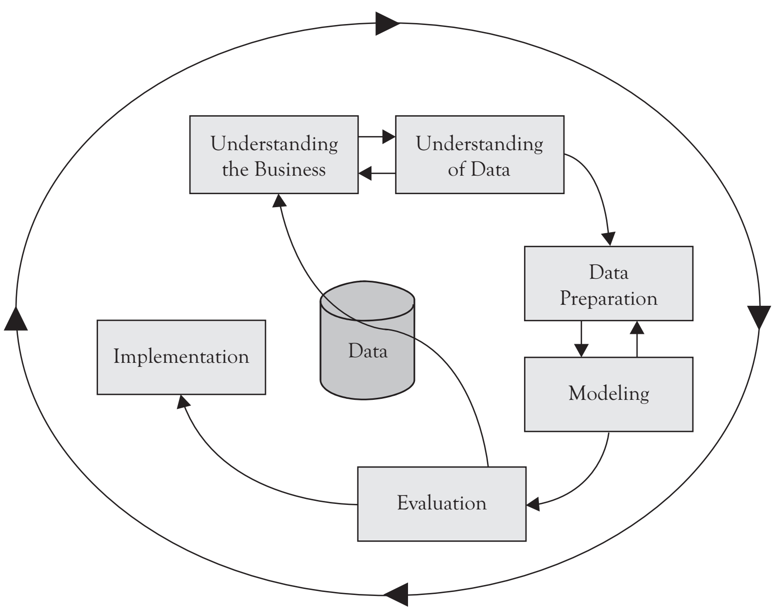


Figure 3.3 Cross-Industry Standard Process for Data Mining

n observation into k sets ($k \leq n$) $s = \{s_1, s_2, ..., s_k\}$ so as to minimize the within-cluster sum of squares:

$$\arg\min_{s} \sum_{i=1}^{k} \sum_{x_j \in s_i} \| x_j - u_i \|^2$$

where μ_i is the mean of points in S_i^n.

Based on this formula, the algorithm for clustering a set of objects (defined by a vector of observed data) $D_n = (x_1, x_2, ..., x_n)$ is as follows:

Stage 1: Choose k initial objects at random and assign each of them to one of the k clusters. For each cluster k, the initial value of the centroid is x_i, the only object in it.

Stage 2: Reassign the objects of a cluster. For each object , assign it to the cluster that is closest to the object, according to a distance measurement (usually the Euclidian distance).

Stage 3: Once all the objects are placed in a cluster, recalculate the centroids of the k clusters.

Stage 4: Repeat Stages 2 and 3 until no more reassignments can be done.

Although the aforementioned algorithm always finishes, there is no guarantee of obtaining the optimal solution. In effect, the algorithm is very sensible to random election of the k initial centers. Therefore, the k-Means algorithm is used numerous times on a same data set to try to diminish this effect, knowing that the most-spaced initial centers give better results.

A clustering method is usually complemented with the technique of Decision Trees, in the particular version of *binary decision trees*, which is considered a *Classification* method. The idea is to know which individuals within a segment have a similar behavior defined using the known data on several variables that may explain such behavior. For a particular segment, the decision tree technique looks for “twins,” that is, clients who have a similar behavior defined by a variable that clearly generates groups that minimize the difference in the values of the variable for the clients inside a group. The technique of binary trees uses division in two groups; so, at the start, two branches are generated, one for each group. Then, for each of these groups, two subgroups are defined using the same idea of minimizing the differences for the values of another variable for clients within a subgroup, creating branches at a second level. And so on, until all the variables for which data are included in the analysis. Clearly, this is a very simplified description; the important aspects of the technique, such as how to select the order in which variables generates groups and to select the "best branches" to obtain better results, will be avoided.[44] The important thing is that once a tree is built, rules that define clients' behavior can be derived. We present a real case of this type developed in a large private hospital.[45] We analyzed historical data for chronic diabetes patients; first, variables that are statistically correlated to risk for diabetes patients were determined based on such data. The ones that are relevant, with data from 1,487 cases, are the ones in Figure 3.4. With selected variables, a Classification is done, from which the binary tree is generated (see Figure 3.5).

```
=== Run information ===

Scheme:     weka.classifiers.trees.J48 -C 0.25 -M 2
Relation:   riesgo_final_SinLDL_binario_1HDL
Instances:  1487
Attributes: 10
            hba1c_bin     Hemoglobina glicosilicada
            hdl-single    High density lipoprotein
            sexo
            colTot_bin    Colesterol total
            tg_bin        Triglicéridos
            edad_bin
            tabaco
            hta           Hipertensión, sí o no
            ec            Enfermedad coronaria, sí o no
            riesgo
Test mode:  10-fold cross-validation
```

Figure 3.4 Selected variables for Classification

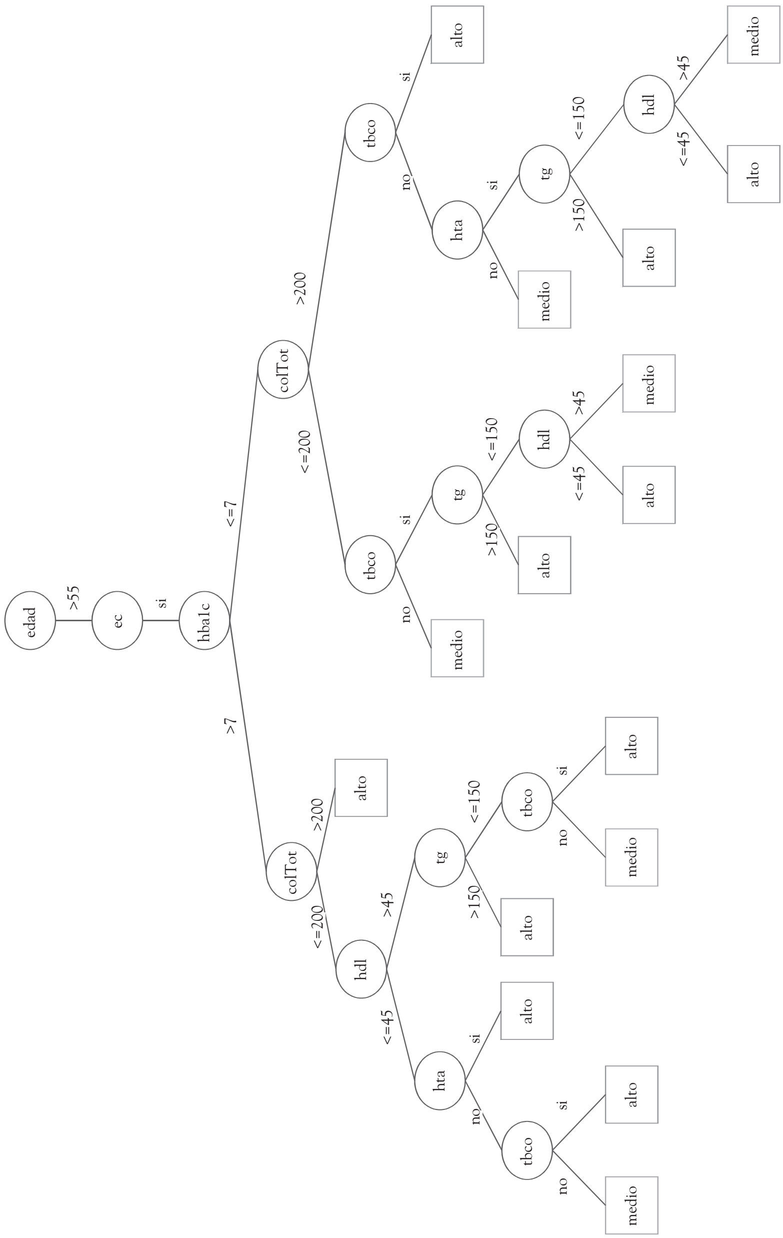


Figure 3.5 Decision tree for diabetes data

The tree clearly shows which combinations of variables with what values define cases with medium (medio) and high (alto) risk. Then, patients who fit the values that define a case can be classified in a risk level and action defined for them accordingly. So, for example, patients with values that mean high risk can be subjected to preventive treatments.

k-Means and binary decision trees are well-established techniques and are much used, which has been facilitated by its inclusion in popular analytical software packages such as SSSP,[46] Rapid Miner,[47] and Weka.[48]

A variant of data-based Analytics is what is called *Process Intelligence*.[49] Its emphasis is in knowing the state of production and establishing the performance of the overall flow for action generation to correct and improve the service. For this, data are systematically collected to analyze the individual steps within a production process or operational workflow and evaluate performance, such as:

i. Process compliance, when process is well-defined, verifying if steps comply with the given sequences and times and informing non-conformities; for example, credit processing. Business Processes Management Suites (BPMS) software[50] allows to do this.
ii. Process flow analysis to discover if there are avoidable delays, frequent avoidable repetition, bottlenecks, overloaded paths, discover exception paths, and the like; these analyses can be done online and information provided to the process operator, based on a business logic that recommends actions such as to avoid dangerous delays, as in an hospital's emergency.

We will treat this type of Analytic as a particular case of the Intelligence Structures we will propose in Chapter 4. A particular variant of this idea is *Process Mining*[51] that does similar analysis as (ii) earlier, but with a different purpose, which is to discover opportunities for process redesign; it is based on complex algorithms, special software, and requires historical data, so, it is adequate for such purposes, but it is not appropriate for online use.

Machine Learning[52] is a generalization of the predictive methods in this section, which has its roots in Artificial Intelligence, having media exposure with success cases as IBM's Watson that has defeated the chess world champion and also the Jeopardy champion.[53] It has also been increasingly incorporated in software products of common use, which offers intelligent options such as predictive text, speech recognition, translation, and the like. Currently, it is becoming more available through products in the cloud, such as Microsoft's Azure, IBM Watson Analytics, and Amazon Machine Learning. Some of these products include the common predictive Analytics—classification, clustering, and regression—but also incorporate other methods, such as text and social network analyses, that discover sentiments, emotions, key words, entities, and high-level concepts; cognitive applications that understand content and context within text and images; personality insights discovery from transactional and social media data to identify psychological traits; and deep-learning neural networks.[54] The common characteristic of these more advanced methods is that as much computational capability you give them, the better the result becomes because the results of previous Machine Learning exercises can be fed back into the algorithms. This means that each layer becomes a foundation for the next layer of Machine Learning, and the whole thing scales in a multiplicative way as time goes by. So, there is continuous learning and the results get even better.

Another class of analytical methods has to do with measuring the productivity and efficiency of a business in order to determine corrective actions to improve its performance. A particular, effective, and proven method for businesses that have replicated facilities or units, such as retail, banks, telecommunications, public health services, and the like, is *Data Envelopment Analysis* (DEA). This method is based on the idea that given data vectors of inputs and outputs for all the units, which represent well the value the service provided and the costs incurred, including historical data about them, it is possible to calculate their comparative efficiency by solving an optimization model that determines their efficiency frontier. This is defined by the units that are comparatively most efficient according to the data. Then, the units that are not in the frontier are not efficient and are candidates for improvement. DEA has analytical complements that make possible calculating potential improvements on outputs by manipulating certain inputs in a defined way.[55] There are also techniques that allow establishing other variables, not considered in the efficiency measurements, which are related to efficiency, and if adequately manipulated, can improve nonefficient units; in particular, variables associated to design considerations, such as unit location, size, mix of services, and the like. So, this method is also valuable in generating configuration design ideas in some cases and evaluating them in terms of efficiency, thus complementing the methodology we will propose. We have applied this technique to 40 public hospitals and shown in practice that it allows to define in a very precise way how hospital services should change to improve their efficiency and also improvements in the EA of the public organization that manages them;[56] we are also currently calculating the efficiency of academic departments at the Medical School of the University of Chile and finding similar opportunities as in the hospital case.

The other type of data-based Analytics we use in this book is *forecasting models*. Next, we outline two types of models of this type found to be particularly useful: Neural Networks, which are the same as in the deep-learning mentioned earlier, and Support Vector Regression (SVR).[57]

The particular type of *Neural Network* we consider is the Multilayer Perceptron (MLP). Its basic units are neurons that are grouped in layers and are connected by means of weighted links between two layers. Each neuron receives inputs from other neurons and generates a result that depends on only the information locally available, and which serves as an input to other neurons. The general architecture of an MLP network is shown in Figure 3.6.

Each neuron operates according to the structure in Figure 3.7, where the output *y* is determined as a function of the weighted inputs.

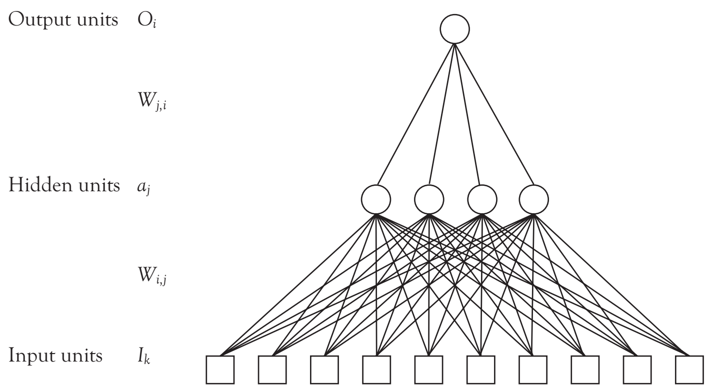


Figure 3.6 Architecture of an MLP network

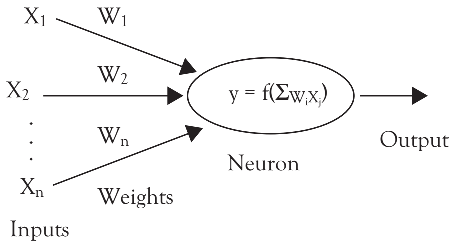


Figure 3.7 Neuron details

Function *f* in Figure 3.7 is called the activation function and may take different forms; the most commonly used one for continuous outputs is the logistic function, as shown in Equation (3.1).

$$f(x) = \frac{1}{1+e^{-x}} \tag{3.1}$$

The structure of the network consists of an output layer with one neuron that generates the desired forecast. The input layer contains the variables that we will use to explain demand, which will be determined subsequently. In the hidden layer, a number of neurons between input and output neurons are used; a high number of them will tend to copy the data (over fitting) and a small number will not generate good forecasts.[58] The basic idea is that historical data predict demand of a given future month. Regarding the network, several architectures can be tested with several parameters, such as the number of epochs to use, the learning rate, and the number of hidden neurons. The output layer contains simply one neuron that generates the forecasted demand in month *N*. The hidden layer contains a number of neurons that provides the model an adequate degree of freedom, usually calculated by: (Number of input neurons + Number of output neurons)/2.

We also present *SVR*[59] for demand forecasting. This technique performs a linear regression in a high-dimensional feature space generated by a kernel function, as described later, using the ε-insensitive loss function proposed by Vapnik.[60] It allows a tolerance degree to errors not greater than ε, as shown in Figure 3.8. The following description is based on the terminology used in Smola and Schölkopf.[61]

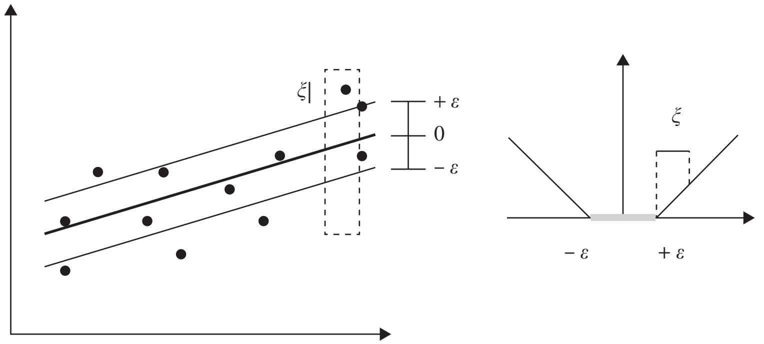


Figure 3.8 Support Vector Regression to fit a tube with radius ε to the data and positive slack variables ξ_i

We start with a set of observed data $\{(x_1, y_1),\ldots,(x_1, y_1)\}$ where each $x_i \in \mathbb{R}^n$ belongs to the input space of the sample (data points) and has a corresponding target value $y_i \in \mathbb{R}$ for $i = 1,\ldots,l$. We assume l to be the number of available data points to build a regression model. The SVR algorithm applies a function Φ, transforming the original data points from the initial input space ($\mathbb{R}^n$) to a generally higher dimensional feature space ($F \subset \mathbb{R}^m$). In this new space, a linear model f is constructed, which represents a nonlinear model in the original space:

$$\Phi : \mathbb{R}^n \rightarrow F \tag{3.2}$$

$$f(x) = \langle \omega, \Phi(x) \rangle + b \text{ with } \omega \in \mathbb{R}^m \text{ and } b \in \mathbb{R} \tag{3.3}$$

In Equation (3.3), $\langle \cdot,\cdot \rangle$ denotes the dot product in $\mathbb{R}^m$. When the identity function is used, that is, $\phi(x) \rightarrow x$, no transformation is carried out and linear SVR models are obtained. The goal when using the ε-insensitive loss function is to find a function f that fits the given training data with a deviation ≤ε and, at the same time, is as flat as possible in order to reduce model complexity. This means that one seeks a small weight vector ω. One way to ensure this is by minimizing the norm $\|\omega\|^2$, leading to the following optimization problem:

$$\min_{\omega,\mathrm{b}} \frac{1}{2}\|\omega\|^2 \tag{3.4}$$

$$\text{s.t}\begin{cases} y_i - \langle \omega, \Phi(x) \rangle - b \le \varepsilon \\ \langle \omega, \Phi(x) \rangle - y_i + b \le \varepsilon \end{cases} \tag{3.5}$$

This problem could be infeasible. Therefore, slack variables, $\xi_i, \xi_i^* \; i = 1,\ldots,l$ are introduced to allow error levels greater than ε (Figure 3.6), arriving at the formulation in Equations (3.6) to (3.9)

$$\min_{\omega,b} \frac{1}{2}\|\omega\|^2 + C\sum_{i=1}^{i}(\xi_i + \xi_i^*) \tag{3.6}$$

$$\text{s.t.} \qquad y_i - \langle \omega, \Phi(x) \rangle - b \le \varepsilon + \xi_i^* \tag{3.7}$$

$$\langle \omega, \Phi(x) \rangle - y_i + b \le \varepsilon + \xi_i^* \tag{3.8}$$

$$\xi_i^*, \xi_i \ge 0 \tag{3.9}$$

This is known as the primal problem of the SVR algorithm. The objective function takes into account the generalization ability and accuracy in the training set, and embodies the structural risk minimization principle.[62] Parameter $C > 0$ determines the trade-off between generalization ability and accuracy in the training data, and the value up to which deviations larger than ε are accepted. The ε-intensive loss function $|\xi|_\varepsilon$ has been defined as in Equation (3.10)

$$|\xi|_\varepsilon = \begin{cases} 0 & if\,|\xi| < \varepsilon \\ |\xi| - \varepsilon & \text{otherwise} \end{cases} \tag{3.10}$$

It is more convenient to represent the optimization problems 3.6 to 3.9 in its dual form. For this purpose, a Lagrange function is constructed and, once applying saddle point conditions, the dual problem is converted to a quadratic optimization problem that is easier to solve, which is the one that provides the estimation of $f(x)$. The accuracy of the estimation depends on an appropriate setting of parameters C, ε, and others.[63] So, the use of grid search to find good parameters for SVR can be applied to test combinations of such parameters.

SVR has been also integrated in software packages such as Rapid Miner, mentioned earlier.

Routing Optimization Models

One of the most well-known optimization problems is the *Traveling Salesman* routing, where a salesman must visit each city in his territory exactly once and must return to the beginning point. There is a traveling cost between all the pairs of cities, and the salesman must plan his or her itinerary to visit each city exactly once and minimize the total cost of their trip. This is a very relevant problem, since it appears in many practical situations such as the routing of trucks in a distribution business to deliver orders to a certain set of clients, the routing of technicians to install or repair telecommunications equipment for requests in a given area, and the routing of salesmen to visit the clients in a given zone. This problem can be seen as a graph with nodes that represent the cities to visit and the edges as the connecting roads, which have a weight assigned to them to represent distance, cost, time, or some other relevant amount; the objective is to find the route that passes by each city exactly once and returns to the initial city, thus minimizing the sum of the weights associated with each edge in the route. For example, the graph in Figure 3.9 represents cities 1, 2, 3, and 4 with the respective weights on the edges between the cities. It is desired to travel the graph touching all the vertices without repeating any one, starting at vertex 1 and finishing at the same one, obtaining a route that minimizes the sum of the weights.[64]

If all possible routes are calculated, it can be seen that the route 1-3-4-2-1 has a cost of 20, which is the minimum, and also route 1-2-4-3-1 has the minimum cost. This enumeration approach is feasible for a small number of cities, but for real problems, the number of alternative

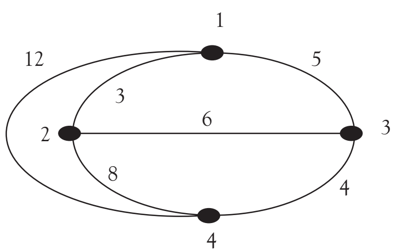


Figure 3.9 Traveling salesman problem example

routes grows exponentially with the number of nodes, so, a more efficient approach is needed. One alternative is a discrete LP model, which is also feasible for a not too large number of nodes. So, for real-life problems, the only alternative is to use a heuristic, which generates a solution that is not guaranteed to be optimal, but only good enough. This problem is a popular test for many general heuristics devised for combinatorial optimization, such as genetic algorithms, simulated annealing, Tabu search, ant colony optimization, and the cross-entropy method.[65]

Next, two heuristics for this problem are presented; one of them will be used in a case in Chapter 5.

The *greedy algorithm* lets the salesman choose the nearest unvisited city as his or her next move. This algorithm quickly yields an effectively short route. For *N* cities randomly distributed on a plane, the algorithm on average yields a path that is 25 percent longer than the shortest possible path.[66]

The other heuristic is based on the S*pace-Filling Sierpiński Curve,*[67] which builds a recursive sequence of fractals, which fills the space in which the nodes to be visited exist; then, the route is built visiting the nodes in the same sequence that the filling Sierpiński sequence determines. This heuristic has many advantages if solutions that are up to 25 percent far from the optimal one are acceptable.

Assignment Optimization Models

Another popular structure of optimization is the *Assignment problem*. In its simplest form, the objective is to assign *n* tasks to *m* agents so that each task has only one assignment and each agent gets only one task, assuming $n = m$, and that the sum of the assignment costs is minimized. We have solved versions of this problem in assigning technicians to customer requests in telecommunication companies, IT specialists to software projects, and for the assignment of operating rooms to medical specialties in a hospital. The simplest mathematical formulation for this problem is the LP model:

Minimize:

$$\min \sum_{i \in A} \sum_{j \in T} C(i,j) x_{i,j}$$

Subject to the constraints:

$$\sum_{j \in T} x_{i,j} = 1 \text{ for } i \in A,$$

$$\sum_{i \in A} x_{i,j} = 1 \text{ for } j \in T,$$

$x_{i,j} \geq 0 \text{ for } i, j \in A, T$.

The variable $x_{i,j}$ represents the assignment of the agent to task , taking value 1 if the assignment is done and 0 otherwise. This formulation allows also fractional variable values, but there is always an optimal solution where the variables take integer values, since the first constraint requires that every agent is assigned to exactly one task, and the second constraint requires that every task is assigned exactly one agent. A and T are sets of equal size that contain agents and task. This version can be easily solved with a standard LP algorithm and also very effective heuristics have been proposed as the Hungarian one.[68]

For more realistic versions of this problem, as the hospital operating room application in Chapter 5, there are complications, such as tasks have execution times and several may be assigned to an agent; agents have a defined capacity available; and the cost structure can be more complex, for example, with multiple objectives. In such cases, the model must be discrete to assure that the assignment of tasks is exclusive, and several more constraints, to take care of the complications outlined earlier, may emerge. Besides these complexities, it is our experience that these types of optimization models can be solved with standard software for discrete problems. However, in some cases, heuristics can be applied, such as Tabu search.[69]

The next problem is also very common in practice, that is, the *Job Shop Scheduling*, which can be described as follows. Let $M = \{M_1, M_2, ..., M_m\}$ and $J = \{J_1, J_2, ..., J_n\}$ be defined as two finite sets. In an industrial context, the problem is proposed as machines and jobs to be scheduled on them. Furthermore, X denotes a set of sequential assignments of jobs to machines, such that each job is done just one time; $x \in \mathrm{X}$ can be described as a $n \mathrm{X} m$ matrix, where a column i shows the jobs that a M_i machine will perform in order, for example:

$$x = \begin{pmatrix} 1 & 2 \\ 2 & 3 \\ 3 & 1 \end{pmatrix}$$

The matrix indicates that the M_1 machine will perform three jobs J_1, J_2, J_3 in the order, while the M_2 machine will execute the jobs in the sequence J_2, J_3, J_1. Also, the cost function $C{:}\mathrm{X} \to [0,+\infty]$ is defined, which is interpreted as the "total cost of processing," and it can be an expression that represents the cost due to the time the machine M_i takes in doing the job J_j. The Job Shop problem corresponds to finding an assignment of jobs $\in \mathrm{X}$, such that $C(x)$ is minimum. It can be solved using several types of algorithms or techniques; the most popular are branching and pruning, Tabu search, genetic algorithms, and search in directed graphs.[70] This last method will be used in the production scheduling case in Chapter 5.

Process Case Management

In many cases, mainly in complex knowledge work, such as investment evaluation, new product development and professional work, such as the one of medical doctors, lawyers, and high-level managers, it is difficult to develop formal analytical models to support or automate such work. There have been attempts to classify this type of work and suggest different approaches to improve it.[71] Here, we will concentrate on the case management approach for this type of situations, which we describe next. Case Management appears in situations in which there is a discrete requirement that runs as a unit throughout a process, for example, care and treatment of patients in a hospital, resolution and execution of a credit in a Bank, attention and resolution of requests in a call center, reception and build-to-order manufacturing, and development of a new product in any company. More formally, Case Management can be defined as a collaborative process of assessment, planning, facilitation, and activation options and services to meet the needs of customers through communication and available resources to produce cost-effective results for them and for the enterprise.[72] While this could define any process, what makes Case Management special is that activities and the order in which they should be performed are not defined. Therefore, the person in charge of executing a part or the whole of a case should have the ability and the authority to define courses of action. This is very evident in medical cases, nonstandard credit, manufacturing or services made to order, and development of new products. What is clear in a case is the result that is to be attained and the staff in charge must define courses of action to achieve this, which clearly falls within the category of knowledge-based work (performed by a knowledge worker). In such cases, the design ideas that we have exposed, which could be interpreted as mechanistic, in the sense of automating knowledge and practices to replace humans, must have a solution to deal with these situations. The solution to these cases is based on several ideas. The first is to give an online computational support appropriate to the activities implied in the previous point, including the use of knowledge management techniques allowing to formalize historical tacit knowledge and, through this, suggest courses of action to the person in charge; for example, a recent application of these ideas was made to the processing of offences by public prosecutors to determine which ones to pursue; the knowledge developed during several years about which factors determine the convenience of so doing was formalized in rules that recommend a course of action to the head of the unit, supported by a computer application.[73] The idea is not to say to the person in charge what do, but help him to determine efficiently and effectively the course of action. Another line of design in these cases is that of project management, since these are handled based on the events and milestones; therefore, if it provides computational support allowing declaring the projects, activities, and milestones, it facilitates the management of cases. An example of this is the private hospital mentioned in Chapter 1, which developed a Case Management solution for innovations projects; this solution will be presented in Chapter 5. Finally, another line of action has to do with collaborative tools that allow people who manage knowledge to communicate online to define actions to be carried out and the necessary coordination; for example, in large engineering projects, where there are people who evaluate and define the project in general (conceptual engineering), others that make detailed engineering by specialty, buy materials and necessary equipment, and those who build, for whom communication and coordination mechanisms are needed to perform their work in a consistent manner. Here, Web 2.0 technology (e.g., blogs, wikis, microblogging, and social networks) can be useful.

From the point of view of design, there is, in addition, the problem of how to represent situations, such as those described earlier, and of different schemes of modeling the situations in which the flows of activities cannot be designed a priori. We will see in Chapters 4 and 5 that Business Process Management Notation (BPMN), the approach of modeling that we adopt in this book, which is presented in the next section, permits, with certain adaptations, adequate representation of processes that manage cases. The key to consider such adaptations aspects are as follows:

- Handling the control flow of the case according to a certain sequence of activities, which falls squarely within the BPMN options.
- Management of activities of a case according to the events that occur and determine it status. These are typically shown in an artifact, which can range from a physical folder that brings together all the background of the case, for example, case records, popular in justice, hospitals and banks, up to complex computer records that capture online the status of the case, which we call "state update and reporting." These artifacts are characterized, in Case Management, by having a clearly defined a beginning and an end. With information provided by the artifact, a series of rules are executed that define what happens next in the process, which falls within what we call business logic. We can also see that, with the concepts of modeling that we will use, these artifacts and the business logic that runs based on them can be represented in BPMN. One case in this line is one of a university hospital in Chile, where a solution for the management of the emergency flow was developed with a continuous monitoring and applying business rules according to the state of such flow, which identify situations and recommend actions to be taken; for example, provide more medical staff and boxes due to a forecasted extreme congestion, free a box because the patient

has already been attended and detect too long delays for processing medical exams that delay the patient.

- Management of communications among the participants in the process, which may not always be designed a priori, that is, this implies that may not be a predefined workflow, but this occurs according to the determinations and needs of the participants. This is the problem more difficult to resolve, since BPMN and other modeling diagrams make difficult the representation of activities that do not have a predetermined sequence and also the interaction with other activities online.

In dealing with the complex problems just described, a new technology has been developed: Dynamic Case Management (DCM), also called Adaptive Case Management. DCM emphasizes run-time Case Management support, which means that the case view can be altered by user actions and systems' events. So, the user is able to add tasks, processes, and participants on the flight at the point of need when executing the process.[74] This technology is really dynamic and adaptive to the needs that the case demands, allowing the user to act and create, and that does not require advance design of the flow nor fixed rules and business logic. In fact, some products include the possibility of on the flight Analytics, so that the business logic can also be adaptive. DCM is still under development, and there is not much reported experience with it, but big players, such as IBM, are betting on it, and hence it should be considered in complex Case Management.

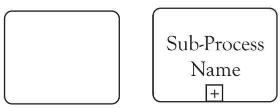
Process Modeling

The idea behind process modeling is to design an organization with formal graphical models that allow representing the options of business and process structures that put into practice a Strategy and an associated Business Model. Moreover, for each process of the structure or Enterprise Architecture (EA), we want to generate models, also formal, that represent the design of the components of such process. For this, we use the BPMN,[75] which is supported as a standard by the Object Management Group,[76] which allows detailing activities, the flow, and the logic of a process.

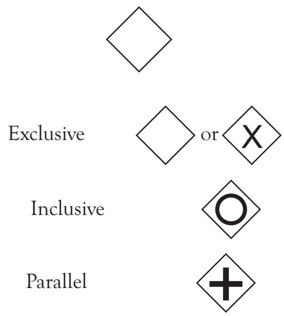
In a nutshell, BPMN is a formal notation that provides many constructs to build process models; here, we summarize the more basic ones. BPMN has a set of three core elements of the *Flow Objects*, as follows:

1. *Event*, which is represented by a circle, is something that "happens" during the course of a business process. Events affect the flow of the process and usually have a cause (trigger) or an impact (result). Events are circles with open centers to allow internal markers to differentiate different triggers or results. There are three types of Events, based on when they affect the flow—Start, Intermediate, and End-diagramed as follows:

2. *Activity*, which is represented by a rounded-corner rectangle, is a generic term for the work organizations perform. It can be atomic or nonatomic (compound). The types of activities are task and subprocess. The subprocess is distinguished by a small plus sign at the bottom-center of the shape, as follows:

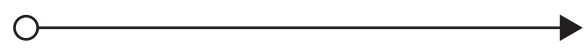


3. *Gateway*, which is represented by a diamond shape, is used to control the divergence and convergence of sequence flow. Thus, it will determine traditional decisions, as well as the forking, merging, and joining of paths. Internal markers will indicate the behavior of the flow of control, as follows:



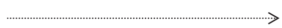
The Flow Objects are connected together in a diagram to create the basic skeletal structure of a business process. There are three *Connecting Objects* that provide this function. These connectors are as follows:

1. *Sequence Flow,* which is represented by a solid line with a solid arrowhead and is used to show the order (the sequence) in which the activities will be performed in a process.



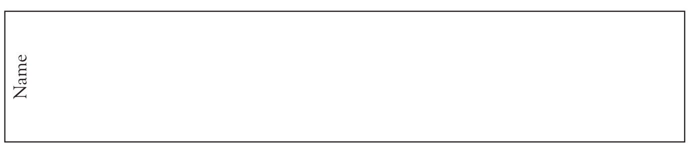
2. *Message Flow* is represented by a dashed line with an open arrowhead and is used to show the flow of messages between two separate process participants (business entities or business roles) that send and receive them. In BPMN, two separate pools, defined as follows, in the diagram will represent the two participants. The message flow graphical symbol is as follows:

3. *Association* is represented by a dotted line with a line arrowhead and is used to associate data, text, and other artifacts with flow objects. Associations are used to show the inputs and outputs of activities and are drawn as follows:



Many process modeling methodologies utilize the concept of "swim lanes" as a mechanism to organize activities into separate visual categories in order to illustrate different functional capabilities or responsibilities. BPMN supports swim lanes with two main constructs. They are shown in the following.

A *Pool* represents a participant in a process, usually at an aggregated level, such as a company, a division, or a department. It also acts as a container for partitioning the aggregate into smaller components, such as an individual, using lanes. Its representation is as follows:



A *Lane* is a subpartition within a Pool and will extend within the entire length of the pool. Lanes are used to organize and categorize activities.

Examples of BPMN modeling that use Pool and Lanes to represent business designs at different detail levels will be presented in Chapter 5.

In the models that will be used to support the design approach we propose, two modeling styles will be used.

The *first style* is a nonprocedural style that follows the ideas of Integrated DEFinition 0 (IDEF0) method,[77] but using a software tool to edit BPMN models.[78] We summarize the conventions of IDEF0 to make this book more self-contained. This technique models processes, subprocesses, or activities by a box (rectangle with rounded corners); defines *Inputs*, which are supplied to them; *Outputs*, which are the product of the transformation that occurs within them; *Controls*, which are policies, rules, restrictions, or any other information that regulates the behavior of such processes, subprocesses, and activities; and *Resources*, which are the necessary elements for their realization. By convention, the inputs are represented by arrows entering from the left to the box; the outputs by arrows leaving to the right; Controls by arrows from above; and resources by arrows at the bottom, as shown in Figure 3.10.

BPMN has many elements of representation, some of which were summarized earlier, and we will use a few of them to implement the first style of process modeling that emphasizes the components involved and their relationships through flows of information. Because BPMN has a clear orientation to the stream and control logic, we must use creatively some of its elements to represent flows of information. So, we will use BPMN boxes to represent processes, subprocesses, and activities, and one of the many varieties of arrows, the sequence one, to represent information flows. As stated earlier, a circle with a bold edge and an envelope in its interior represents a flow and associated event that is terminal within the diagram in question, which relates to a given destination in another

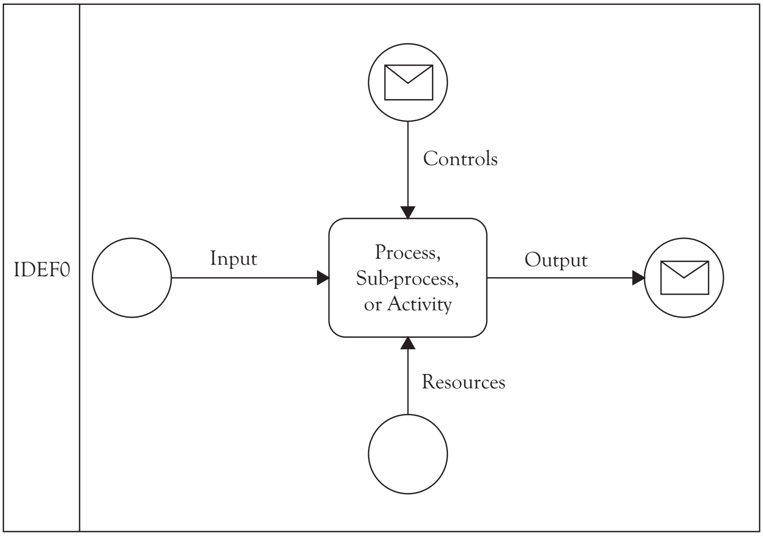


Figure 3.10 Conventions of IDEF0

diagram or outside the company; a similar circle, except for an edge without bold, represents an initial event and associated input flow; a simple circle and associated event initiates or terminates (bold) the process. These elements allow to link the diagrams of different degree of detail, such as those generated in the scheme of hierarchical decomposition of IDEF0, which will be demonstrated in the following chapters.

At this stage, we will give a very simple use for Pools and Lanes. Pools, which are represented as separate tracks in the diagrams, are used to represent entities or different businesses running self-sufficient processes. The relationships between activities of different pools are represented in BPMN as a special type of dotted lines called Message Flow. Given these adaptations of BPMN to represent high-level processes in our conception, it is not possible, in general, to directly use simulators or executable code generators, which are discussed later, associated with this language for this level of modeling, since the representation is asynchronous; in other words, there is no strict sequence and many things may be happening simultaneously. But these models can be easily converted to models executable with simulation software as shown by Barros et al. in a case of emergency patients processing in a hospital.[79]

The *second style* of modeling, detailing the first style models by progressive decomposition of higher level elements (hierarchical decomposition), will be used when we get to the detailed design of processes, including the logic associated with the computer support; for these, we will adopt BPMN conventions in its conception of sequence and control logic, which leads to synchronism. Here, we will define two substyles: one that does not intend simulation and implementation of processes by executing them and another allowing for this. The difference between these is the degree of formality of the representation, since, in the second case, strict conventions of BPMN that make feasible the simulation and execution must be respected. The advantage of this second variant is that, under certain conditions, the computing support to the process can be generated automatically, without the need for computational design or writing code. This is feasible because BPMN was designed to make graphic representations, which comply with certain conditions, to be converted to the conventions of software that can generate execution. These types of software, called BPMS, have proprietary complements to BPMN that make the execution feasible and provide the possibility of using web services, which contain logic that cannot be modeled with BPMN that interact with the suite. This type of technology is illustrated in Barros and Quezada.[80]

In summary, depending on the level of design, as defined in Chapter 1, in which we find ourselves within the modeling and design objectives that we pursue, we will use different styles of representation, which can be defined as consistent and complementary. But BPMN does not allow, as stated earlier, to design complex logic that execute Analytics embedded in the internal tasks of each activity, particularly those that provide automatic support to complex decisions in the form of algorithm or heuristics. Here, we have the opportunity to integrate the analytical techniques mentioned in the previous section by means of logic, which is encapsulated in computer programs that are called by the activities of the BPMN during the execution of the process by means of a technology such as web services.[81]

The union of the approach of structural design of businesses processes and analytical methods, made possible by the type of modeling just presented, generates the possibility of a new class of business design, which we will call *intelligent solutions*, to be presented as BI structures in Chapter 4. The differences in these solutions with the traditional approaches—which only improve the handling of information in a process, as the Enterprise Resource Planning software typically do, or rationalize the processes, eliminating the existing unnecessary activities or improving them with logics based on experience—are to approach thoroughly and rigorously the decisions that exist within a process. To support such decisions, Analytics is used as explained in the previous section. We have important accumulated experience of Analytics embedded within processes that has allowed us to incorporate it in the patterns used for such integration, which will be summarized in Chapter 4 as Business, Architecture, and Process Patterns.

The hierarchical modeling approach based on BPMN allows managing the complexity inherent in integrating very different mental models and tools—problem that was outlined at the beginning of this chapter—since they are progressively introduced, as design goes from structural to detailed. Thus, for example, at the top of the modeling hierarchy, the conceptual models for Strategy determination, Business Model definition, Capabilities determination, and consequent Business Design are the most relevant. Subsequently, Business Design is made operational in Business and Process Architectures, modeled with the first modeling style with BPMN, based on patterns. As this architecture is decomposed with detailed design of its component processes, Analytics provide the tools that allow generating business logic, which assures that the innovations conceived at the structural level really produce the desired results. This results in BPMN designs modeled with the second style that have embedded business logic and appropriate Information System support allowing their execution. This hierarchical modeling approach will be present in all the cases reported in Chapter 5.

Evaluation Theories and Methods

A method that attempts to evaluate a service architecture design is based on Design Structure Matrixes (DSM). Some authors propose using this method on Enterprise Architecture (EA) analysis,[82] but concentrate mostly on the structure of IT-related elements, and this is not systemic according to the definition we have given. The basic idea they propose is to represent relationships among architecture components by means of a DSM, which shows their dependences. Then, by mathematical manipulations of such matrix, measures such as visibility, degree of relationships, and cyclic groups and their ranking can be calculated. These show, for example, the degree of clustering of the components, where typical situations can be: one large cycle group that contains the core elements; multicore with various similar cyclic groups; and a hierarchical structure with multiple cycle groups. These structures have different characteristics in terms of, for example, the percentage of the architecture affected by a random change, which is important in software architectures. The application of these ideas to business components and their relationships is still under development.

Another more inclusive approach to evaluation is simulation. Formal architecture models, as the ones we will propose in the next section, can be simulated to predict performance. For example, different configurations for health emergency and surgical services are evaluated by simulation by Barros.[83] Another example is a Massachusetts Institute of Technology's (MIT) PhD thesis,[84] which considered a particular situation faced by a two-billion aerospace defense organization, with operating units in several segments. Collaboration problems existed among these units; hence, management decided a strategy of using budget allocation to induce integration. Then, a business design, similar to the one we will present, was proposed for the development and sales of new products and services and the collaboration of the different units. Such design was evaluated with a set of models: discrete event simulation models for processes; system dynamics for causal dependencies, temporal relationships, and allocation of resources; and agent-based modeling for simulation of microbehavior. These models were combined in a hybrid simulation model that allowed performing an economic evaluation for variants of the business design.

Alternatives to evaluate, and also to justify in advance certain designs, are management and economic theories. This subject was introduced by Barros,[85] and it is treated in detail in other publications,[86] so, we only give a brief summary here.

First, we review *coordination costs and structures*. The coordination cost is one of the components of the production costs of the economic theory of production—together with the materials, labor, and several others—which can increase at a rate greater than linear in relation to production, as a company grows; they are affected by diseconomies of scale due to the complexity of management inherent to the large size of an organization.

One can induce greater coordination in an organization by various means, which produce different cost effects. They are coordination mechanisms that come from disciplines, such as organizational theory, economics, operations research, IT, and management in general. Among others, we can mention rules, hierarchy, planning, collaboration, and the elimination of relationships that need to be coordinated. Several of these mechanisms can be boosted with IT. The problem is, then, to choose a right coordination level by using economic evaluation; for example, if we currently have a low level of coordination, up to which level it is convenient to increase it? It is also a relevant question when a company is decomposed into separate smaller components to eliminate relationships and avoid coordination. The answer to this question has to do with the visible and hidden costs that are induced by a certain degree of coordination. The obvious costs associated with coordination are those relating to the method used to coordinate. To increase coordination, more personal and more time, increased processing of information and more hardware, software, and communications to support coordination are required. If this were the only cost, there will no justification to coordinate. However, there is a cost little visualized in practice, which is the one associated with the consequences of not coordinating. Poor coordination implies that the organization's resources are used in a manner much less than optimal. In particular, slack resources[87] appear, which are the ones that are assigned implicitly or explicitly to absorb the consequences of the lack of coordination. For example, excess inventories to correct the lack of coordination between sales and production.

Then, the choice of an adequate level of coordination becomes an economic issue: to balance the cost of coordination with the cost of the consequences of not coordinating. These costs move in opposite direction when the degree of coordination is increased.

There is another option to manage coordination costs, which is to split a company into smaller units to make them operate in a relatively independent way. This idea is equivalent to the classical divisionalization exercised by many large companies in the world, begun by General Motors that established different divisions for different car models, and is equivalent to the MIT's architecture "Diversification model" presented before. This clearly simplifies coordination and reduces costs associated to produce many different products in the same facilities. But, it may increase slack resources due to the challenge to maintain capacity fully occupied, due to demand restrictions, and duplication of resources that could be shared. Malone[88] defined coordination structures to manage the situations just described; they are: product hierarchy, centralized markets, functional hierarchy, and decentralized markets. These correspond to configurations found in practice with other names, such as divisional for product hierarchy, where all decisions about a line of products are taken by a product manager, as opposed to functional where there are central activities that manage a shared function for all product lines, such as sales or logistics. This is obviously related to our idea of Enterprise Architecture, since they correspond to different configurations one can use for the business, and also to Modularity, since shared functions in functional architectures can be designed using such idea. Malone also formally models these structures using production, coordination, and vulnerability costs; hence, using an a priory evaluation of such costs may approximately prescribe the desirability of each structure for a given situation, accepting the limitations of a simple evaluation method.

Transaction costs is the next evaluation factor we consider; they occur when a company makes use of the market to purchase goods and services. This includes the external cost of coordination that must be incurred when using the market: costs ex ante to acquire market information and negotiate a deal; and ex post ones, to prevent fraud and fix it when it happens. Williamson,[89] winner of the Nobel Prize, extensively developed this concept and determined the characteristics of transactions, industries, and markets that affect transaction costs in a fundamental way. The concept of transaction cost allows answering a key question: What is the role played by the market in the definition of the structure of a company? The answer is that organizations and their hierarchical structures exist to replace the market, like allocator of resources, and save transaction costs. Looking at this option from the opposite point of view, we can propose using the market instead of hierarchies, by contracting product and services in the market to assemble our offer. This idea has resulted in the externalization tendency we see today in the world, which is founded in a reduction of the transaction costs due mainly to technology. Thus, electronic markets (e-Market), which allow trading products online with access to a much wider range of options, generating transparency and producing near-perfect competition, reduce a portion of the transaction cost. The rest of the cost, which has to do with the implementation of the transaction, can also be reduced by using the Internet, by automating payment and satisfaction of the agreed transactions processes. However, there are aspects, as a breach of agreements or quality problems, which persist as transaction costs. For those who want a direct relationship with a supplier, there is also Internet technology to facilitate the transaction. In short, technology significantly reduces transaction costs and, therefore, encourages the use of the market and tends to shrink organizational hierarchies, reducing the vertical integration of the companies; this does not exclude the possibility of integrating in a supply chain several different companies on the idea of an extended enterprise. This trend is consistent with the idea that a company concentrates in what its key competences (core skills) are and outsource what it is not vital.

Another evaluation factor is *agency costs.* In the agency theory, the owner of a company or his representative is called the principal and the subordinates are the agents.[90] This economic theory recognizes that the assumption behind the theory of the firm, that it maximizes utilities, is too restrictive to analyze the behavior of its managers. The agency theory proposes the alternative vision that a company is a set of related contracts among individuals with their own interests. Put another way, an enterprise is a set of agency contracts, by means of which a principal (entrepreneur) hires agents (employees) to perform a service for him or her. The assumption of behavior that this theory makes—possibly more realistic than the one of the traditional theory of the firm—is that an agent, to maximize his individual utility, prefers less work and more rewards and that does not care about the welfare of the principal or other nonpecuniary benefits, such as honor, group spirit, integrity, and pride of self-realization.[91] From these ideas, costs that the traditional theory of the firm does not consider can be identified. Firstly, we have the costs that result due to discrepancies among the objectives of the principal and those of the agents. To exemplify this, let us consider the typical problem of a sales target that a manager wants to meet. To induce the right sales effort, he or she uses some incentive—for example, a fix amount or a commission—for the salesmen, which is a cost. Despite the incentive, the target may not be accomplished, resulting in a loss respect to what the principal expected. Then, there are other ways to induce that the agents act according to the principal's objectives: one is to use a centralized approach, where very precise plans and instructions are prepared, at a cost, for the agents, and the principal has control mechanisms to make sure that results are as expected; and the other is decentralization, where the agents have freedom to act, but have performance metrics by means of which they are evaluated. Hence, if a centralized approach is used, there are: an alignment cost to induce right agents' behavior, a monitoring cost to correct deviations and residual costs, representing the differences between what it is expected and what finally results; these are the agency costs, where the first two may be reduced by decentralizing, while the third one increases. But, there is another set of costs that depend on the degree of decentralization. Here, we have information processing costs that include the information necessary for the principal to make decisions about agents' behavior, which increase as decisions are more centralized. Also, opportunity costs arise due to lack or erroneous information for the decision makers, which increase as decisions are more centralized. This is very simplified summary of this theory, but it should be clear that several different costs should be considered when deciding on decentralization of activities and the methods that are used to align agents with the objectives of the principal.

Then, we have the *cost of change,* which is generated in market situations where customers become captive and have big disincentives to change the provider of a product or service. The disincentive is measured by the cost of opting for a new product, which includes, for example, the loss of any asset purchased by the customer as part of the product or service; the new acquisitions to make; the cost of training to use the new product or service, and any other cost of adaptation necessary to be able to take advantage of it. A classic example of high cost of change is software products, particularly operating systems. Indeed, since the mainframe operating systems of IBM until the current Microsoft Windows, it has been very complicated and expensive for users to switch to another product. In this case, the cost of change is generated, in addition to investing in new software, because there are considerable costs of renovation or adaptation of all applications that run on the current operating system—but not in another competitive product—and training the staff to make it work and operate. These costs can be monumental for a large company that has many computers and applications that run on an operating system and large number of people who use them. It is clear that the cost of change introduces rigidities and generates friction in the economy, making markets less competitive. The cost of change originates from multiple factors, such as incompatibility of equipment, transaction costs and learning, uncertainty about the quality of unproven brands, cost of learning to use a new product, discount coupons and similar mechanisms, psychological change cost, and contractual costs. The cost of change is also incurred by the companies that provide the product or service, which include the costs of opening accounts for and the uncertainty about the quality of new customers. Either the company or the customer has to pay these costs, and the investment is lost at the end of the relationship. The effects generated by these costs are as follows.

The most obvious effect is that the cost of change affects the customers—transforming them into captives—and creates, therefore, the potential for monopolistic profit. In particular, Klemperer[92] has shown that the individual demand of a company becomes more inelastic and diminishes the rivalry with other companies. This leads to segmentation in submarkets; each submarket being monopolized by a company. This leads to a particular form of competition, in which, efforts are focused in competition for market share in the stages of initiation of customers with the product, as we have seen with the browsers, storage in the cloud, and micro blogging. This implies that prices are lower at this stage, since they are set for market share that will be valuable in the future, due to the monopoly effect. An example of this behavior are banks giving zero maintenance cost or gifts to students of universities, so that they open accounts; computer equipment offered at reduced prices to educational institutions to capture the preferences of students in future purchases; companies automakers who accept small gains on cheap models to capture customers who can then buy more expensive cars; and insurance policies reduced to new customers. This competition may also lead to price wars when introducing new products or when a new group of customers enters a market. Once customers become captive, the prices that are charged to them are higher than they would have been if there was no cost of change.

Another effect of the cost of change is that companies have less incentive to diversify, which reduces the variety of products, providing consumers less incentive to move—incurring the cost of change between equivalent products. On the other hand, companies that sell a single version of a product are at a disadvantage since customers, having a high cost of change, prefer a single provider with a product line, for example, an operating system with versions for desktop computers, departmental servers, and corporate network. This favors the existence of companies with product lines. Also, the cost of change discourages new companies entering the market, since they have to capture customers reluctant to incur change expenses, which additionally reduces competition. Then, companies that opt for a strategy of cost of change are, at the time, choosing a structure for the company and for the market.

Finally, we have *network externalities,* which appear when the utility that a participant gets when he or she is in a network increases when the number of users of the same goes up. This idea was developed for physical networks, such as telecommunications, which had monopolistic characteristics. However, the most interesting case occurs when several companies are competing in a market with these features. The key to the existence of externalities is that consumers are in the same network. The size of this network will depend on the type of market. In some cases—as in cars—the network will be formed by consumers of a certain brand of a company. At the other end, the network will include all companies that sell in the market and its customers; for example, the DVD market. The property that determines the size and scope of a network is the fact that the products of different companies can be used interchangeably. In communication networks, this has to do, for example, with the fact that the subnets of different companies are interconnected and that a user on a subnet can communicate with any other. In hardware, the similar effect is that the software for a computer can be used in other machines and in durable goods, such as cars, is the set of brands that can share common services.

In markets where there are several networks that compete for the same consumers, their expectations about the future size of such networks leads them to decide on which to choose. This generates demand externalities and, consequently, economies of scale on the demand side. Katz and Shapiro[93] show that, depending on such expectations, only a company will have more than zero production or there will be several companies in the market. In other words, if consumers expect that a company and its network will be dominant, they will be willing to pay more for the company's products and it will be, in effect, dominant. This effect is called a *positive feedback.*

Another important question is about what incentives a company has to sell products that are compatible with others in the market, either through formal or de facto standards. It can be shown that firms with good reputations or large pre-existing networks will resist the compatibility, and those with small networks or precarious reputation shall foster the compatibility.

The digital economy has as a main characteristic—the existence of network externalities. Now, while there are physical networks—as the Internet—virtual networks dominate. These networks can be physical such as hardware and software—for example, Wintel—or for information products, such as Internet browsers—for example, Google Chrome and Internet Explorer; another current example is social networks, like Facebook.

The aforementioned positive feedback—in which the stronger becomes strongest—explains a lot of situations, in which a product has managed to dominate a market by removing others or leaving them with a very small stake in it. Classic cases of this type are the VHS versus Betamax and DVD versus VHS; Wintel versus Mac; Excel versus Lotus 1-2-3; and NT versus Novell.

Unlike the traditional supply economies of scale—that have diminishing returns at a high volume because of the complexity of coordination and control—the economies of scale of demand do not dissipate with size; they increase as the number of users increases. A company should ride this effect until it reaches critical mass and take off while some others fail.

CHAPTER 4

Design Framework for Intelligent Enterprise Architectures

We define our framework as a set of concepts, practices, and general design structures that can be used to generate a complete service design. We start from the Ontology presented in Chapter 1 that structures all the design elements, in particular, the business and architecture design components. We also recall that our approach relies on patterns that serve as reference models for generating design proposals. Patterns basically model the structures of components and relationships that must exist for a business to function properly. Besides, they may also provide alternative structures that are appropriate for different ways of handling a business. Then, the components of the framework are divided into:

- *Intelligence Structures* that provide options on how Analytics can be included in a design.
- *Business Patterns* that are derived or abstracted from vast experience and knowledge generated in a service design, including our own and the one published in the literature, which emphasize the different structures, components, and relationships a business may adopt in providing services to their clients.
- *Architecture and Process Patterns* that make business service designs operational and support the different design levels defined in Chapter 1, detailing how such designs can be implemented, including the technology support needed for their execution.

These patterns are documented in other publications that also show how they have been widely used in real projects.[1] We give a summary here oriented to provide a foundation for the cases to be presented in Chapter 5.

Intelligence Design Structures

We now show how Analytics can be incorporated in alternative design structures that offer different complexity levels of the Analytic types 1.0 to 3.0 defined in the previous chapter, which can be applied when performing the design levels identified in Chapter 1, assuming that the first and second levels will generate innovation processes that will be routinely executed to adapt the business to a dynamic environment.

The use of Analytics in our design proposal aims to providing business logic that supports *intelligent* business development and management, as explained in the section "Business and Process Intelligence" of Chapter 3. In order to formalize the options, a service designer using Analytics has, we propose *Intelligence Design Structures* that provide several levels with increasing complexity as follows. We start with a basic case, shown in Figure 4.1, where business processes, which are structured as in the design levels of Chapter 1, have as unique information technology (IT) system support providing nonintelligent information that just report the state of the processes. Then, we complement this structure with intelligent support using the ideas and tools we have so far presented, trying to show how such processes, which are in routine execution, can be supported by Analytics and IT. The general structure we propose is summarized in Figure 4.2, where the intelligent support in introduced as a general component that can be implemented with four intelligence levels, summarized in such figure. Such levels are then detailed as four different structures that define how they can be implemented.

Intelligence Structure I

The first intelligence level corresponds to using Analytics 1.0, as defined in the previous chapter, the main idea being to develop and implement simple business logic that, based on the state of the process, discovers the

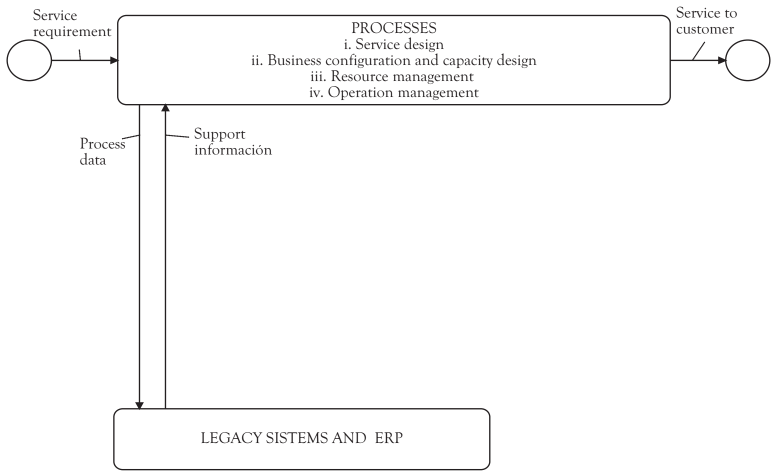


Figure 4.1 Basic structure

need for action, and possibly, recommends actions on process execution and management, which is presented in Figure 4.3. Logic can be based on several ideas:

- Simple rules based on experience and process metrics, which show that the process is not operating as expected; for example, waiting time before a step of the process that is not according to a service metric in credit processing in a bank, order processing in retail, patient treatment in a hospital emergency, and claim processing in insurance. There is Business Process Management Suites (BPMS)[2] that allows to model and execute this type of processes, using Business Process Model and Notation (BPMN), including metrics definition and their monitoring.
- Formalization of expert knowledge based on semantic modeling and similar techniques; for example, formalization of medical criteria in an emergency triage to determine illness severity for a patient, which is applied with patient data using a computer program that recommends a priority for him or her. Similar cases to this are logic for surgical list prioritization, for detecting failure on trucks based on sensor data, and for credit evaluation, as reported in Barros.[3]

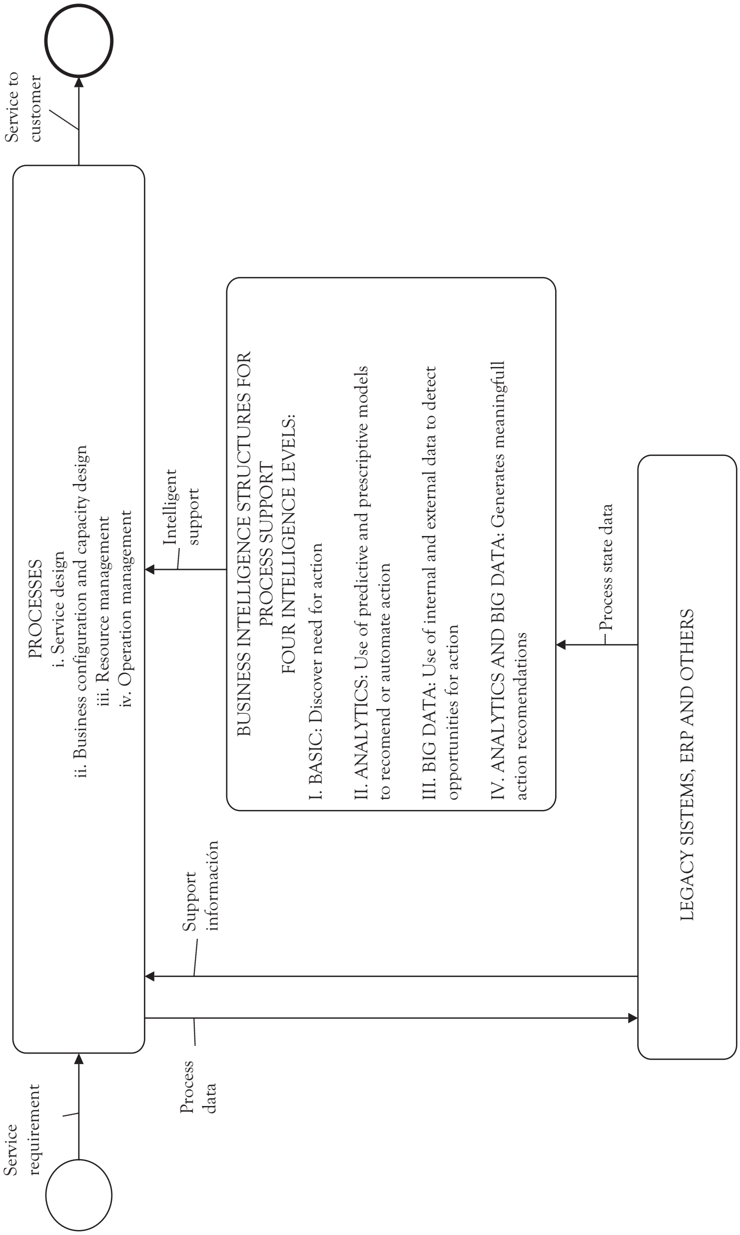


Figure 4.2 General Intelligence Structure

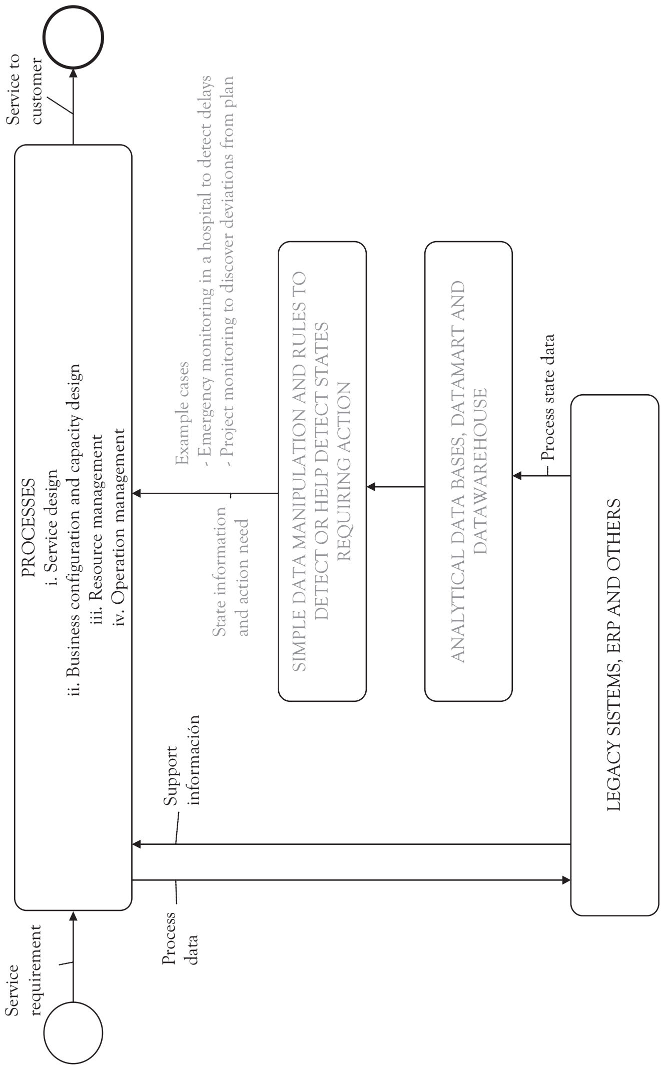


Figure 4.3 Intelligence Structure I

- Use of formal metrics obtained by Balanced Scorecard[4] and similar techniques that applied on state data determine which parts of the process are not according to the plan.

Intelligence Structure II

This structure uses predictive and optimization models, allowing to make a well-founded recommendation on how to act on the process, including the possibility of influencing the customer, as presented in Figure 4.4. This structure is superimposed on the previous one, to show the possibility of using both of them in a coordinated way. The card-processing organization, presented before, that uses card information for developing predictive customer use models, allowing banks to make proactive offers to them, is a case of use of this type of Intelligence Structure, when only internal information is used. Barros[5] presents several real cases that also use this structure on optimal paper production management, flight demand management in an airline, proactive sales management in an office equipment distributor, chronic disease management in a private clinic, preventive compliance checking of labor law infringements, sawmill optimal production planning, and management of a large workforce in a food distributor; it is also possible to have applications oriented to business developments, such as a real case of use of demand forecasting and simulation models to design an hospital's emergency configuration and capacity.[6] Other well-known cases of this type are Amazon and Walmart on predictive and optimization models use.

Intelligence Structure III

This structure, shown in Figure 4.5, builds on Intelligence Structure I by introducing big structured and unstructured data coming from different sources—Web, cloud, contact center, sensors, social media, logs, Internet of Things (IoT), and the like—and sophisticated data manipulation and analysis technologies, in the line of Analytics 2.0 defined in Chapter 3. Examples of such technologies are Hadoop for data storage, advanced multistructure data architecture, and in-memory databases; high definition models to discover patterns—for example, clicks patterns

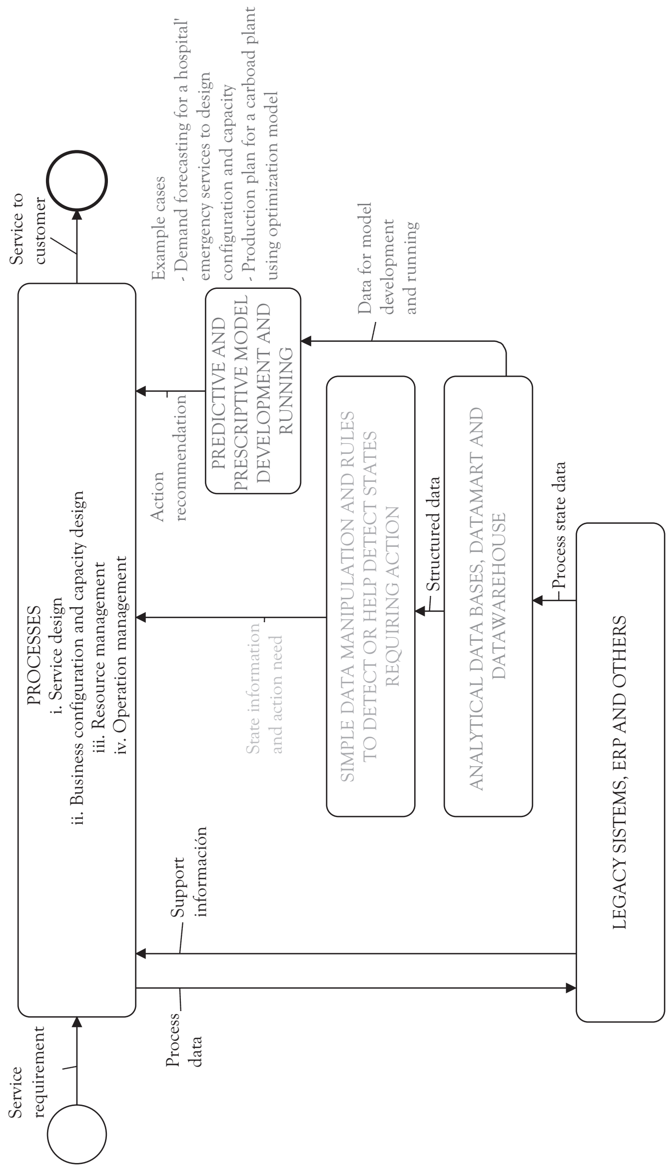


Figure 4.4 Intelligence Structure II

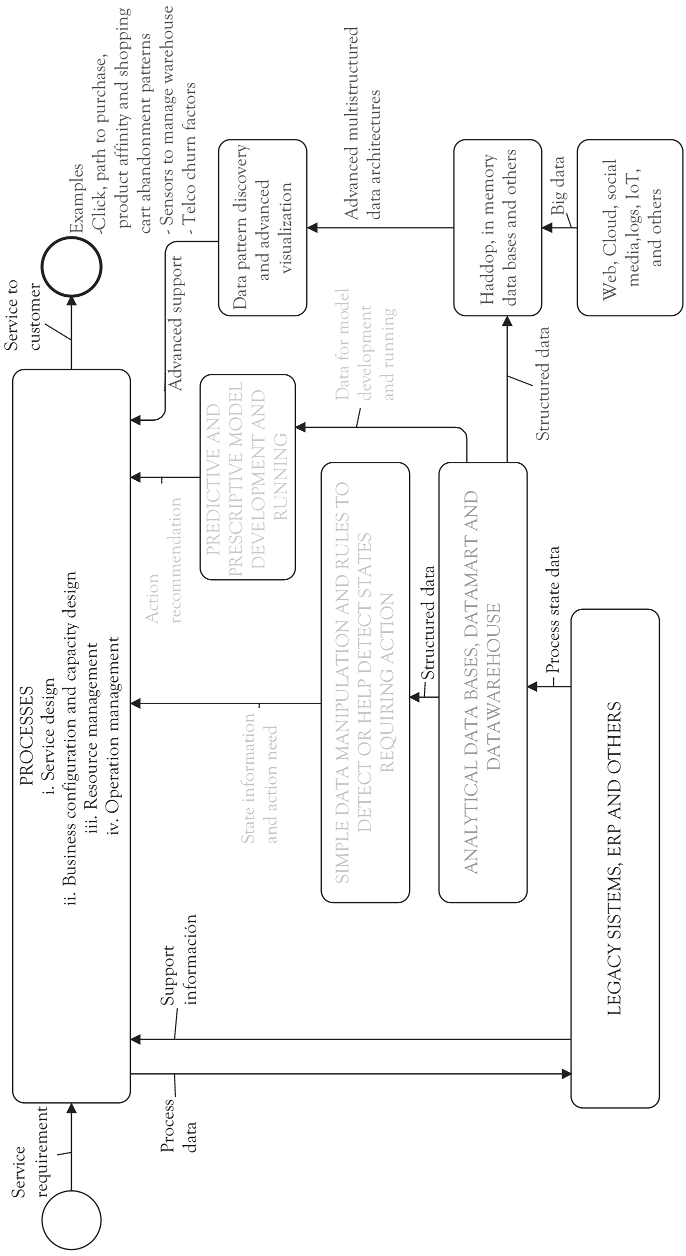


Figure 4.5 Intelligence Structure III

for customer buying on a commerce site—and find path to purchase, product affinity, and shopping cart abandonment; and advanced visualization. Real cases of use of these technologies, besides the examples given for Analytics 2.0 use, are a medical supplies company that uses sensors to monitor employee and product movements in a warehouse in order to determine what to do in real time to expedite shipments and make better use resources; and a Telco that combines Web usage with contact center interactions to identify important churn factors, resulting in the identification of hundreds of at-risk churn targets worth millions per year.[7]

Intelligence Structure IV

In this structure, Analytics, in advanced versions, is applied over traditional data and big data to generate meaningful actions over the service processes (levels i to iv), as shown in Figure 4.6. Actions may be generated by advising, recommending, and in some cases, automating them by means of prescriptive models. Actions may be related to service delivery, service processes management and execution, service capacity adjustments, and new business development, including for example, creating new business models, discovering new product offers, and monetizing data to external companies. The general objective in doing this is to provide business agility at the different design levels. The Analytics involved in this structure are of the 3.0 type, which, besides the data techniques mentioned and exemplified before, include truly intelligent approaches, such as web mining, text mining, voice recognition and processing, image recognition, and Machine Learning. These are necessary to make sense of the big data coming from the Web, social media, the cloud, mobile devises, IoT, and sensor data a company may collect. Cases that use these ideas are:

- Netflix, which has developed a movie "recommendation engine" based on customer behavior that relies on an algorithm that clusters movies, connects customer movie rankings to the clusters, evaluates ratings online, and considers current use web behavior to ensure a personalized web page for each user; it also has a testing culture for new business

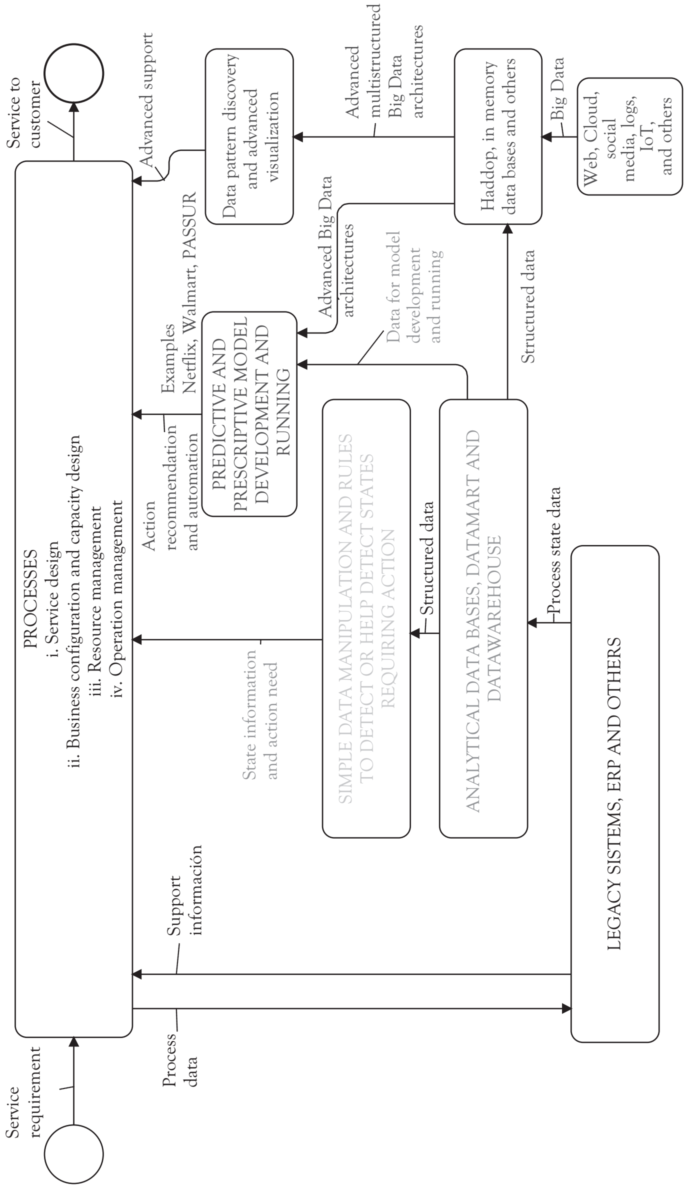


Figure 4.6 Intelligence Structure IV

developments that uses surveys, website testing, concept development and testing, advertising testing, Data Mining, brand awareness studies, subscriber satisfaction, channel analysis, marketing mix optimization, segmentation research, and marketing material effectiveness. Machine Learning is behind the "recommendation engine" and other analyses.[8]

- Walmart, besides historic use of demand prediction with its own data, has introduced mining of social media data to predict shoppers' purchases and act on that basis to plan logistics, which is also optimized with mathematical models.[9]
- In reducing planes' landing time delays at airports, a major U.S. airline requested PASSUR Aerospace a solution to improve arrival estimates. Such solution was offered as a service called RightETA. It calculated these times by combining publicly available data about weather, flight schedules, and other factors with proprietary data the company itself collected, including feeds from a network of passive radar stations it had installed near airports to gather data about every plane in the local sky. PASSUR started with just a few of these installations, but by 2012, it had more than 155. Every 4.6 seconds, it collects a wide range of information about every plane that it "sees." This yields a huge and constant flood of digital data. What's more, the company keeps all the data it has gathered over time, so it has an immense body of multidimensional information spanning more than a decade. This allows sophisticated analysis and pattern matching. RightETA essentially works by asking itself "What happened all the previous times a plane approached this airport under these conditions? When did it actually land?" After switching to RightETA, the airline virtually eliminated the gaps between the estimated and actual arrival times. PASSUR believes that enabling an airline to know when its planes are going to land and plan accordingly is worth several million dollars a year, at each airport.[10]
- In the credit card case we have mentioned several times, besides proactively generating offers for customers using data

mining on transaction internal data, currently tweets are being analyzed using text mining to discover product mentions in order to be able to detect opportunities for offering the customer credit card promotions in real time for products he or she is considering. This case also shows the possibility of continuously analyzing credit card use data to discover new business opportunities by developing new services for banks; such services are novel and attractive offers that, based on banks' customers' behavior, allow to increase card use. Besides the tweets data, they are considering other social media data and customers' location data to generate other offers.

- A solution related to sensor data collection and processing for better network management is currently being developed by a startup in Chile. The main idea is to manage data for monitoring networks for distribution of water, electrical, telecommunications, and the like, to detect problems and act accordingly. For this, they use advanced sensors that generate data about key network variables to determine, with appropriated models, any malfunction and act on real time to make corrections or inform headquarters to take actions on problems. Technology used is machine-to-machine and the IoT.

Business Patterns

For organizations that provide the business services we intent to design a simple conceptual model is proposed that shows an aggregated view of components and relationships involved in a business design, which is shown in Figure 4.7. In such a model, a *Value Stream* is a set of interrelated operating activities or processes that go from generating orders for a client to successfully delivering the product or service. It has a more restricted scope than the typical Value Chain defined by Porter[11] and others, and the one we will define later; a business may have several Value Streams. The *Management System* is a set of interrelated activities that decides about actions necessary to define and direct the Value Stream to fulfill clients' requirements, including short-term management, such as sales and operations or logistics, in addition to longer-term strategic

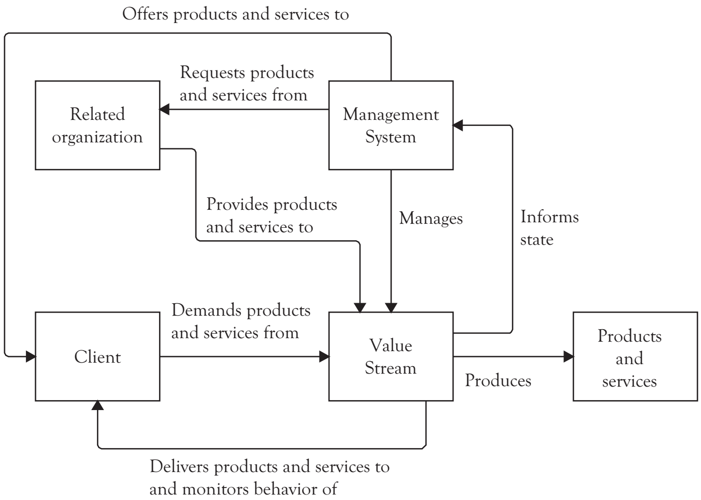


Figure 4.7 Basic entities and relationships in a business

planning, new product development, and other new Capabilities development. Financial, human, and other resources management is not explicitly included. The rest of the components and relationships in Figure 4.7 are self-explanatory.

Furthermore, the domain of organizations for which these patterns apply has the following characteristics:

1. They have products or services offerings that can be standard or customized for a client, but there is just one line of business, so, we exclude holdings or other organizations with several business lines; examples of the first type are retail banks, distribution of office products, distribution of heavy machinery for mining, software distribution, and software development, and examples of the second type are government as a provider of multiple services and a holding, such as IBM, that sells from computers to consulting services.
2. There may be several separate product or service Value Streams, but they share a common executive management; all the streams may be part of a unique Business Model, but there is also the possibility that they execute different models, as we will exemplify with cases in this chapter.

3. Even if the main line of business may be product-oriented, there is the possibility and interest in developing complementary Value Streams to provide services associated with the products.
4. Emphasis on the Value Stream is in service definition, order taking, operation, and delivery.
5. Other resources, such as human and financial, are not explicitly considered.

For service organizations of the type described by the model in Figure 4.7, several *Business Patterns* (BPs) can be abstracted from experience. They show how the elements in such a figure can be structured in different configurations of components that generate a desired Capability. As explained in the Chapter 1, the need for such Capability is derived from a Strategy and Business Model, and is related to some kind of innovation that an organization wants to perform on its business. Then, the BPs will show the new business components that are necessary for particular innovations, beyond the basic structure in Figure 4.7. The more relevant innovations in services relate to the more changing and dynamic demand for services and to the fact that it is not possible to "inventory" services in the classical sense associated with manufacturing. Moreover, demand, when occurs, is difficult to manage, since there are constraints for its release to "production" that go from cases where demand cannot wait, as in hospital urgencies, to situations where Service Level Agreements (SLAs) must be met. These ideas have been elaborated from adaptations of the theory of constraints (TOC) to services,[12] and they imply the need for Capabilities in services that are able to determine creative ways to tackle such a type of complex demand. As the BPs show, some answers to this challenge are to track and monitor demand using Analytics to predict in advance customers' needs; to continuously monitor service processes to know when they are not adequately processing demand and take corrective actions to fix them; and constantly evaluate the services performance to discover opportunities for improved or new services.

The patterns proposed emphasize on the introduction of Analytics that will be embedded within the components of the management system, which implies innovation and redesign in the way the business is performed. Several of such patterns, which have been developed based on experience and knowledge generated by hundreds of projects, are presented in the following sections.

Business Pattern 1: Client's Knowledge-Based Selling

As stated earlier, business design is oriented by Strategy and Business Model. In summary, the common aim of the organizations that have motivated this pattern called Business Pattern 1 (BP1) is to advance to:

1. Strategic positioning in the line of giving integral services to clients, as defined by Hax and Wilde[13] and summarized in the "Strategy" section of Chapter 3.
2. A Business Model based on providing value to clients by personalized services, in the idea of getting toward lock-in, generating "captive" income, and the advantages of better pricing; for this, the key processes are those that implement the Capabilities, which will be discussed later, and the resources are mainly professional people who can develop these Capabilities.

Real cases of use of these ideas are to actively monitor customers to model their behavior and generate customized offerings, just as Amazon does constantly; a bank that proactively offers insurance to groups of clients it has found are potential buyers of such products, by means of predictive models generated by Data Mining on historical data; and an IT consulting company that, through semantic modeling of the experience and knowledge generated with clients' projects, has been able to proactively generate ideas for new high-value solutions for them. Other examples of the same approach, given before, are Netflix and Walmart in their recent effort to predict shoppers' purchases using social media data. All these firms predict what Davenport calls "Next Best Offer," and the pattern we put forward goes in the same direction.[14]

To implement the Strategy and Business Model objectives of this pattern, according to the ideas in Figure 1.1, there is a need to generate

Capabilities that allow to capture and organize customer data, to process such data with analytical machinery—Data and Web Mining, including analysis of data in social networks, semantic analysis, and the like—and to generate ideas, based on the analysis, for proactive offers to clients. A pattern, BP1, for this situation is shown in Figure 4.8, modeled with BPMN with the high-level first style, where the key idea is to complement typical components a service has with more advanced and intelligent management elements that define what is required to generate the new Capability. One of the typical components in Figure 4.8 is the Basic Management System, which includes the traditional practices of marketing and sales management, as supported by a standard customer relationship management (CRM) software, in addition to the operations and logistics management necessary to generate the products or services requested by customers. These basic practices will be enhanced with new components that will have embedded Analytics-based models that allow generating new knowledge about clients and actions based on it. For modeling simplification, all the data have been summarized under the label "State information," which includes items such as buyers' purchasing history, website navigation logs, data about organization's products collected on social networks, and the like. The flows in the model represent the typical relationships among the components; some of them are information flows, such as "Orders" and "Behavior results," and other

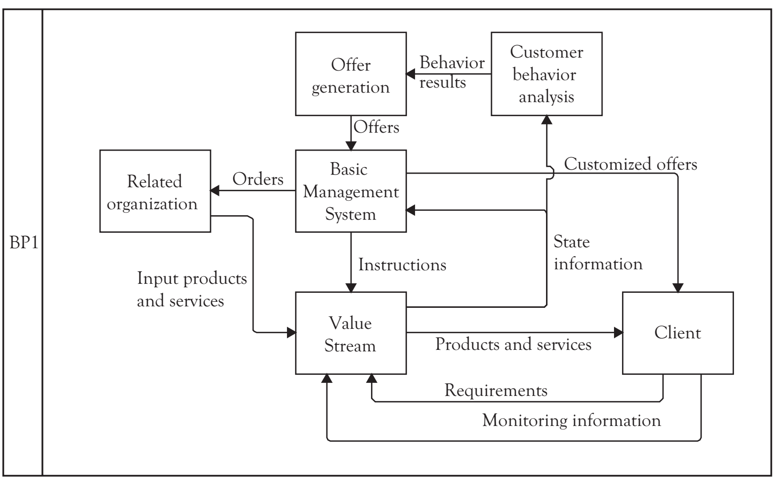


Figure 4.8 Business Pattern 1 (BP1)

flows of material things, such as “Input products,” and in some cases, “Products and services.”

An implemented case of use of this pattern in one of the largest retail chain in Chile is the analysis of sales behavior in a department store for seasonal items that should be sold out before the seasons finishes. Here, the necessary analytical Capability was to be able to develop a pricing model, based on the Demand Economics theory, which allows offering products at the right price that assures the selling of all the stock before the end of the season and maximizes the revenue that can be obtained. Such pricing has to be dynamic, adapting the price according to sales behavior during the season. The necessary processes are buyers’ sales behavior data capture, data analysis for price determination, price communication and implementation, and sales monitoring to evaluate pricing. Another related process is a sales campaign design based on the sales monitoring and pricing models. A more detailed case, including design models, is presented in Chapter 5 of this book.

This pattern is an instance of application of the *Intelligence Structure II* of the previous section, since it incorporates specific components that allow developing predictive models to make proactive (Next Best) offers to customers; it may also include the analyses of the *Intelligence Structure IV,* when social media data is included. Its emphasis is on operational design, concentrating on the marketing and sales operations. It is economically justified on the ideas of cost of change, presented in the section “Evaluation Theories and Methods” of Chapter 3, aiming to customer lock-in.

Business Pattern 2: Creation of New Streams of Service

Again, from a Strategic and Business Model point of view, in this pattern, organizations aim to:

1. Further integration with the customer, in the line of integral services to clients, with new streams of business services that provide innovative added value services to them.
2. High-value services, including the possibility that clients outsource to the provider part of their business using the new Value Streams,

in the idea of getting toward lock-in, generating “captive” income, and the advantages of better pricing; for this, the key processes are the Capabilities, which will be discussed later, and the resources are mainly professional people who can develop these Capabilities.

One case that has motivated this pattern is one large bank that has a branch dedicated to small businesses that is constantly looking for new services for them. Using the approach of this pattern, they have been able to generate at least two new Value Streams. In one of them, the bank facilitates the transactions between distributors or manufacturers of food and domestic goods and small groceries that buy such goods for selling to their customers. The bank does this by providing credit online based on predictive risk models, when the goods are delivered, to these usually cash-short business. It has been able to incorporate some of the largest distributors in the country, who cooperate by providing lists of clients and the data for risk model development; they also act as a processing channel, by means of palm computers operated by the drivers of the delivery trucks, to access bank’s systems to execute the credit for tens of thousands of these small businesses. Another Value Stream converts small- and medium-sized hardware stores into sellers of credit for the bank when their customers want to buy expensive equipment and do not have the money to pay or other credit alternatives. The bank provides an online system for sellers to access the bank, deliver the necessary information, and receive an immediate answer for the customer’s credit, for which a sophisticated mathematical risk evaluation model is used.

The Capabilities needed in this case are, in addition to the ones in BP1, to be able to process the customer analysis data to generate ideas for new services and economically and technically evaluate them, and then to design and implement the selected services as new Value Streams, as shown in Figure 4.9. This requires a permanent, dynamic, and innovative Capability to visualize new business opportunities based on the analysis of customer data, with the appropriate Analytics, which generates added value offers for clients, and it is constantly generating and improving new Value Streams to implement such offers. This pattern is called Business Pattern 2 (BP2).

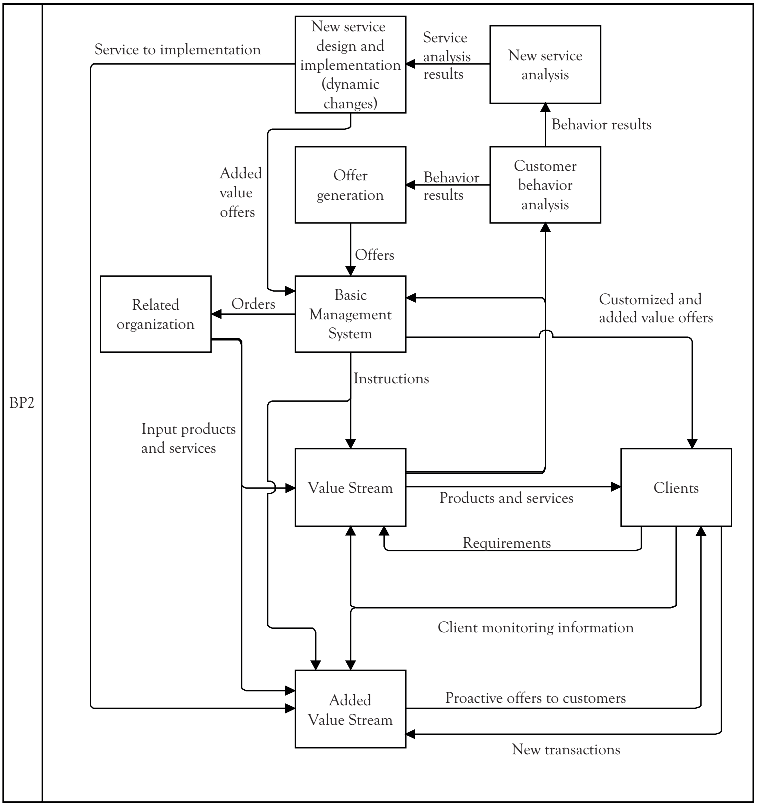


Figure 4.9 Business Pattern 2 (BP2)

A case of the use of this pattern, presented before, is a financial data-processing organization that, based on analysis of credit card transactions it processes for banks, has been able to discover characteristic behaviors, for example, of card use and card closing. This allows to dynamically defining proactive campaigns to be executed through the "Added Value Stream" to offer deals to groups of card clients, on behalf of the banks, according to their behavior; this new business creation is dynamics and continuous, since, as explained before, new sources of data are being considered, as tweets and other social media. Another case, also mentioned before, is a distributor of heavy machinery to the mining industry that, besides the current business of just selling equipment, wants to be able to offer added value services for equipment maintenance; these will be based on online equipment monitoring, by means of remote sensors mounted in them, in the idea of IoT, which feed state data to the service company systems that allow to generate corrective actions by means of predictive maintenance models. These new Value Streams, when they execute externalized customers' processes, produce a lock-in effect that makes it difficult for them to terminate the service.

Different streams may execute different Business Models. For example, the financial-processing organization case, which will be further developed in Chapter 5, has one Value Stream that executes a traditional model of mechanical transaction processing for banks with low added value, and another Value Stream that makes proactive offers to banks' customers, which generates a high value for them.

This pattern is based on *Intelligent Structure IV*, since powerful Analytics applied on local and external big data are needed to generate new business opportunities, or Intelligent Structure II when only internal data is used; its aim is business design. Here, in designing new services and their production in a dynamic way, the ideas of Modularity and Platform Design are applicable as we will show in Chapter 5. It is economically justified on the ideas of cost of change, presented in the section "Evaluation Theories and Methods" of Chapter 3, aiming at customer lock-in. In some cases, transaction costs may be the justification, when new Value Streams take charge of activities currently performed by the customer, in an outsourcing mode, using technology that minimizes such costs; for example, the cases of the financial data-processing organization and the distributor of heavy machinery presented before in this section.

Business Pattern 3: Internal Learning for Process Improvement

This pattern is based on the following objectives defined in a Strategy and Business Model:

1. The positioning that is selected is the best product, according to the definition by Hax and Wilde[15] in the variant, also defined by Porter, of operational effectiveness.
2. The value that is to be generated for clients is to provide attributes for the products that are appreciated by them, such as low cost, due to

better efficiency, quality, on-time delivery, and the like; key processes are related to discovering how to generate more value by process redesign and implement such redesigns; and key resources are again human resources that are able to innovate on processes, including users who have to adapt to new ways of doing things.

The Capability that is needed for such Strategy and Business Model is to be able to systematically analyze the organization processes, in particular the Value Streams, to detect opportunities for process improvement. This should lead to very effective and efficient processes, which are also convenient for the customer. The Business Pattern 3 (BP3) in Figure 4.10 provides a way to implement such Capability, with an emphasis on the use of Analytics to systematically analyze the origin and possible solutions for process problems using hard data. Real cases on which this pattern is based relate to the processing of claims events, operational risk events, and technological risk events (three different cases in various banks) to

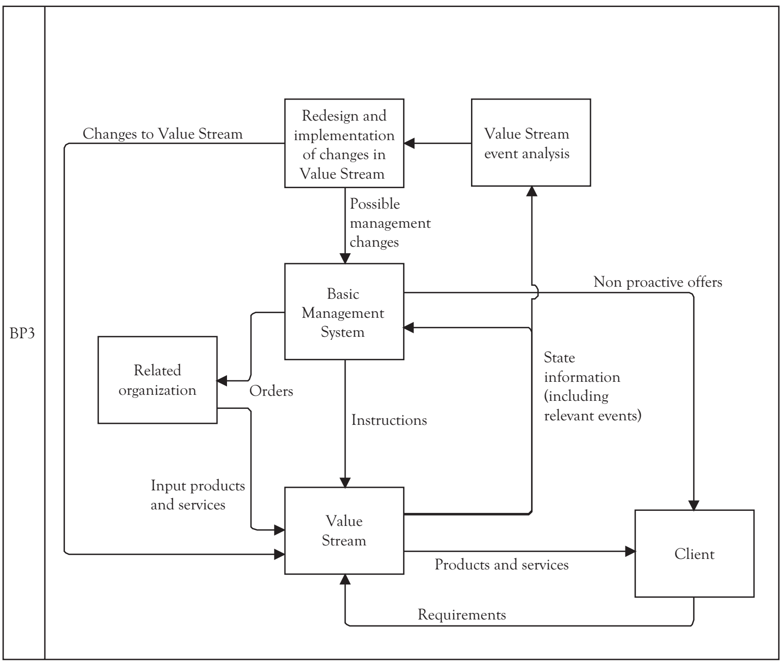


Figure 4.10 Business Pattern 3 (BP3)

discover the most important factors responsible for the generation of such events, and redesign the processes to eliminate their effects; also the analysis of events in the workflow of patients in emergency, ambulatory services, and surgical operations in hospitals to discover events that delay or introduce risk in the treatment of patients to redesign the associated process and eliminate such events; also, the monitoring of software development in an organization that gives services based on such software to discover opportunities for producing software of better quality, on time, and with better use of resources to improve the service to clients. Recently, we found that this pattern is fully applicable to public organizations. For example, one public case concerns the inspection of labor practices that businesses engage in, which is done by a government agency to ensure that businesses comply with labor laws. The application of the pattern generated a change in inspection practices from a mostly random approach to concentrated control on organizations that, through predictive Analytics, have been determined to engage in behaviors that imply probable violation of labor laws, notably increasing the effectiveness of the inspectors to correct situations that harm workers. This case will also be presented in detail in Chapter 5.

A recent case of use of BP3 is the application of DEA, as explained in the section "Business Process Intelligence" of Chapter 3, to 40 public hospitals, which allows to measure efficiency, and based on that, to define in a very precise way how hospital services should change to improve their efficiency;[16] we are also currently calculating the efficiency of academic departments at the Medical Faculty of the University of Chile and finding similar opportunities as in the hospital case.

This pattern covers the possibilities of designing configuration and capacity, use of resources, and operational processes; possible *Intelligence Architectures are I, II, and III*, with simple rules, predictive and optimization models, and analyses with big data. The economic justification of this pattern is the elimination of slack resources or waste due to identification of poor coordination practices behind them, as in the DEA efficiency management cases and the Telco churning prediction presented before.

Business Pattern 4: Performance Evaluation for Replanning and Process Improvement

This pattern assumes:

1. A Strategy of operational effectiveness with well-defined levels of performance by means of Key Process Indicators (KPIs).
2. Creation of value for clients because of assurance of well-performing processes, according to strategic objectives (KPIs), generating products or services that are appreciated by them, such as low cost, due to better efficiency, quality, on-time delivery, and the like; key processes are those related to Strategy development, discovering how to attain the desired KPIs by process redesign and those that implement such redesigns; and key resources are again human resources that are able to innovate on processes, including users who have to adapt to new ways of doing things.

This model builds on projects developed for two software developers, where Strategic Planning was implemented with performance indicators and data collection to measure performance. Based on the analysis of actual performance as compared to desired values, analysis and process redesign made it possible to increase performance due to better process operation. Projects of the same type of Strategic Planning and control for three technological services providers produced similar results.

Other classic case in which this pattern is based is the management by process that Boeing uses for its A&T division, where all processes have well-defined KPIs to measure their performance that are closely controlled.[17]

The Capability necessary in this case is to be able to generate formal strategic plans with a well-defined methodology, such as Balanced Scorecard[18] described in Section "Strategy" of Chapter 3, which provides specific objectives for the operation of the business quantified in values for selected KPIs. Also, another Capability that is needed is to be able to measure actual performance, compare that with the desired KPIs, and then to take action to make changes in the Value Streams to correct the

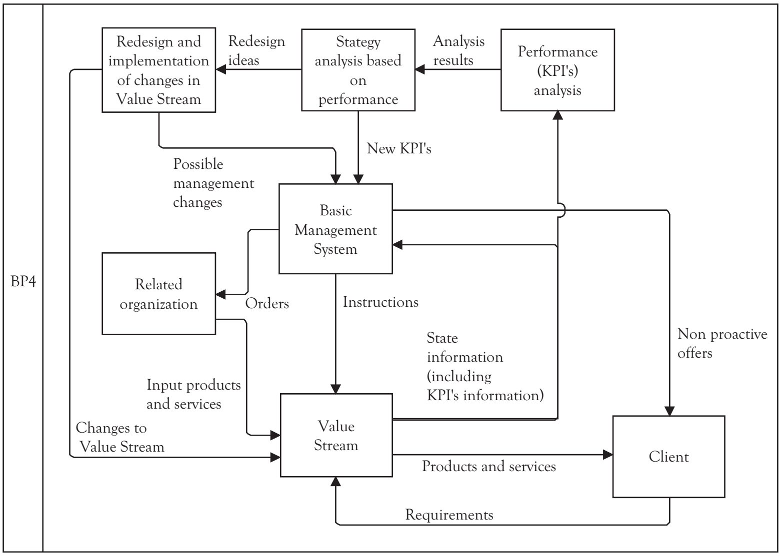


Figure 4.11 Business Pattern 4 (BP4)

situations that hinder the accomplishment of strategic objectives. The pattern that provides these Capabilities is in Figure 4.11, which is called Business Process Pattern 4 (BP4).

This pattern is centered on the analysis and redesign of the operational processes with simple business logic of the *Intelligence Structure I.* It can be justified by an increase in coordination by better practices that produce value by elimination of slack resources associated to non-KPI's compliance.

Business Pattern 5: Product Innovation

This pattern is based on the following objectives from the Strategy and Business Model definitions:

1. The positioning that is selected is the best product according to the definition of Hax and Wilde in the variant of differentiation, so the organization aspires for a product or service that is unique in terms of attributes valued by customers. It may also go in the direction of integral services to customers when the new service is specifically adapted to their needs.

2. The value that is to be generated for clients is related to the product or service characteristics that make a difference for him, such as functionality, ease of use, top technology, and the like. Key processes are related to discovering how to generate more value by a better service or product design and implement such designs; and key resources are human resources that are able to innovate on the design.

The Capability needed for such Strategy and value generation is to be able to systematically analyze the product or service performance, in particular, the Value Streams, to detect opportunities for product improvement. The Business Pattern 5 (BP5) in Figure 4.12 provides a way to implement such Capability, with an emphasis on the use of Analytics to systematically analyze with hard data the origin and possible opportunities for product redesign or for new product generation. Part of this data is internal to the organization, but through the flow "Product use monitoring," including access to social networks, data about

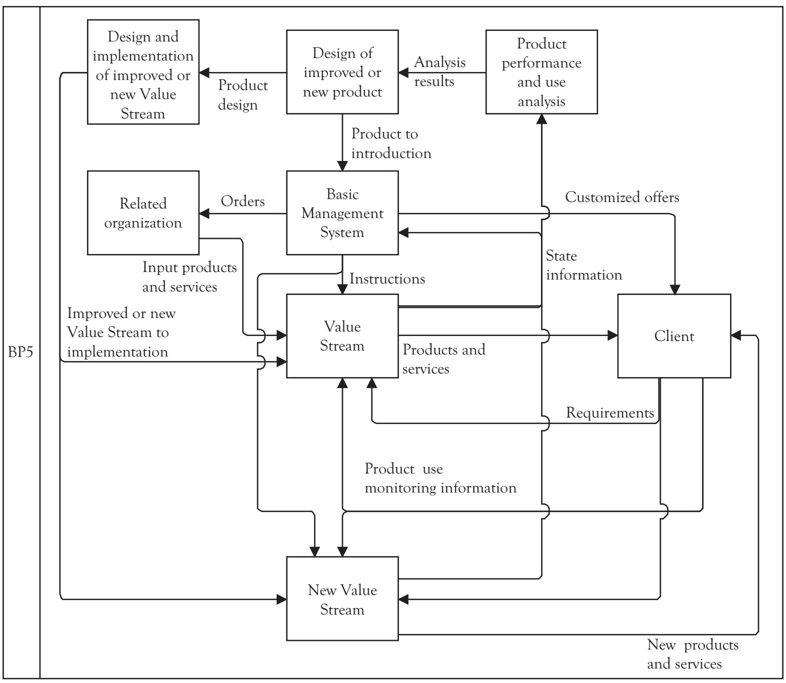


Figure 4.12 Business Pattern 5 (BP5)

customer behavior in connection to the product use and evaluation can be collected. A case in which this pattern is based is the design of a new e-learning education service for high school students, where experience existed in providing customized reinforcement for specific academic topics they have problems with. The business was doing well, but data showed that it was long, hard, and not always successful the generation of contents for a student's specific needs. Then, a formal analysis of the content available, including semantic modeling, showed that a better organization of such content in the line of Modularity allowed to develop a business logic that generated content adapted to the particular needs of a student,[19] similar to the maintenance case of the section "Modularity and Platform Design" of Chapter 3. All the other cases summarized in the same section—municipal services, mental health services, and global logistics services—are examples of the approach proposed by this pattern. Another case in which this pattern is based is a large private hospital, also mentioned before, where the problem solved was to manage the generation of ideas for hospital services innovation; for this, a new Capability was created to assure the generation, evaluation, planning, and implementation of innovative new health services for their clients. This case will be expanded in Chapter 5.

It is clear that, in improving and designing new service or products, to have access to market information about competitive products, available technologies, product needs, and the like are also needed to complement internal information. This is not shown in the model, but, when available, it should be incorporated to enhance the Capability.

A case in which this pattern has been applied concerns a public agency that assigns research and development funds to projects performed by universities and other research entities, which did not have the Capability to monitor projects, evaluate their results, measure effectiveness of the research—hopefully, when possible, in economics terms—and when results were not satisfactory, improve the design of the several Value Streams they have or create new ones. This means, for example, to be able to change criteria for research project evaluation and fund assignment for any stream or redistribute funds among streams in order to increase the effectiveness of funds use; and to create new streams for funding research in new areas of knowledge that are important for the country.

Another case of use of this pattern concerns a Scientific Information Publishing multinational organization, which has decided to convert itself from scientific information producer (Publisher) to generator of high-value research information for their customers: government, funding bodies, and university management. For this, it has created a new Value Stream that is based on the processing of the published research data—academic output in journals, licenses, patents, spinoffs, prizes, awards, and so forth—to produce analytic information and consulting services that help policy making, funding decisions, and, in general, research management in private and public organizations. So, the Strategy is an integral service to customers by generating information and consulting services adapted to their needs for research management. The Business Model is to create value for customers by helping them improve the results of their funding or research. This case will be further developed in Chapter 5.

This pattern aims to business design using *Intelligent Structures II, III, or IV,* since predictive models or complex analyses on internal data or of big data may be necessary to identify new service opportunities. Here, in designing new services and their production in a dynamic way, the ideas of Modularity and Platform Design are applicable, as we will show in the next chapter. The economic justification is of this pattern is the cost of change aiming at customer lock-in, by providing customized services that no other can offer; for example, the publishing case aforementioned.

Business Pattern 6: Optimum Resource Usage

The common aim of the organizations that have motivated this pattern, called Business Pattern 6 (BP6), is to advance to:

1. Strategic positioning in the line of giving the best product in its version of operational effectiveness, summarized in the "Strategy" section of Chapter 3.
2. A Business Model based on providing value to clients by means of excellent service at competitive prices; for this, the key processes are those implemented by the Capabilities that will be discussed later and the resources are mainly professional people who can develop these capabilities.

Real cases on which this pattern is based are the following: a large paper production plant that identified the opportunity to increase output by better production scheduling, using a mathematical model in addition to a manufacturing enterprise resource planning software already implemented, which resulted on $1.2 million additional sales over a test period of five months, which will be detailed in Chapter 5; two large telecommunications firms that optimized the assignment of installation and repair technicians to customers' requirements using a model that allowed to comply with SLA promises and guaranteed good use of technicians' time, generating, among other things, optimal routes to visit clients; and a food processing and distribution company that used models to optimize the assignment to customers of a large selling team that sells to small businesses distributed all over the country, increasing sales by about 20 percent, which will be also presented in Chapter 5. The emblematic case of a company that can be assimilated to this pattern is Walmart, due to the very impressive optimization of all its logistics.

This pattern requires generating Capabilities that allow having the abilities to detect opportunities for better resource usage and the tools to develop models, mathematical or heuristics, to produce optimal use. The pattern, BP6, for this situation is shown in Figure 4.13, where the key idea is to complement typical components that a service has with more advanced and intelligent management elements that define what is required to generate the new Capability.

More detailed applications of this pattern, including optimization models, are presented in the section "Operating Management Processes Design" of Chapter 5.

This pattern aims to configuration and capacity, and resource and operational management design using Intelligent *Structures II or IV,* since predictive models on internal data or complex analyses of big data, and prescriptive mathematical models may be necessary to analyze resources' use and design improved processes that optimize their use. The economic justification of this pattern is an increase in coordination by well-designed practices, based on formal models, that produce value by elimination of slack resources due to their better use.

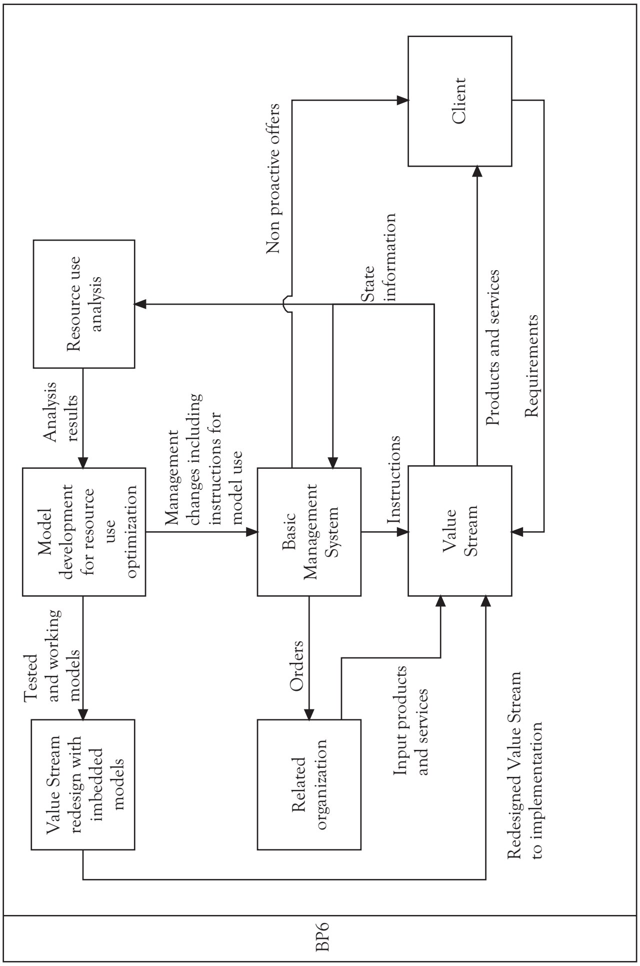


Figure 4.13 Business Pattern 6 (BP6)

Architecture and Business Process Patterns

The Business Patterns of the previous section generate the need to implement the Capabilities they define. What is proposed here is to map these Capabilities into previously developed *Architecture and Business Process Patterns*[20] that can be adapted to any domain in order to model service processes configuration options. So, it will be shown that any design based on the Business Patterns can be converted into corresponding processes design by means of an instantiation or specialization of the Architecture and Business Process Patterns that are presented later. All the patterns are based on extensive experience with process design in hundreds of real cases, and share the idea that there are four aggregations of processes, called macroprocesses, which exist in any organization; they are:

1. *Macroprocess 1 (Macro1) or Value Chain*: Collection of processes for the production of the goods and services the firm offers to its customers, which begins with their requirements formulation and ends with the satisfaction of the requests; it includes all the management and operating activities related to marketing, sales, supply, production, and logistics necessary to capture and generate the service. We call this macroprocess *Value Chain*, adopting a definition slightly different from Porter's that includes other processes in it, such as the development of new products and the management of supporting resources, such as personnel and financial;[21] such processes are included as part of other macroprocesses in this proposal. *Value Streams* are contained within Macro1 (Value Chain), and there may be several of them, explained using cases in the following chapters.
2. *Macroprocess 2 (Macro2) or new Capabilities development*: Collection of processes for the development of new Capabilities that the firm requires to be competitive, such as new products and services, including new Business Models; necessary infrastructure to produce and operate those products, including IT infrastructure; and new

business processes to assure operational effectiveness and value creation for customers, establishing, as a consequence, IT-based systems.

3. *Macroprocess 3 (Macro3) or Business Planning*: It contains the collection of processes that are necessary to define the direction of the organization, in the form of strategies, materialized in plans, programs, and budgets with well-defined objectives.
4. *Macroprocess 4 (Macro4) or support resource management*: Collection of support processes that manage the resources necessary for proper operation of the other macroprocesses. Four versions of these processes can be defined *a priori*: financial resources, human resources, infrastructure, and materials.

These process types are called macroprocesses because they contain many related processes, subprocesses, and activities that are necessary to produce key services, for internal organizational use or external clients, such as those offered to customers, strategic plans, and new facilities.

Recently and independently, several proposals of constructs similar to what we call macroprocesses have been made, which were reviewed in the section "Enterprise Architecture and Design Frameworks" of Chapter 2. For example, the process structure used by HP based on Supply Chain Operations Reference (SCOR) model has the following macroprocesses: Design Chain, similar to Macro2; Business Development, to Macro3; Enabling Processes, to Macro4; and Supply Chain and Customer Chain that together form Macro1.[22] New versions of SCOR also include these new classes of processes.[23] Also, the typology proposed by The Process Classification Framework of APQC[24] can be assimilated to our macros in the following way: what they define as "Develop Vision and Strategy" is similar to Macro3; "Design and Develop Products and Services" is part of Macro2; "Market and Sell Products and Services," "Deliver Products and Services," and "Manage Customer Service" conform to Macro1; and "Management and Support Services" is similar to Macro4.

What our approach and proposals, such as SCOR, APQC, and Enhanced Telecom Operations Map (eTOM),[25] have in common is that they provide reference models and general process structures, in given domains, as a starting point to design the processes for a particular case. The key idea is to formalize knowledge and experience in such models, reuse such knowledge when designing, and avoid reinventing the wheel. However, the main difference between our proposal and other approaches is the relationships among the processes, at different levels of detail allowing to show with more realism and precision how the process model is expected to work in practice.

Process Architecture Patterns

The four macroprocess patterns just presented can be combined into different structures depending on the type of businesses. We call these structures Process Architecture Patterns, modeled in BPMN as explained in Section "Process Modeling" of Chapter 3. The most basic pattern is shown in Figure 4.14, where only one instance of each macroprocess is included, and therefore, there is only one Value Chain; also, the relationships with clients, suppliers, and other entities are not shown in detail. In real complex cases, there may be several Value Chains, each of these containing several Value streams, integration of processes with clients, suppliers, and business partners and other relationships.

All the architecture patterns we define are based on the general structure in Figure 4.14, which shows the interaction of the different macroprocesses with markets, customers, and suppliers by means of information flows and the internal flows, such as "Plans" generated by Macro3 that direct the behavior of the other macroprocesses; "Needs" that request "Resources" to Macro4; flow of "Resources" and feedback flows of "Ideas and Results" to monitor processes and initiate new plans in Macro3, and change in Capabilities in Macro2. All these interactions will be detailed in the cases to be presented in Chapter 5.

Since our patterns model business practice, they must represent different business structures. Here, we define structure types based on the classification developed at the Massachusetts Institute of Technology (MIT),[26] which was summarized in the section "Enterprise Structure and Design Frameworks" of Chapter 2. This classification defines the following business structures: Diversification, Unification, Coordination, and Replication.

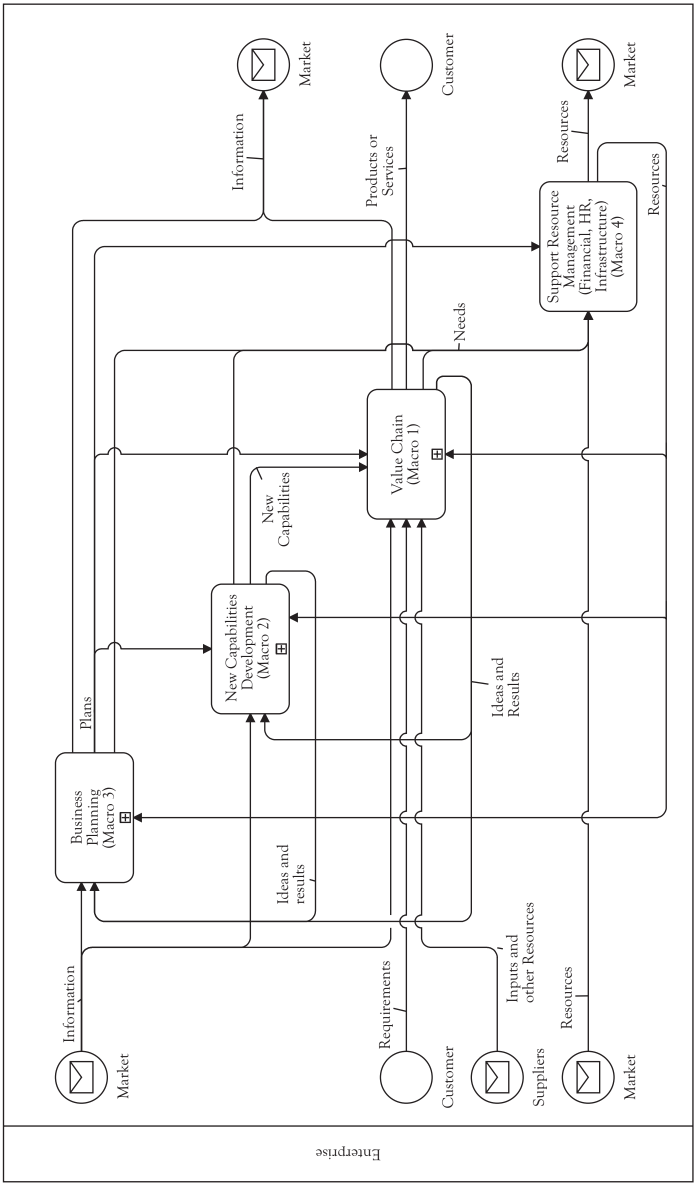


Figure 4.14 Macroprocesses Architecture Pattern

Then, we consider the following architecture types:

1. Businesses with just one Value Chain of the Macro1 type.
2. Businesses with several Value Chains, each of which operates independently (Diversification of MIT's classification).
3. Businesses that have several Value Chains, each of which operates independently, but may share some supporting central services, such as business planning (Macro3), product design (Macro2), and financial, IT, and human resources services (Macro4); they may also use instances of centrally defined processes in their operations (Coordination and Replication of MIT's classification).
4. Businesses that have several Value Chains, which share some of their internal processes—which are common services such as logistics, IT, and supply, some of which may be outsourced—and supporting central services (Unification of MIT's classification).

The Process Architecture Patterns types are shown graphically in Figure 4.15, where we represent, in a simplified way, the structure of the basic pattern of Figure 4.14, which is integrated into such patterns. These types can be mixed to form many other structures, as one architecture pattern that is partially of the Diversification type, but have some business that follow the Unification type.

Each of these structures will have different architecture patterns, some of which are elucidated later. Interestingly, they all can be derived from the basic structure presented at the beginning of this section.

One Process Architecture Pattern to be presented in some detail, as defined in Figure 4.15, is of Unification with shared services that is modeled using some of the constructs of BPMN,[27] which is shown in Figure 4.16. The basic idea of this pattern is to factor out the different Value Chains (i), which generate the services organization offers, several Internal Services (j) that may be centralized because of economies of scale or scope, transaction costs, agency advantages, and other economic reasons.[28] For example, risk analysis for credit authorization for several banking business lines, supply management for several production business lines, and IT support in any business with several product lines. We notice that some of the shared services can be outsourced to suppliers.

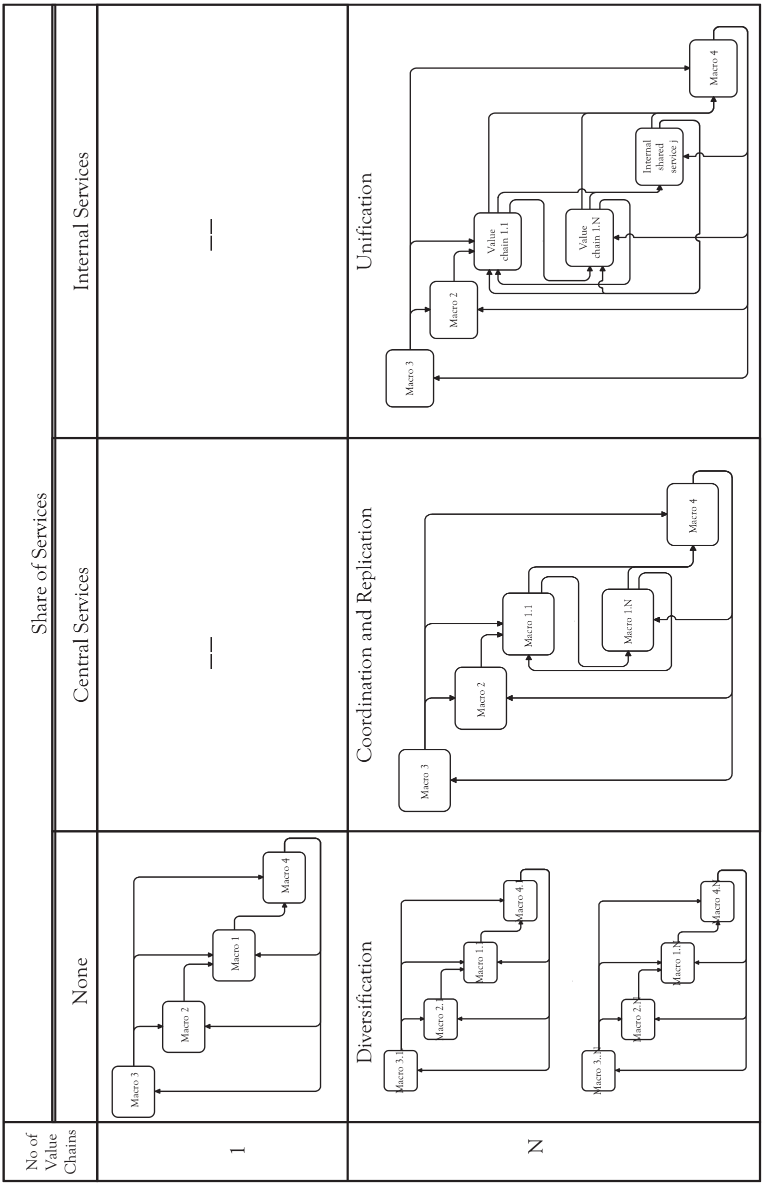


Figure 4.15 Types of Process Architectures

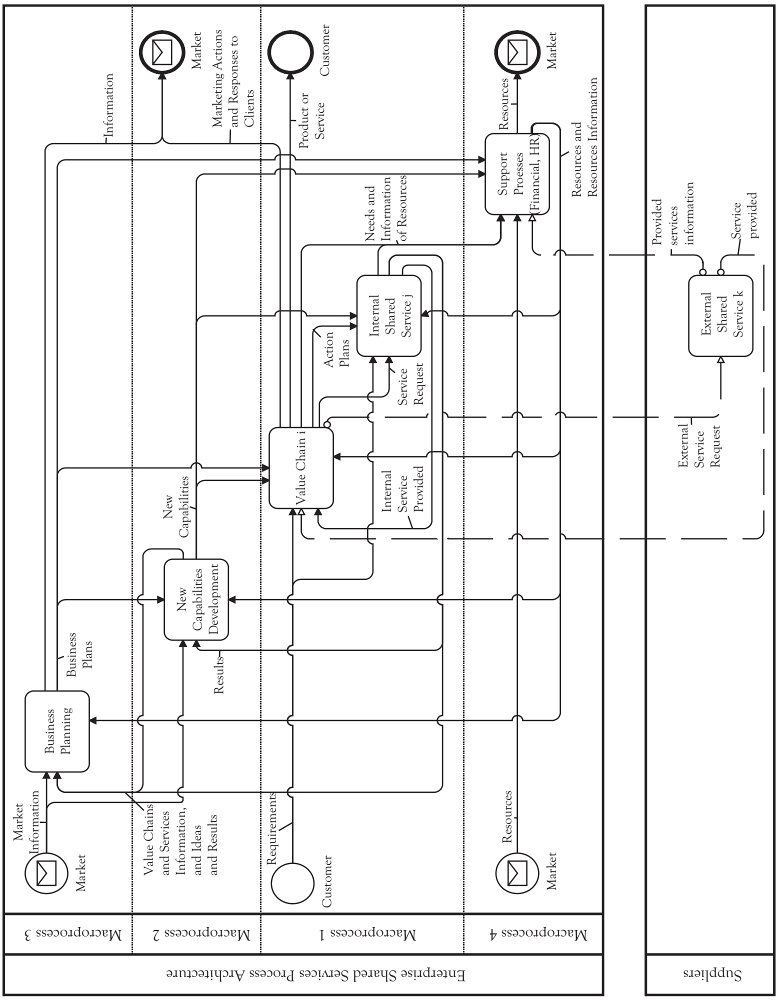


Figure 4.16 Shared services Process Architecture Pattern

Later, in Chapter 5, the application of this architecture to several cases will be presented.

The Process Architecture Patterns proposed are Enterprise Architectures (EA) with emphasis on the dimension of processes, but other architecture dimensions, such as organizational structure and IT (systems, data, and infrastructure) architecture, which were reviewed in the section "Enterprise Architecture and Design Frameworks" of Chapter 2, are present in the proposed structures. Thus, the different architectures of Figure 4.15 obviously imply particular organizational structures as defined by MIT's classification. The dimension of IT architecture is more hidden, but, for example, shared services imply a centralized structure of systems, data, and infrastructure to support the shared services. It implies that the process structure dimension, corresponding to an explicit business design, determines the other dimensions of organization and IT structure, as modeled in Figure 1.1.

We now consider more complex architectures that are necessary to represent designs in situations where there are several business levels, including cases such as holdings with several business lines; large banks with various service models, for example, personal banking, businesses (small, medium and large) banking, investments services, and import or export services; mining complexes, including mines, processing plants, foundries, and services, such as water and electrical production, with several locations; large retail enterprises; public health networks; and the justice system. We have done EA design—in our version—for all these types of business, and from them, we have synthesized our experience in the proposal that follows.

First, we have observed that the situations covered have the following common characteristics:

1. There are several organizational levels that take the form of a central management component—holding management, bank headquarters, mining executive level, retail executive office, public health authorities, and justice authorities—and several structure levels such as holding's companies, divisions, product or service lines, and locations; such levels usually form a sort of hierarchy, with many branches that may be completely independent from each other, but

there are cases in which they interact by exchanging goods, services, and clients.

2. Levels can be managed in a centralized way, in the style of MIT's Unification structure, or with several degrees of decentralization, up to fully decentralized, where lower level units have full control over their business, as in MIT's Diversification structure. This generates one of the most important design decision, which is the degree of centralization of the architecture. The economics behind this decision are based on the agency theory, summarized in Chapter 3, which advises to balance the cost of decentralization, mainly residual loss due to results not according to the principal interests, and cost of all the management machinery necessary to run the business in a centralized way. Modern Business Intelligence we have proposed in the Intelligence Structures in this chapter and advanced Analytics reviewed in the previous chapter, plus ever-decreasing IT cost have made less costly the centralization approach. This makes possible to have structures that have processes with Analytics-based business logic, which are centralized in the sense that they are centrally designed and include optimization criteria considering the principal interests. But, such processes appear as decentralized because they are directly used by operators by means of appropriate Information Systems, who receive instructions or advise from such systems, producing actions according the principal interests. This may be interpreted as a solution that is good for principal and agents, being some sort of best of two worlds.
3. There is a clear difference in managing Strategic Planning and new Capabilities as compared with the operational issues, so they can have different solutions in the design of the structure. Then, in some enterprises, strategic and business development issues may be naturally centralized, but operational management may be more decentralized. For example, our experience with the Chilean Public Health Network is that all investments on new capacity should be centralized in order to assign resources where they produce more social value,[29] but operational health provision in health facilities works best in a decentralized way. But in some cases, where coordination among operational facilities is necessary to produce global optimum

results, as in the case we present later in this section, some operational decisions may be centralized.

The architecture model in Figure 4.17 intents to represent in a general and systemic way the components under design in a multilevel structure, as previously described, and their relationships. The centralization design issue is modeled by the flows between structure levels, represented by lanes in the BPMN convention, which are Enterprise, Division, and Operating Unit. Such flows may go from very precise and detailed plans, programs, and instructions, in the centralized option, to general policies and guidelines in the decentralized alternative. In each level, the basic macroprocesses structure of Figure 4.14 is replicated and instantiated according to the level needs. Each level may have several instances, which are modeled by a generic one: "i" for Divisions and "j" for Operating units. In each level, we do not include the macroprocess "Support Resource Management" for simplification. Some of the key design issues that should be considered in applying this model are as follows:

1. How to distribute "Business Planning" and "New Capabilities development," of Figure 4.17 among levels is an important decision, which, according to the previous discussion, may be naturally centralized in some situations; but in some cases where the Diversification model applies, they can be decentralized. Economic analysis, as outlined before, is a way to decide on this issue. Centralized management of some operations needs to be analyzed, since there may be coordination and share of experience issues among Divisions and Operating units that well-managed, with appropriate Business Intelligence (BI), can generate large benefits, with moderate costs of developing processes and systems needed. The case we present next is an example of the coordination issue. A case of share of experience possibilities is one of the largest copper mining complexes in Chile, where experience of using sophisticated online control of metallurgical processes, with detail measurements of processes state and use of predictive models for action taking over them, was developed for one of the many plants of this type in the complex. The result was a significant increase in the copper recuperated from the mineral

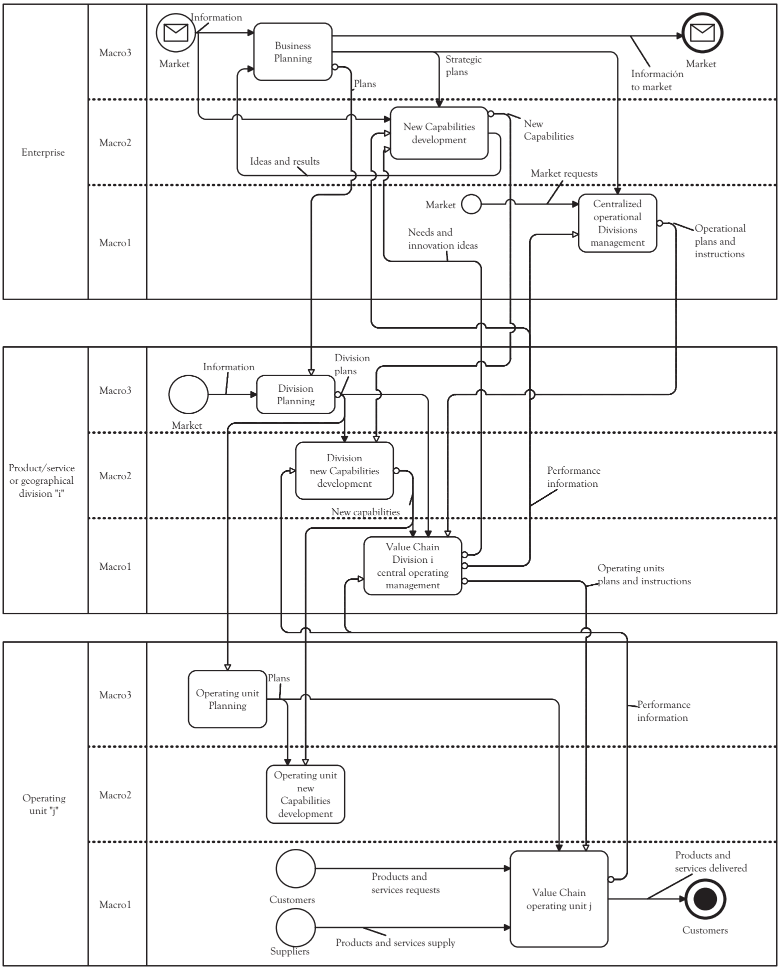


Figure 4.17 Multilevel architecture pattern

processed; then, the same approach was tested in other plants with good results. Given these results, which projected to all the plants mean hundreds of million dollars in net benefit; the control was centralized in facilities common for all the plants, where all of their metallurgical processes are monitored online and actions taken on them.

2. Share of services is another design decision, since there are several services that can be centralized at a high level in the proposed structure. Supply management is one of these, since there are many benefits in its centralization in enterprises that consume similar items. This

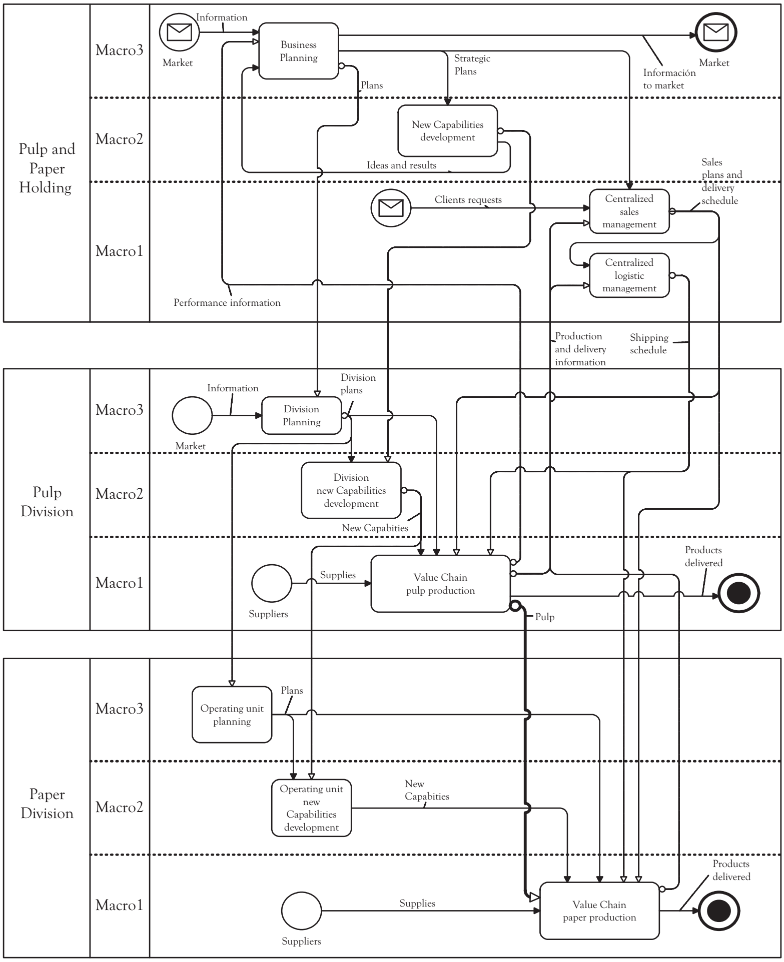


Figure 4.18 Multilevel architecture for a pulp and paper holding

is so because buying a product or service in large volumes for several Divisions and Operating units means better prices and service, possibility of negotiating delivery just-in-time to avoid investment in storage, and eventually, outsourcing of the service to a trusted supplier. A good example of this possibility is Chilecompra, a service that buys for the whole of Chilean public sector, with transactions in the order of nine billion dollars; it provides, among other possibilities, predefined contracts, auction assigned, with suppliers of certain standardized items that define a fixed attractive price and delivery time that any public unit may use.[30] Also, logistic services are a possibility, including outsourcing, where an interesting case is FedEx that offers such services to deliver goods for companies that sell in large quantities to other companies, taking charge of all their outbound logistics.[31] Finally, an obvious candidate for centralization and outsourcing are IT services, an option that has been taken by many enterprises all over the world.

We give an example of use of the pattern to illustrate the issues involved in the design of the architecture in a particular case. This is the real case of a pulp and paper holding, simplified to present what is more relevant in its design. It presents an example of a centralized architecture, where two key processes that correspond to what is "Centralized operational Divisions management" in Figure 4.16 are executed at the holding level; this is shown in Figure 4.18, where all the components of the architecture are included. It is a two-level architecture, where the processes "Centralized sales management" and "Centralized logistic management" direct and support Divisions. For example, sales, which are made for exporting and several months in advance to regular customers, determine which Division will provide what and the schedule of delivery; it also determines the transfer between Divisions, since pulp is needed by "Paper Division" to produce paper. "Centralized logistic management" does shipping scheduling to foreign markets to meet the promised delivery dates. Economic justification of this structure comes from the benefits of centralized coordination and optimization, using appropriate BI supported by IT, to make good use of resources and assure quality service to customers.

Other applications of this pattern are the design of the funds assignment structure of the Chilean Public Health Network based on a DEA analysis[32] and the design of the geographic service structure of the same network, which will be presented in detail in the follow up volume dedicated to health cases.

Business Process Patterns

For each of the macroprocesses contained in the process architectures, detailed Business Process Patterns (BPPs) have been developed that give, in several levels of detail, the processes, subprocesses, and activities that should be executed in order to produce the required product or service. Patterns are normative and include what is recommended as best practices and solutions that have worked in hundreds of projects, as mentioned earlier. So, they formalize knowledge and experience about how a process should be designed, allowing reuse of such patterns, thus avoiding to start from a very expensive "as is" process documentation, proposed by methodologies such as Business Process Management.[33] These patterns include the relationships that should exist among processes, subprocesses, and activities. They have been documented in several books published in Spanish[34] and papers in English for international journals.[35] Hundreds of practical projects have validated such patterns by using them as a starting point for business process redesign. This has allowed their gradual improvement with the experience of more than 10 years of projects. Examples of the use of such patterns will be presented in the following chapters.

Macro1: Value Chain

One of the patterns is *Macro1* of Figure 4.19, also modeled with the first BPMN style, as explained in the section "Process Modeling" of Chapter 3, which is proposed to represent the *Value Chain* of any of the architectures of the previous section.

Next, each process of Macro1 is explained.

"Customer management" includes all the activities of analysis and marketing that are required to induce and to guide the customer to buy; the activities of sales and contacts for services with the client; and the processing of orders, including the decision of feasibility and convenience of accepting them. These details are in the decomposition of Figure 4.20. This type of diagram is very intuitive and could be understood without explanation. Nevertheless, if it is necessary, particularly to express details of business logic, complex flows with many decisions or algorithms, as it is for credit approval, BPMN modeling can be used, as it will be shown in the cases presented in Chapters 5. In this level of detail, the different analytical tools, mentioned in the section "Analytics" of the Chapter 3 that are embedded in the process to detail decision business logic, appear in explicit form; for example, in the detail of "Deciding requirements

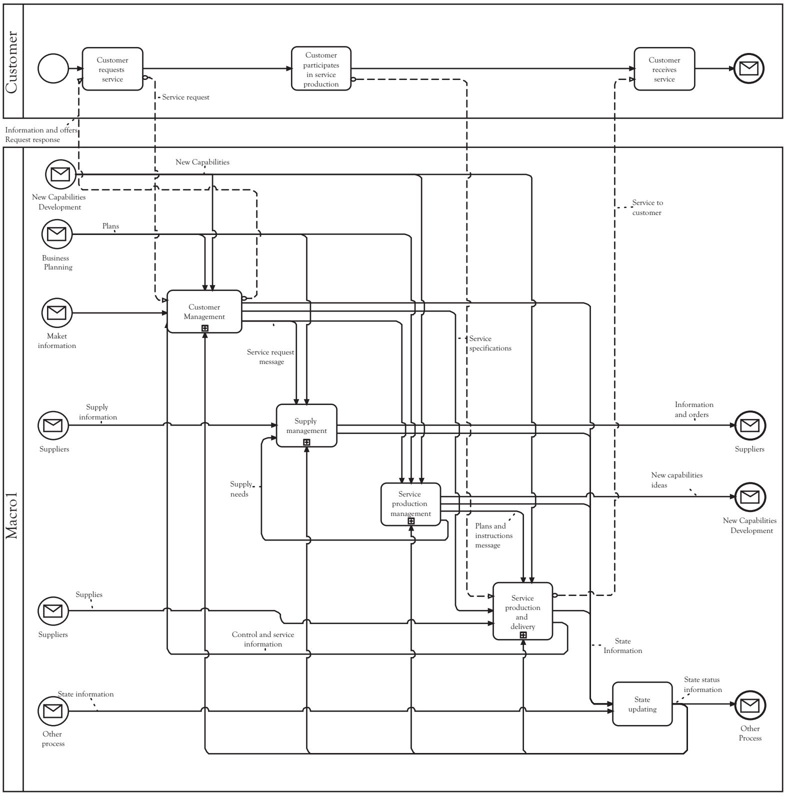


Figure 4.19 BPP for Macro1

satisfaction" of Figure 4.20, rules derived from Data Mining analysis of customer data can be used to evaluate client risk and decide to process a requirement. One particular situation in this process occurs when the customer is involved in the definition and specification of the required service in the idea of cocreation; traditional cases of this type are professional, legal, and engineering services, in which what will be provided is defined by a Services Executive and the customer in "selling and customer request processing" and "deciding requirements satisfaction" of Figure 4.20, where the level of service and price are negotiated. Other similar cases are investment services customized for the client and many other situations in which, as a Strategy, the customer or a supplier gets involved in what McKinsey calls distributed cocreation in an extended company; an example of this is Loncin, a Chinese manufacturer of motorcycles that

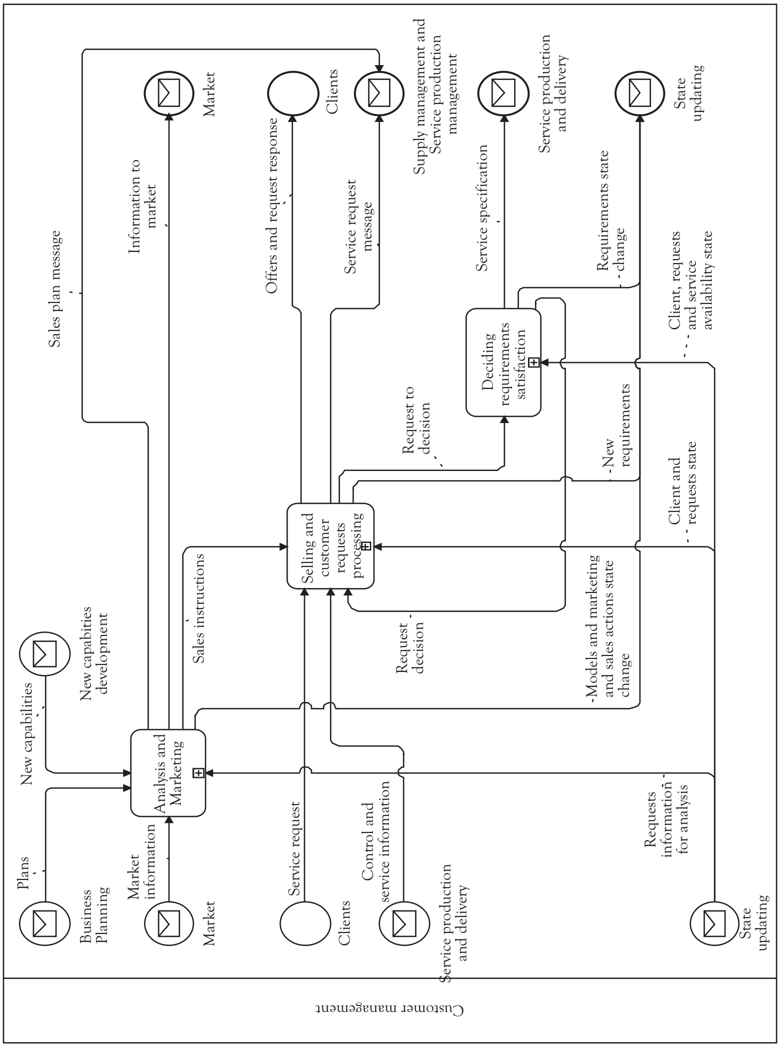


Figure 4.20 Decomposition of customer management

generates only general specifications of its products and leaves its suppliers to do the detailed designs of the components, collaborating among them.[36] This is much different from the outsourcing of activities of a business, in which the outsourcer defines the service in detail. A variation of the cocreation idea is to use the clients as innovators, like a newspaper in Korea that is written by its clients, LEGO that has invited its clients to propose new designs and rewarded those who did well in the market, and Threadless that offers shirtsleeves designed by its clients.[37]

Further decomposition to give more design details for "Customer management" is shown in Figure 4.21 for "Analysis and Marketing" of Figure 4.20, where the typical process of analytical "Knowledge Discovery and Data Mining" (KDD), explained in Chapter 3, is shown as "Customer and sales analysis," inserted in a process that intends to generate customers' characterizations that allow predicting their behavior to feed risk analysis, marketing campaigns, and sales planning. When there is complex Analytics included in the execution of a process, as the ones just exemplified, we speak, as stated before, of a business logic that specifies the way in which the process will be performed with the analytical support. These ideas will be exemplified with cases in the following chapter.

In Macro1 of Figure 4.19, "*Supply management*" relates to the determination of the supply requirements; to find the adequate suppliers for each one of them; the planning and programming of the deliveries, including inventory management; and to control such that the requirements are correctly satisfied. Relevant Analytics to be considered within the process in this case are inventory optimizations models, supplier's evaluation models, and logistics models.

"Service production management" makes the required planning, programming, and control for the generation of products or services, including the analysis of demand, the planning of capacity, and the logistics of distribution, as shown in the decomposition of Figure 4.22. The same can be done with the subprocesses of this figure; for example, "Demand analysis and management" is decomposed in Figure 4.23. Analytics is present in this figure with forecasting models in "Demand forecasting and characterization" and mathematical and simulation models for capacity analysis and planning; examples of use of these techniques will be given in the following chapter.

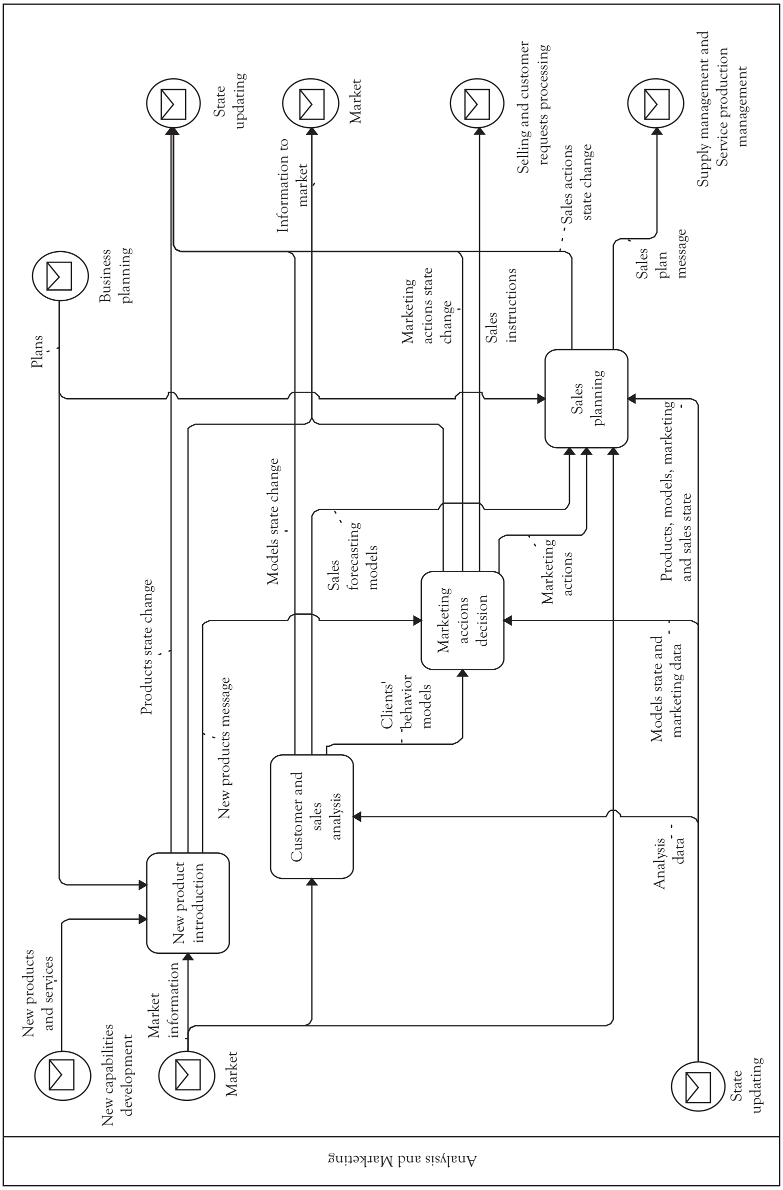


Figure 4.21 Decomposition of analysis and marketing

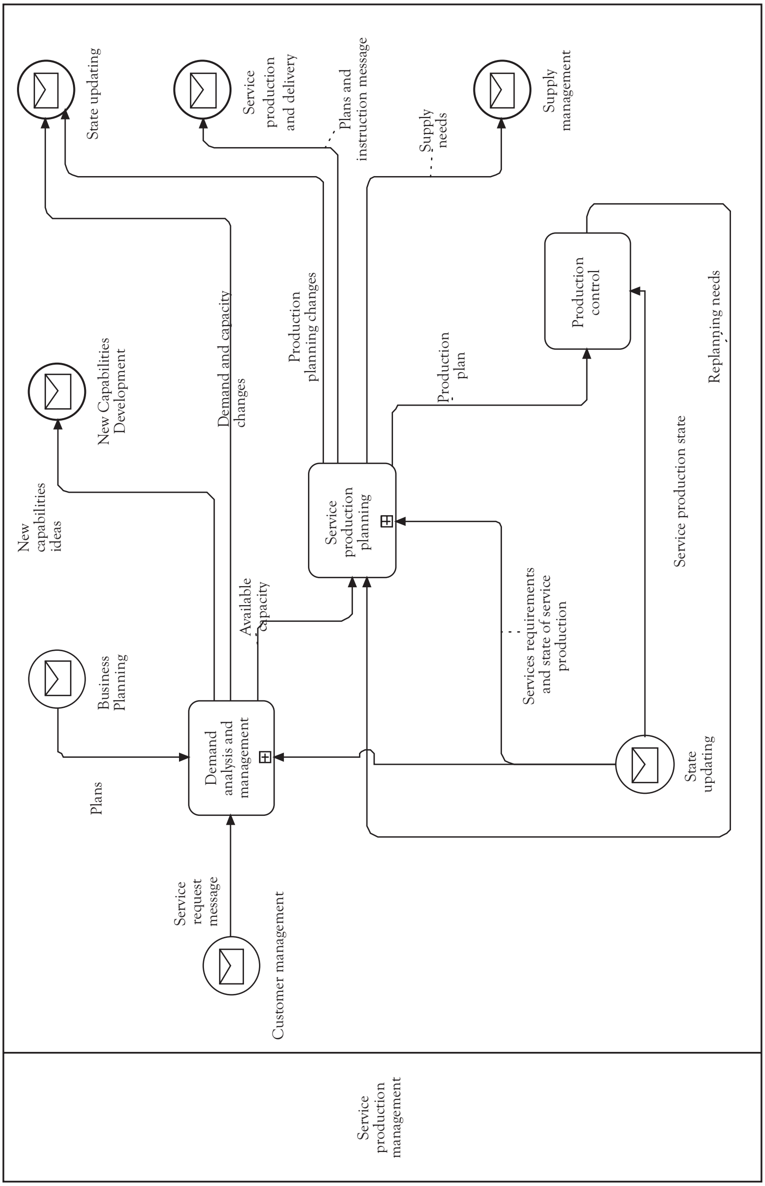


Figure 4.22 Decomposition of service production management

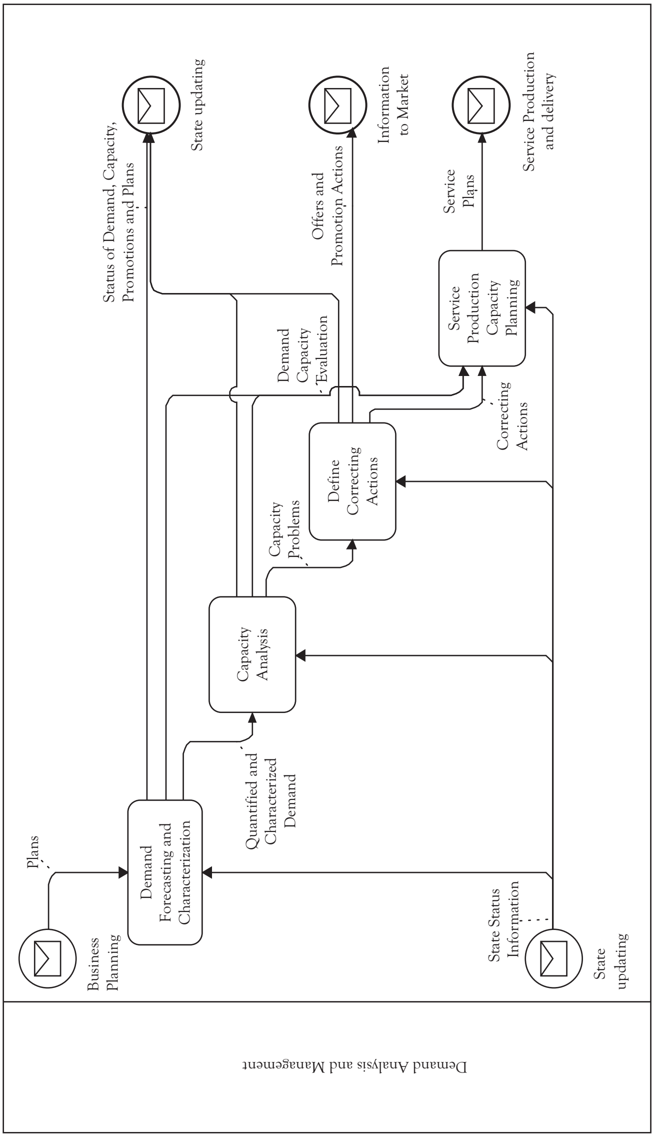


Figure 4.23 ***Decomposition of demand analysis and management***

"Service production and delivery" in Figure 4.19 puts into practice the plans and programs of the previous processes, performing the physical activities of generation and distribution of services or products; for example, product manufacture, development of software, execution of consultancy activities, treatments of patients in a hospital, and operation of telecommunications networks. Here, in some cases, the client is involved in the process, as explained before; for example, as patients in a hospital or as in legal services delivery, appearing another facet of the idea of service cocreation.

In Figure 4.19, *"State updating"* includes all the data-processing activities, and also databases, that enable updating of the relevant states of the entities involved in the processes. Then, the activities that are executed in such processes have access to all the required information to execute the business logics they perform. In particular, all the information required to run the supporting analytical models must be available. In other words, the business logic defines the information-processing requirements that "State updating" should satisfy. This is represented in Macro1, Figure 4.19, by the flows of the type "State information" that go from each process to "State updating," allowing to store the data needed by the processes. Also, there are flows back from "State updating" of the type "State status information" to each process that represent the information required by each of them. In the decompositions of Macro1 in Figures 4.20 to 4.23, they are made explicit by flows from each process or subprocess to "State updating" and by flows feeding each of them coming from the same "State updating."

"State updating" appears in all the macros described later and plays a similar role as in Macro1, so, we will not repeat the explanation of its participation in such macros. We only should add that all the "State updating" components of the different macros allow generating information flows for interactions of the type presented in the architecture of Figure 4.14, by sharing their contents.

The previous diagrams emphasize what we indicated previously: participant processes, activities and their relations, avoiding strict sequence, and control logic, that is, it is an asynchronous representation. In this modality, the most important idea is to model how the processes and activities are coordinated through information flows to fulfill the global objectives of a macroprocess. For example, in Figure 4.19, the flow "Service request message" and "Service specifications," with the cooperation of the "State information" and "State status information" flows, make possible that the processes "Supply management," "Service production management," and "Service production and delivery" know what the customer wants and when, so that they can take coordinated actions to plan and execute the activities to get supplies, execute the service, and deliver it satisfactorily. Figure 4.21 is another example in which the subprocess "Customer and sales analysis" provides, through "Client's behavior models," information about future demand, clients' predicted behavior and recommendations for new offers and new services, which will allow "Marketing actions decision" and "Sales planning" to define actions and plans based on hard data to coordinate the work of sales people in "Selling and customer request processing" and in "Deciding satisfaction of requirements," of Figure 4.20, to get the best of their efforts. These coordination ideas will be further illustrated with several cases in the next chapter.

Macro2: New Capabilities Development

Another macroprocess is *New Capabilities Development (Macro2),* which is detailed in Figure 4.24. This pattern is intimately related to the creation of Capabilities of innovation within a company. This can be expressed in several levels.

First, the most obvious innovation concerns the material elements that improve the Capability of the company to compete in the market, such as new products and services, additional or renewed infrastructure, new information systems and IT in the form of new equipment, networks, and software. In some cases, all these elements can be provided in a coordinated way within a large innovation project; for example, a new product that requires infrastructure as a new plant with computing technology to control the productive processes and a new management system.

A second type of innovation that can be superposed on the previous one and is more general consists of creating Capabilities of management by process, including the organizational structure. This includes a methodology, like the one presented in this book, to develop a process that

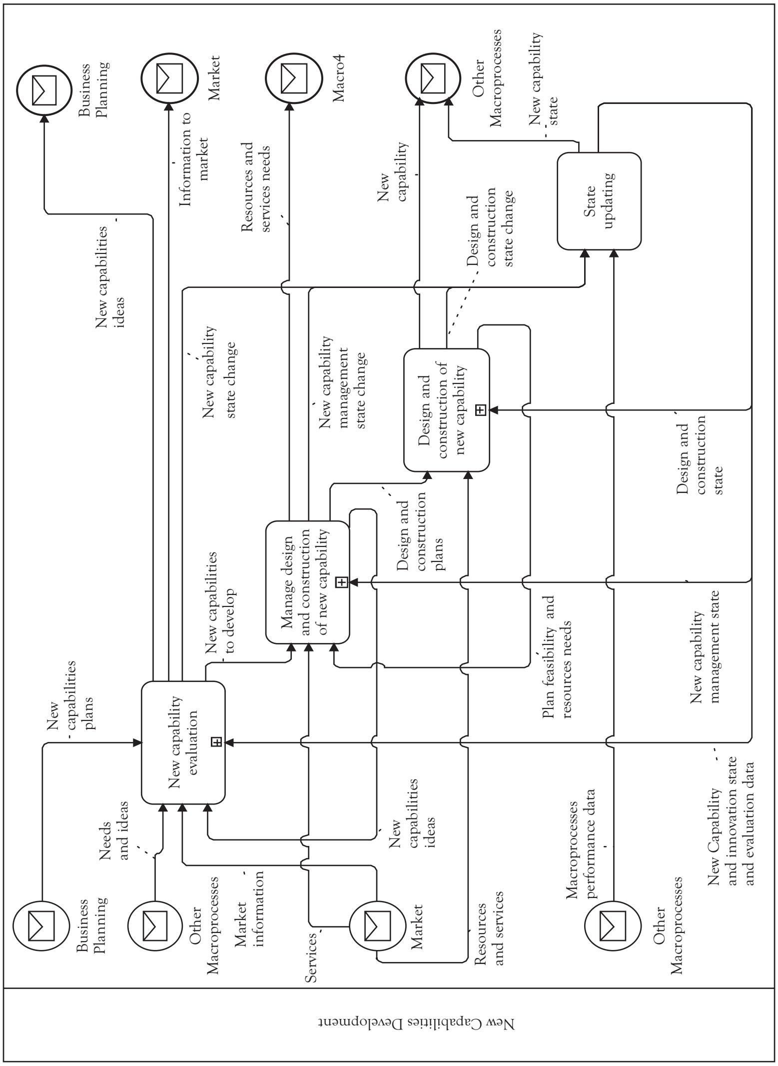


Figure 4.24 New Capabilities Development (Macro2) pattern

designs processes. That is, we must have the permanent Capability to develop instances of new macroprocesses of types 1, 3, and 4, in addition to the Capability to develop new processes to generate the material elements mentioned in the previous paragraph. This concerns the traditional idea of continuous improvement, but with a more innovative structural and systemic emphasis. Evidently, here there is a recursive approach, already mentioned, in which everything that we design in the different macroprocesses can be possibly changed in the future by scrutinizing its performance with a process that designs processes, and from such scrutiny, generates the changes. This is related to BP3, and we will provide examples of designs that implement this idea in Chapter 5.

The last level of improvement of Capabilities is still more ambitious, since it tries to develop general abilities of innovation applicable to any of the previously enumerated Capabilities. In other words, it is a process of creating innovations applicable to any particular process of new Capability development. For example, IBM has developed a process that encourages employee participation in the generation of innovative ideas, which later initiate specific projects of development of new Capabilities. Other examples are the innovation methodologies of General Motors with their approach CENCOR (Calibrate, Explores, Create, Organize, and Realize) and Mayo Clinic with SPARC (See, Plan, Act, Refine, and Communicate).[38]

This link between new Capabilities and innovation necessitates a strong relationship between this macroprocess and Macro3, since such innovations must be communicated to and be aligned with the Strategy of the organization.

Since the development of new Capabilities is done by means of projects, Macro2 has the typical processes for the management and execution of projects, in addition to the support of "State updating" to determine and to communicate the situation of the activities of the projects to the other processes of Macro2. The processes of this macro are in the model of Figure 4.24 and operate as follows:

"New capability evaluation" is, in a basic version, the analysis of the information that motivates and justifies an innovation project and the formal economic evaluation to decide its implementation. For example, to make a market study and to calculate an economic index associated

with the investment for the development of a new product; to analyze indicators of performance of the processes of the supply chain—for example, complaints, times of delivery, losses, and costs—to determine if a redesign is necessary, and to calculate economic indicators to justify such redesign; and to evaluate proposals of new infrastructure to determine its operational and technical feasibility. It may also include more creative efforts to improve a business by means of innovation capacities; this has to do with formal processes, like the ones exemplified in this same point (CENCOR and SPARC), which try to generate, in a systematic way, new Capabilities in new products and services, new technology in the production processes, new Business Models and corresponding processes.

"Management of design and construction of new capability" executes the subprocesses and activities necessary to determine the essential resources for the project, obtains and assigns such resources, and generates a plan for the project. For example, it determines that, for the development of a new product, a prototype must be constructed, assigns personnel with the required abilities to a work group that develops such prototype, and provides an action plan; and, for a redesign project, determines the required professionals and assigns it to them, besides providing a work plan for such project.

"Design and construction of new capacity" executes the allocations and the plans originated in the management processes, carrying out the necessary activities. For example, making the design and construction of a prototype according to a plan; performing the redesign of a process according to a work program; and designing and constructing new infrastructure following a plan.

The processes of Macro2 can be decomposed as for Macro1, arriving to the detail level in which better practices can be recommended, for example, for evaluation, planning, and programming of projects. The decomposition of Macro2 is illustrated with the detail of "New capability evaluation," which, as shown in Figure 4.25, has two subprocesses.

"New Capability analysis" is centered on using all the operational information that is generated in Macro1 and Macro4 and attending to the suggestions from them. Such information relates to indications that suggest improvements in the operation of the processes of an organization. A concrete example of this idea is looking at the information of

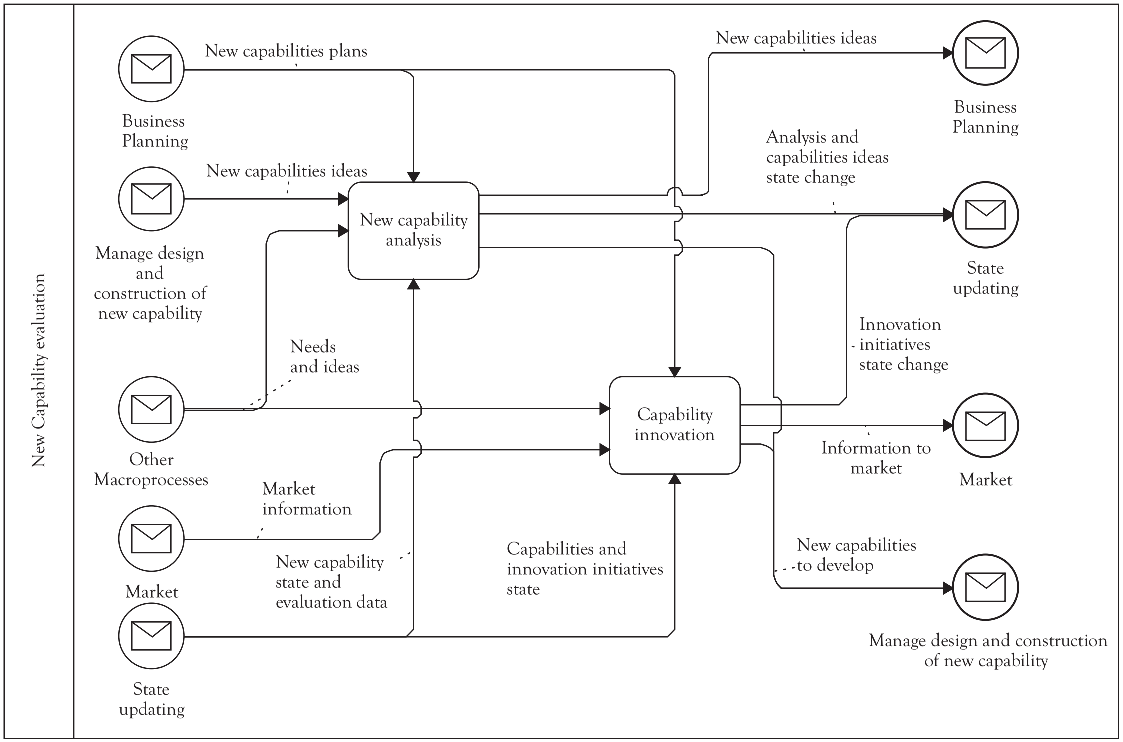


Figure 4.25 Decomposition of new capability evaluation

operational risk events that mean an economic loss for an organization, which gives clues on where and why those events happen, and indicates the necessity to generate process-improvement projects that mitigate or eliminate them; this idea was implemented in projects for two banks. Other examples of these type of information are client's complaints, problems of quality in products and services, and nonconformity in metrics such as sales quotas, percentage of products delivered at a promised date, and supply availability. The analysis of this information originates ideas of process redesign projects that must be evaluated for possible execution.

"Capability innovation" includes formal processes, like CENCOR and SPARC, which try to generate new Capabilities of various types in a systematic way: new products and services, new technology in the productive processes, new Businesses Models, and corresponding processes.

Again, in this pattern, there are clear coordination flows, as "New capabilities to develop" that determine which Capability is to be designed and built by the other processes of Figure 4.24; and the flow "New capabilities ideas" coming from "Management of design and construction of new capability" that feeds back experience from the people building the capabilities that can contribute to improve innovation.

Macro3: Business Planning

Macro3 is presented in Figure 4.26, where the component processes are "Define Vision, Mission, and Positioning," "Strategy development management," "Strategy development," and "State updating."

The process *"Define Vision, Mission and Positioning*" works with the information about political aspects, economic tendencies, technological developments, regulation factors, and similar; based on such information, it explores the opportunities of innovation in the business and defines the Vision, or the desired future state of the company, proposes goals and objectives (expected results), and develops an evaluation model to measure results with appropriate indicators. Also, the strategic positioning in the concepts of Porter, and Hax and Wilde should be defined, as reviewed in Chapter 3.

"*Strategy development management"* has two main subprocesses: one that produces the "Strategy development Plan" and another of evaluation

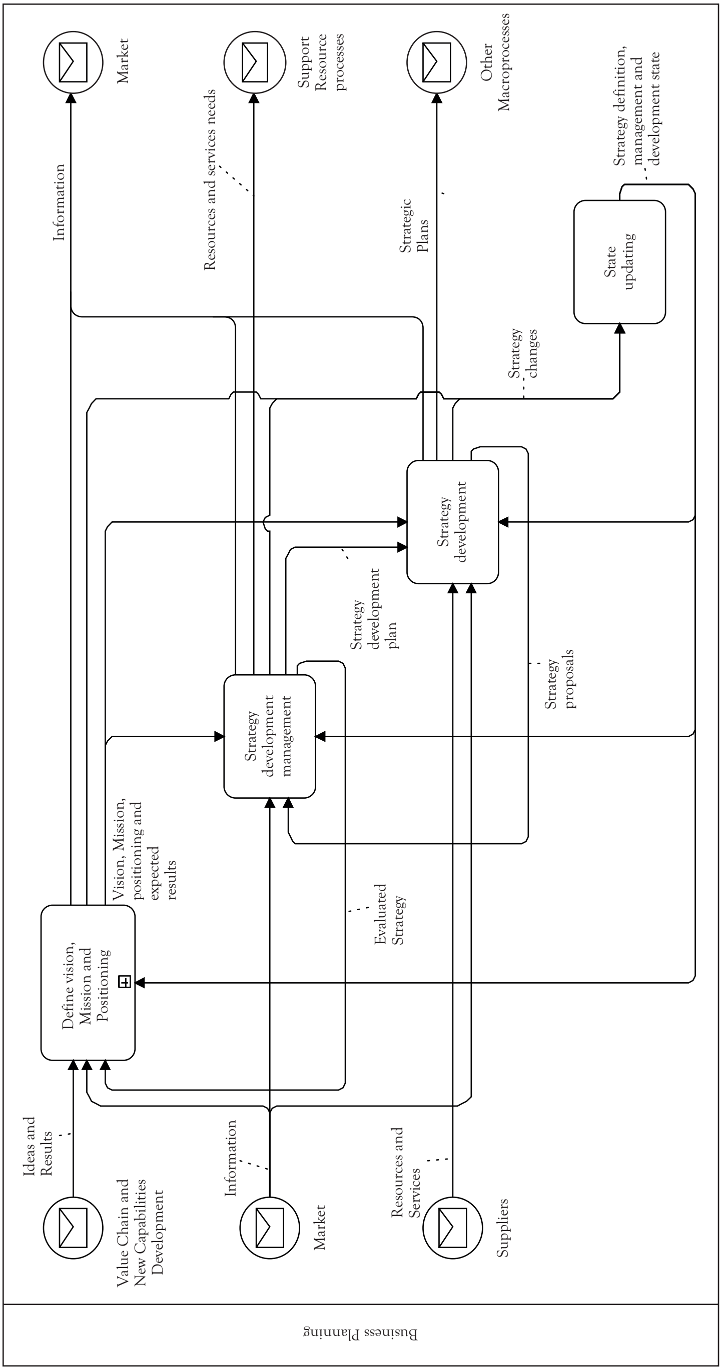


Figure 4.26 ***Business Planning (Macro3) pattern***

of Strategy proposals, which considers new strategies generated by this subprocess and the actual performance of the strategies that have already been implemented, and generates the flow "Evaluated Strategy." "Strategy development Plan" includes the allocation of the human, financial, and other resources necessary for the development of the strategy or its adjustment, and the preparation of programs to execute the planning work. The Strategy evaluation has a purpose to assure that Strategy proposals are aligned with the Vision of the company, and that there are suitable metrics to measure its performance. In addition, it measures the performance of the strategies already implemented, which is established by means of comparing the metrics' current values with the goals, for which information from the other macroprocesses through "State updating," mainly from Macro1, is used. Clearly, these evaluations may trigger improved plans to guide the work of "Strategy development."

"Strategy development" has, among other tasks: (a) to define the Mission of the company that makes the Vision operative; (b) to generate and to evaluate strategic options for current or new businesses, including Business Models; (c) to define the organizational structure; (d) to transform strategies and other courses of action into detailed plans and programs, including budgets, and performance metrics for the activities to be executed by the other macroprocesses; and (e) to adjust strategies based on the macroprocesses performance under the direction of "Strategy development management." One of the most important tasks in this list is the generation and evaluation of strategic options, since they determine the competitive advantages of a company. Here, the ideas presented in Chapter 3 prove useful.

Macro4: Support Resource Management

The last pattern is *Macro4: Support Resource Management*. This applies to any resource the organization uses, and different instances of this macro can be developed for each of them. The processes involved, shown in Figure 4.27, are described as follows.

"Obtain resource," which relates to the needs determination and execution of actions to obtain resources such as personnel, machinery, financial, spare parts, supplies, and others of the same type; then, its purpose is to

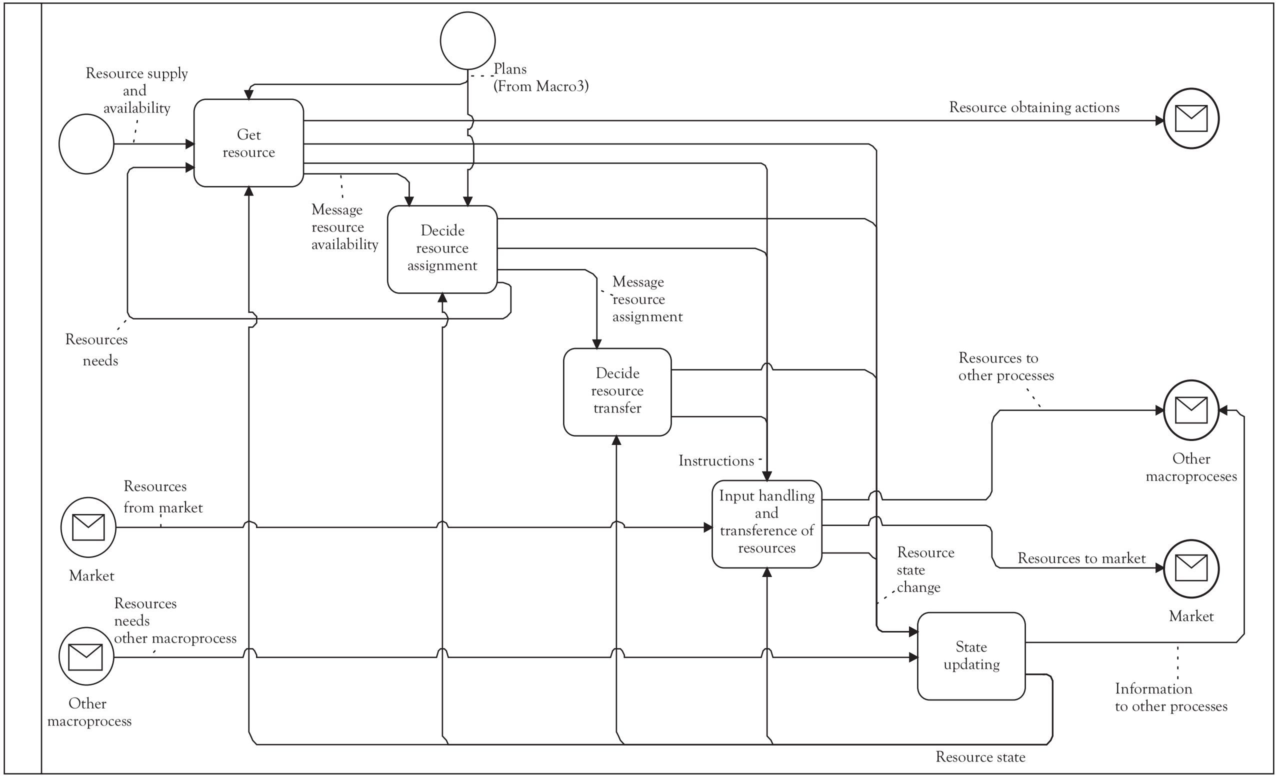


Figure 4.27 Support Resource Management (Macro4) pattern

estimate the resources and organization needs and to assure that these are provided, deciding, for example, to contract people, to request financing, to acquire new equipment, and to outsource the provision of supplies.

"Decide resource handling" that assigns the available resources to the requirements of other macroprocesses, such as new contracted employees to units of the business, computers to employees who require them, office space to new business units, and budgets to units of the business. Also, it includes the decisions about actions on the resources that improve their capacities, such as employee's training, equipment maintenance, money investment, and the like.

"Decide resource transfer" that determines which resources must be sent outside the company, such as obsolete equipment, money to be paid to suppliers, invested money, transferred or fired employees, and surplus supplies.

"Input, handling, and transference of resources," which executes the typical handling of resources, such as incoming by means of, for example, contracting personnel, receiving and storing equipment, supplies and receiving money from clients; application of resources to different uses, for example, giving a specific position to a contracted employee, to train personnel, to maintain equipment, to invest money, and to give computers to the people who have been assigned them; and transference of such resources outside the business by means of, for example, the sale of obsolete or surplus equipment, to pay to suppliers, to transfer invested money to the financial institutions, and to fire or transfer personnel.

Macro4 has several more levels of detail that show its subprocesses and activities, which can be seen in Barros.[39]

We observe that an important feature of our BPPs is the specification of the relations that must exist between processes, subprocesses, and activities. In the case of Macro4, in Figure 4.27, it is clear that control flows such as "Message resource availability," "Message resource assignment," and "Instructions" provide the necessary coordination between processes. This is reinforced by "Resource state change" that provides information about resources status to "State updating," which feeds back such a state to each one of the processes. Also, it is clear that there are flows that coordinate Macro4 with other processes, such as "Resources need from other macroprocesses," "Plans," and "Resources to other processes."

CHAPTER 5

Design of Service Offerings: Methodology and Cases

We first conceptualize the service design problem, using the design levels given in the first chapter of this work and propose a methodology that integrate all the disciplines reviewed in Chapter 3 and uses the Design Framework proposed in Chapter 4. Then, we illustrate the use of the methodology with cases that cover all the design levels.

Design Levels

We defined the following hierarchy of design levels in Chapter 1:

i. *Business service design* that delivers the structure of components of the service—production, management, supporting, and others—and their relationships, together with the interaction with the environment that generates a business Capability, which provides value to customers according to a Strategy and Business Model. It represents *what the business does* and does not yet map to organizational units, area, or product. For example, the case of the private hospital we have presented shows that the Business Model of leading on medical treatments and technology requires new Capabilities in the form of new activities that discover and manage innovations of this type. Analytics may have an important role at this level when there are customer data, both internal and external big data, which can be used to develop new services, as presented in the case of the financial credit card data-processing organization, which has used such data to model customer behavior to discover new business opportunities for the banks it serves.

ii. *Business service configuration and capacity design,* which includes, when necessary, the detail *design of the service and its production* *process*, as will be exemplified with cases in following sections; it also covers the identification of the management processes that should be present to assure that the service is provided in an effective and efficient way; and also the determination of what capacity each process should provide in order to be able to attend the demand according to desired Service Level Agreements (SLAs). This level is based on a Process Architecture design. This design has two versions: the first is when there is a one-time redesign of the service, and due to the dynamics of the market, it is not expected to change in the short time. The other case is when, due to demand behavior changes or possible frequent innovations in service technology, it is necessary to continuously redesign the service and its production and management processes; this means that another level of processes is required, designed to produce service designs (design for producing designs recursively), which provides a *continuous Capability* for doing this, generating innovations *required to keep the service competitive*. In this level, ideas coming from Modularity, Platform Design, and Case Management are relevant to design the service components that should be present in a given situation, and the examples given when we discussed these approaches, particularly health services, show the power of being able to continuously adapt the service to customers needs. Analytics can also be used here to model demand and determine optimal capacity.

iii. *Resource management process design,* that is, people, equipment, and supplies that are necessary *to provide the capacity established in (ii).* For example, in hospitals, the number of doctors of different specialties who will work in each shift. This requires well-designed processes that, based on the forecasted demand, plans and assigns resources in such a way that capacity is dynamically provided at the minimum cost. Such processes are executed regularly with a frequency that depends on the dynamics of the demand. Analytics is relevant here to optimize capacity available.

iv. *Operating management processes design,* which are necessary for the day-to-day scheduling of the demand over the resources in order to provide the required level of service and optimize their use. For example, in public hospitals, there are usually waiting lists of surgery patients that should be scheduled in operating rooms in such a way that priorities associated to the severity of the patients' illnesses is met and use of facilities is maximized. Analytics is relevant here to optimize resource use.

This can be interpreted *as a hierarchical top-down approach,* where business components *are progressively designed in increasing* levels of detail, always starting with previously defined components and processes. In an ideal world, this assures a systemic, consistent, and efficient *global business design*. However, it is not necessary to do it all at once; the advantage of a top-down approach is that, once upper levels of design are performed, detail design may proceed with selected components of global design, as it will be shown in the examples to be presented in the following paragraphs.

Alternatively, one may take any lower level of design, ii to iv, without having a global business design, as defined earlier, and proceed with a design at such level, accepting what will not be designed as given and determined by previous decisions on how they are structured and performed. We will call this a *local design* case. This situation arises when priority, timing, resources, and other restrictions do not make viable a more systemic approach. All that will be proposed for these levels is applicable independently of not having made the design of the previous levels.

We will present cases of both of the preceding approaches in following sections.

It is important to notice that design levels i and ii may be executed just one time to generate a new business design, configuration, and capacity, which will get implemented, possibly, with new resource management and operating processes that execute the new business design. On the other hand, levels i and ii can generate new processes for producing designs that are routinely executed when the dynamics of the business require continuous innovation, as exemplified in some cases before and that will be present in more cases in what follows.

Methodology

Based on the ideas in the previous section, our proposal for service design is as follows.

At the outset, we assume that the business under design is looking for innovations in their services to make it more competitive, which may imply going from increasing its productivity to changing in a fundamental way the offer and value to clients or to provide entirely new services. To accomplish this, we define the following steps, not necessarily sequentially implemented:

1. Start with an innovative Strategy and Business Model.
2. Derive the need for new Capabilities to implement the Business Model; this implies defining new practices over existing activities or new activities that are created for this purpose. For example, new BI practices to develop customers' predictive models to be able to make service offers adapted to their needs.
3. The business is designed to include such Capabilities using Business Patterns, presented in Chapter 4; the design defines how the new Capabilities are inserted into the current business structure or form a new structure. This may require the redefinition of the service itself; for example, the case of a financial information processing organization that has one Value Stream executing a traditional model of mechanical credit card transaction processing for banks with low added value, which has decided to implement another Value Stream that makes proactive offers related to credit cards to banks' customers, based on BI predictive models developed with the transaction data, generating a high value for them; this case will be further developed later. This step covers *level i* design, as defined in the previous section.
4. Process Architecture designs are generated, including configuration and capacity of its components; they should be aligned with the aforementioned, possibly including additional detail design of the service as well as its production processes, as will be exemplified in next sections. For example, hospitals' emergency services may have different configurations in terms of its processes: among others use of a Triage (patient classification), a fast track line, and several different lines of service; once components are determined, enough capacity has to be provided in order to have a desired patient average waiting time. This step covers *level ii* design, as defined in the previous section.

5. Detail design that makes operational the architecture of the previous step is performed, including processes that manage the resources required to provide the service efficiently and with adequate quality. Also, the operations management processes are designed. It covers design *levels iii and iv*.

These ideas are summarized in the conceptual model of Figure 5.1.

Figure 5.1 shows the components of the Design Framework in Chapter 4 that support each of the steps of the Methodology. In the cases we will present in the following sections, we will show how they are applied in producing a design. In their application, we will use the logic and set of rules that follows.

First we consider how to determine the Capabilities and the Business Pattern that are required according to Strategy and Business Model. For the Capabilities, we only provide a guide, considering certain typical situations that illustrate the line of reasoning that should be applied. Most frequent cases of Strategy we have found consider the positioning of Best Product, with variants of Operational Effectiveness and Differentiation, and Integral Solutions to Clients with variants of Redefining Clients' Relationship and Integration with Clients,[1] as defined in the section "Strategy" of Chapter 3.

With the positioning of Operational Effectiveness, the emphasis is on price competition with services that are usually a commodity; so, the value provided to customers is mainly low price, with quality according

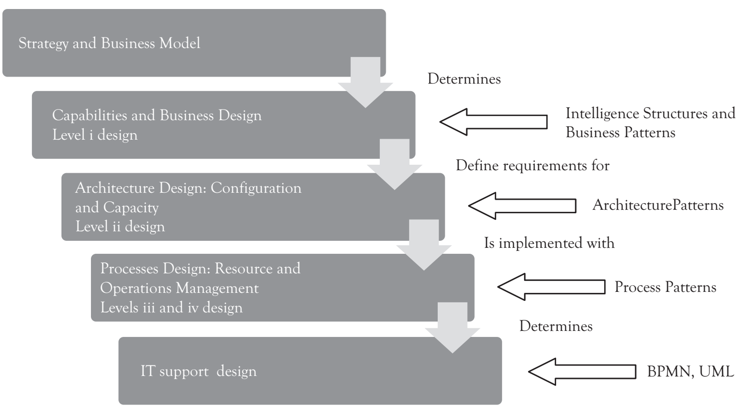


Figure 5.1 Service design methodology

to market standards. Then, the main Capability the business needs has to do with "being able to lower costs as much as possible," without compromising on quality. For this, there are two approaches: (a) to redesign the production of the service, using a level ii design, or (b) to concentrate on optimizing the use of resources, using levels iii or iv design. In terms of Intelligence needed, option (a) needs Analytics as proposed in Intelligence Structure II, in the previous chapter, which allow to optimize configuration and capacity of production of the service. For option (b), relevant Analytics are the ones of Intelligence Structure I, to identify and correct situations of waste of resources and eliminate them, or Intelligence Structure II to optimize the use of resources. So, if we select the positioning of Operational Effectiveness, we end up with clear options of design level in which to concentrate and Intelligence Structure that should be used.

For Differentiation positioning, the Business Model should be to offer, ideally, a service that is unique and provides more value to clients than any alternative. For this, the necessary Capability is being able to continuously improve the service, adding features that increase value, for which a level ii design is required to redesign the service itself and its production process, as defined in the previous section; however, complementary, design levels iii and iv are necessary to put into practice the product design. As to Intelligence needed, Analytics as proposed in Intelligence Structures II or IV, as defined in the previous chapter, are needed that allow to determine customer service's evaluation and preferences and to optimize the configuration and capacity of the production of the service; which structure is more relevant will depend on the importance of big data to study customer behavior.

For Integral Solutions to Clients in the variant of Redefining Clients' Relationship, the key is to know the client in order to offer customized services to people or other businesses. Then, the necessary Capability is being able to process information available for clients and discover behaviors that suggest services he or she will appreciate. Design level ii is required if it is necessary to redesign the service itself and its production process, as suggested by a customer's behavior; complementary, design levels iii and iv are necessary to put into practice the product design. However, there may be cases in which only level iv is required, since there are situations in which, without a complete redesign on the service, we can introduce Analytics into current marketing and sales processes to offer the same service, as shown in Macro1 decomposition in Figure 4.21, but personalized; for example, the product suggestions that Amazon does and the office equipment distributor we will present later in this chapter. Intelligence needed, as it is clear from the previous analysis, is Intelligence Structure II or IV, depending on the relevance of big data to develop customer's behavior models.

For Integral Solutions to Clients in the variant of Integration with Clients, the aim is to be part of the client's Value Chain, performing services that provide high added value to the business served. Clearly, we are in the case of a B2B situation; then, the necessary Capability is to able to process information available for clients and discover situations that suggest services he or she will appreciate. Design level i is required in cases in which the service needs a new business line, and level ii to design the service itself and its production process according to customers' needs; however, complementary, design levels iii and iv are necessary to put into practice the product design. Analytics needed are the ones included in Intelligence Structures II or IV, depending on the relevance of big data to develop customer's behavior models.

In all the Strategy and Business Models variations analyzed, we conclude, from the Capabilities needed in each case, which are the design levels that should be performed and the Intelligence Structure that applies in order to comply with a required positioning and value to be generated for customers.

Now, we show how to determine the Business Pattern that applies to define a first approximation to a Business Design. For this, we start with the design level and Intelligence Structure that apply to the business situation under analysis, determined as just explained. For this, we propose Table 5.1 that gives, for each combination of design level and Intelligent Structure, the possible Business Patterns (BP) that apply to the case. This table shows in it cells that, for each design level and given Intelligence Structure that may be used, there is one or a few BPs that apply for Business Design. This was outlined when the BPs were presented in the section "Business Pattern" of Chapter 4 and the table just summarizes the design options.

Then, Table 5.1 is a tool for selecting the applicable BP, depending on the Strategic Positioning and Business Model that, in terms define the design level and the necessary intelligence, to be applied. Examples of cases, which have been described earlier, illustrating the combination of approaches are provided for each table cell.

The BP selected according to Table 5.1 is then instantiated to the case under design, as will be shown with several cases in following section.

Table 5.1 Design Matrix for selecting applicable BP

Intelligence Structure	Design level			
	i Business design	ii Configuration and capacity	iii Resource management	iv Operational processes
I: Basic	N/A	N/A	N/A	**BP3** Emergency monitoring **BP4** Boeing management by process
II: Analytics	**BP5** E-learning high school students Private hospital innovation planning **BP2** Bank services small businesses	**BP6** Public hospital configuration and capacity **BP5** Private hospital configuration design	**BP6** Operating room resource management **BP3** DEA hospitals	**BP1** Office equipment distributor sales management Retail pricing seasonal items **BP3** Labor law inspection **BP6** Cardboard plant production planning Walmart logistics

III: Big data	**BP5** Publishing new product	**BP3** Publishing software development configuration	**BP3** Centralized supplies for Government	**BP3** Telco churning
IV: Analytics and big data	**BP2** Credit card offerings using tweets Machinery mainte-nance Netflix new businesses	**BP6** Walmart products offering **BP5** Research funds assignment to projects	**BP6** RightETA fleet management	**BP1** Amazon offerings Netflix recom-mendations **BP3** RightETA flight management

Next, the relationship between Business Design, materialized in an instantiated BP, and process architecture is examined. The selected BP is implemented through processes, for which the following rules apply:

1. Business Pattern "Client's knowledge-based selling" (BP1) implies a redesign of Macro1, as will be shown in the case of the international office equipment distributor in the next section; so, the Process Architecture is just Macro1. This applies only when there is not a need for structural changes of the Value Chain, which is so in cases where the Analytics can be readily inserted in its current processes, and also clients' predictive models are stable and do not need continuous review.
2. All the other BPs require that the design includes the ability to continuously reconsider, through several means, the situation and performance of the Value Streams and, based on this, propose changes to such streams or new ones. Hence, a structure that generates new designs for the streams is required. This implies that Macro2, "New Capabilities Development," must be a part of the Process Architecture, together with the Value Streams of Macro1, which are to be continuously changed. This can be relaxed when any of the following conditions apply:

   a. Structural change is made just one time, since there is not a need for reconsideration
   b. Stable environmental conditions make unnecessary continuous change
   c. Improvements can be part of Macro1 or Macro4
3. In architectures derived by rules (1) and (2), Macro3, "Business Planning," may appear when changes to Macro1 should be aligned with Strategic Planning; this is particularly required in the Business Pattern "Performance evaluation for re-planning and process improvement" (BP4). Also, Business Pattern "Product innovation" (BP5) usually requires an architecture with Macro3, since this type of innovation should be aligned with or approved by the strategic level.
4. In all, the aforementioned architectures, Macro4, "Support Resource Management," may appear in the architecture depending on the need to assure that a certain resource is available to supply the other macros in the architecture; a particular case in which Macro4 may be the main macroprocess is when, under the Business Pattern "Optimum resource usage"(BP6), a particular Value Stream of Macro4—for example, human resource provision, financial management, or equipment maintenance—is the one under design.

Cases that illustrate the use of all these rules will be presented in the following section.

Cases for Different Design Levels

Here, we present a representative set of real-life cases in which the Methodology presented is applied to the different design levels that have been defined. Some of the cases will cover several levels, illustrating the idea of hierarchical design, while other will focalize on just one level, but the relationship to the other levels will be established.

Design Level i: Business Design

Next, we present several cases in which the purpose is to produce an structural innovation of a business that increases its competiveness.

Credit Cards Transaction Business Case

A case that we have used as an example for many of the ideas we have presented is a large organization that offers card transaction services to banks and their clients. They provide several mechanisms and a network, which allow clients to process transactions with credit cards and other payment instruments, such as debit cards, giving the service they want—money withdrawal, buying goods, and the like—and to process the transactions to inform banks and clients of the financial results generated.[2] This company wanted to evolve to valued-added services according to the following Strategy and Business Model.

The Strategy is to deliver integral services for banks and their clients, and a Business Model that provides value through new services that allow the proactive selling of card products according to the client's needs, which is to be executed by the business under design. The new value this organization provides for banks is to sell card products in a more focalized way that will increment transactions and their amount; and the value for banks' clients is to offer them services that are more adapted to their needs. This means that the service organization has to generate the following Capabilities:

1. Be able to structure transaction data to discover, by means of Analytics, clients' behavioral patterns that present business opportunities, such as spending patterns for certain groups that suggest the selling of cards with certain characteristics, or behaviors that suggest card closing.
2. From behavior results, go on to define new service offers and associated campaigns to harvest opportunities.
3. Finally, create the necessary Value Streams—including the design and development of new sale processes, software support, human resources provision, and other resources needed—to put into practice the campaigns for the selling of new services, which today do not exist. Furthermore, do this dynamically in time according to new opportunities that are discovered by Analytics to derive new services.

To provide these Capabilities, the Intelligent Structure IV is needed, since not only the credit card data is relevant, but data coming from social media provide insights on customers' behavior and sentiments. In this case, tweets have been determined to be relevant. By combining the design level i, the Intelligent Structure IV, and the emphasis of this case in a new business that necessarily will need a new Value Stream, Table 5.1 directs us to BP2, "Creation of new streams of service;" hence, this pattern can be specialized to this case as shown in Figure 5.2. The Capability of generating campaigns and adapting Value Streams or designing new ones has to be dynamic and permanent in time. We also notice that the "Design of the Value Stream and Implementation" of the figure does, among other things, a design of the service itself and its production process continuously in time, providing a Capability of continuous improvement.

International Scientific Publishing Multinational Organization Case

Another case of Business Design concerns a Scientific Information Publishing multinational organization, described in the "Business Patterns" section of Chapter 4, which has decided to convert itself from scientific information producer (Publisher) to generator of high-value research information for their customers: Government, Funding Bodies, and University Management, to support research management and policy making. The Capabilities necessary in this case are to be able to analyze the research information available in the company and multiple other sources, including the ones on the Internet. With the results obtained, it is intended to generate new services that support customers' research decisions. With this, we conclude that we need a design level i and Intelligence Structure IV, since Analytics over big data is necessary. Hence, from Table 5.1, the design of this business is in the line of BP5, "Product innovation," since a capability to dynamically generate new adapted services for customers, based on an analysis of the behavior and performance of the current ones and market information, is required. This implies the development of new or modified Value Streams or Value Chains. In this case, the current products behavior and performance relates with how the analysis of the content of the publications this organization produces and the research information in it can be packaged to generate other products that provide value for clients, particularly, research organizations. To generate more value, it is necessary to integrate this company research

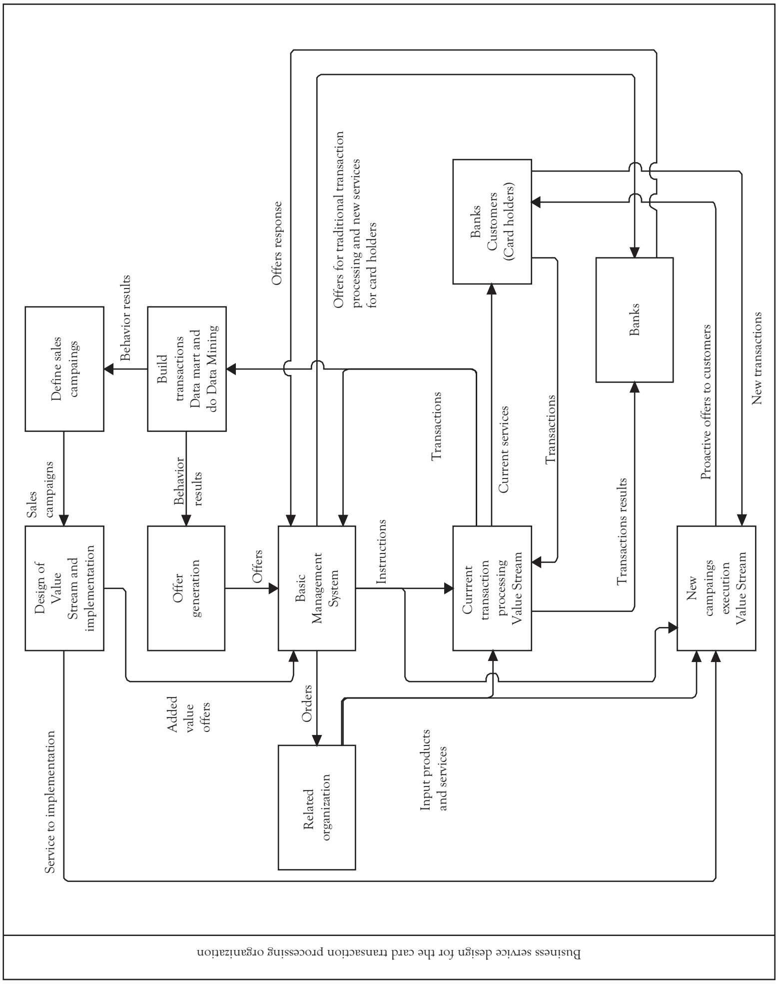


Figure 5.2 Business service design for the card transaction processing organization

information with the information generated by other organizations: competitors, who also produce scientific and technical publications, and other companies that produce related information such as patents, awards, market studies, and the like. Most of this information is publicly available by paying market prices.

On the basis of these ideas, the specialized BP5 for this case is shown in Figure 5.3. The new Capabilities required are clearly shown in the top components of such figure, where research information analysis, design of new products, and development of new Value Streams are performed.

Private Hospital Case

We now present the case of a private hospital, summarized in Chapter 1, one of the largest in Chile and considered among the best in Latin America, which has defined the following Strategy and Business Model:

1. This hospital wants to be distinguished as the one that provides the best treatments with the best required technology; so, they are clearly in the line on best product with an emphasis on differentiation based on continuous innovation in the services they provide.
2. The value they aspire to provide is to assure patients the right treatment that minimizes health risks for them at a competitive price.

Then, the Capabilities this hospital needs are: the possibility to evaluate the performance of the several Value Streams that provide services to patients; to identify opportunities for improvement of the medical procedures and introduction of new technology—for example, a new imaging equipment or a robot to perform surgeries—that make a difference for the patient; to be able to formalize all these opportunities as formal investment project and rigorously evaluate them to determine the ones to execute subject to budget limitations; and design, plan, and execute the selected projects that create or modify the corresponding streams, which implement the new ideas. In doing this, the opportunity exists to use formal Analytics to forecast needs, evaluate investment projects, and plan them; then, the Intelligence Structure II applies. Notice that some of the innovations imply change in the medical practices, which means we are

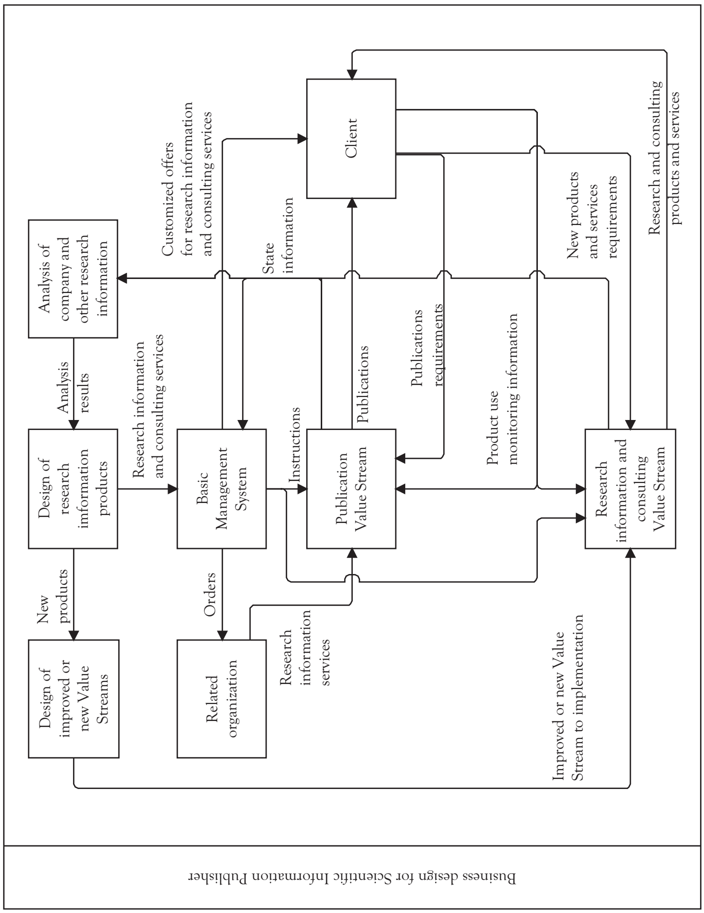


Figure 5.3 ***Business design for scientific information publisher***

redesigning the service itself and its production processes. All this clearly points to BP5, "Product innovation," as confirmed by Table 5.1.

The situation in the hospital before the reported design was that ideas and projects were informally defined and presented in an annual budgetary procedure, involving hundreds of U.S. million dollar investments, to the Board, which decided on which projects to execute without any formal evaluation. The new design, which has been successfully working for about 5 years, is based on the specialized BP5, shown in Figure 5.4, which clearly defines the requirements in a new design, with an emphasis on learning how to redesign the services based on observation and analysis of the use and performance characteristics of the current services.

Other Cases

Besides the cases presented earlier, we will summarize some other cases of radical business redesign, which show the potential of transforming an organization with tools that incentivize innovative thinking.

The first case relates to a *food production business*, where the Strategy and Business Model pointed toward strengthening its competitive advantage and consisted supplying most of the small food retail shops in the country with its products, through a large force of salesmen who periodically visited such shops, and a good logistic capability to produce and distribute the goods.[3] The challenge was to manage the growth of the portfolio of clients, with quality. To increase the clients, and simultaneously, to improve the service to retain them seem opposed objectives in a portfolio of more than 40,000 clients. Subsequently, a redesign was performed and implemented with good results, and this company ended with a top and unique Capability to sell and distribute products all over the country, in particular, those requiring cooling facilities. Then, the innovation idea generated by the designers was to offer selling and logistics services to small niche food-production businesses that do not have good distribution channels. This idea was successfully tested with a few producers, and hence implemented as a new Value Stream, since it shares many resources of the traditional Value Chain. From the point of view of Strategy, this organization clearly moved to integral services to the new small food producer partners, and the Business Model evolved to provide

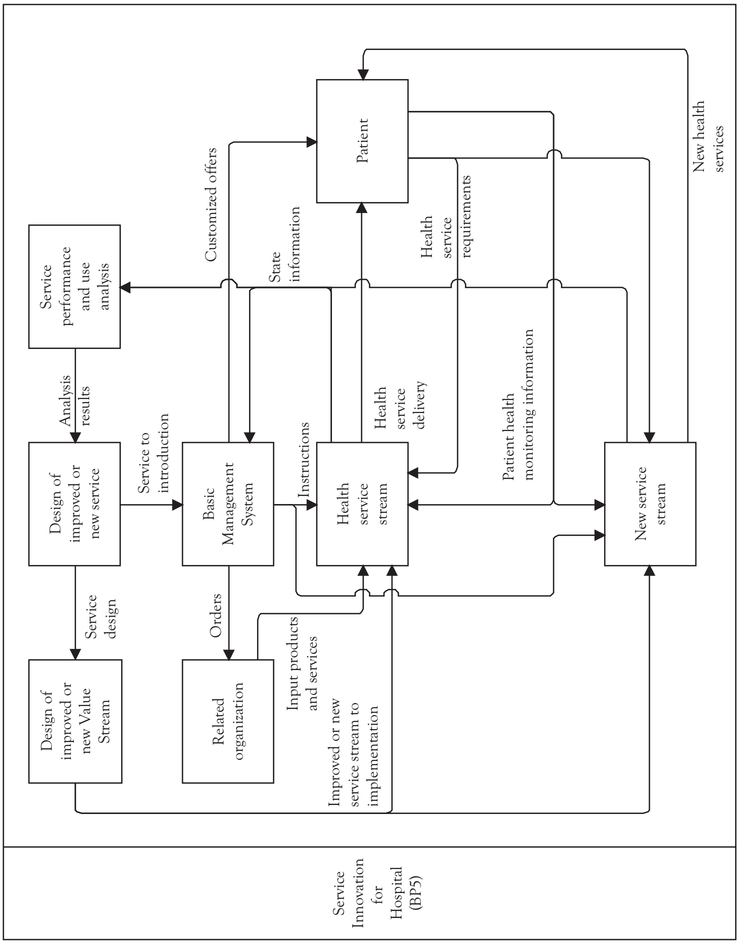


Figure 5.4 Business Design for the private hospital case

value to these customers through integral selling and distribution services. Analytics in the style of Intelligence Architecture II is necessary to optimize logistics and sales management. As to a BP that applies in this case, according to Table 5.1, is "Creation of new streams of service" BP2, where a Capability to design a new service, with a completely new Value Stream, and associated business exists based on the analysis of the performance of the selling and distribution of products and other market information. This was a very innovative move that changed the life of this company; so much that it was acquired by one of the leading food producers in the country, and is now part of a holding that has the largest market share in the line of food products this company supplies. This is an interesting case of network externalities for a large community of small shops and many small food producers that supply them, since when a shop joints the network, value increases for all participant food producers by increased demand, and similarly when a food producer joints, for the offer.

The second case concerns a *small certification business,* which gives consulting services to companies that want to adopt one of the several norms, such as ISO 9001. Its traditional business was to hire professionals, mostly business graduates and engineers, and train them to accompany and facilitate the certification process of the company that wanted the service.[4] The first idea this company had was, using Analytics in the style of Intelligence Architecture II, to more formally manage certifications and to improve the certification process, according to their experience and good practices coming from project management, and to develop brand new systems to support such process; all this led to the use of the Business Pattern "Product innovation," BP5, and a detail design based on this. Implementation of the design produced good results in terms of improved service to customers, due to a better guaranty of quality and on-time delivery, and much better use of professional certification resources. A by-product of this experience was that, since most of the certification experience and knowledge was imbedded in the business logic included in the process and supporting system, the certification business was less dependent on having people on the payroll to perform the job. Hence, the first change the owner of the business did was to work with outsourced professionals to perform the certification work, which was successfully implemented and meant that he need not have any professional staff. The certification was done by the outsourced professionals using the process and system the company provided them, which, on the one hand, assured good results by following the logic included in the solution, and on the other, allowed full control of the certification by the owner by monitoring its status and taking corrective actions when needed. But, this was not all: The second innovation was to start outsourcing, by using the cloud, the process and system to other certification companies that did not have the possibility to have access to equivalent solutions. Hence, he invented a new business, which he is currently exploiting. Another subproduct of this solution is that he can monitor the processes of their certified customers. Then, another new line of business that alerts customers of problems with their processes has been developed, for example, detecting nonconformities and consulting services to fix them. In terms of economic analysis of these innovations, the formalization of practices reduced the transactions costs and allowed externalization; also, such practices and their enforcement and control assured that the interests of the principal (owner) were well taken care of.

Next case is one of an *e-learning education service* for high school students, where experience existed in providing customized reinforcement for specific academic topics in which they want to improve oriented to obtain good results in national tests. The business was doing well, but data showed that it was long, hard, and not always successful the generation of contents for a student's specific needs. Then, the owners decided to go from a mostly human-based approach to one in which a formal design of the service in connection to the value to be provided to the student will permit its full automation. So, the level i design is needed and Intelligent Structure II applies, since analytical models should be developed to determine what learning a student needs based on knowledge evaluation information. Then, BP5 applies, as stated in Table 5.1. In the next section, the design of the service in itself is presented, as a particular case in which this determines all the other processes that are necessary to run the business in the new e-learning approach.

The last case corresponds to a *large regional electrical distribution company* in Peru that, in improving profitability, decided to follow the Strategy of providing new services to their customers for generating solutions to technical problems, which are not well-managed. The Business Model is then to provide more value to them by reducing the costs associated to electrical use by better energy management. It was determined that the main potential for doing this was distribution to big accounts, industries that consume large amounts of energy, that have themselves internal distribution networks and electrical machinery needing maintenance. Hence, the opportunity was, given the large experience and already developed maintenance processes this company has, to offer big accounts full maintenance services for their electrical installations with the promise of lower costs and downtime. The necessary Capability is then to be able to design optimized maintenance services, using Analytics in the style of Intelligence Architecture II, with predictive and optimization models to assure availability and minimize costs. Also, to be able to dynamically adapt them to customers' needs. Thus, the BP in this case is BP2, "Creation of new streams of service." This case is similar to the one in Chapter 3 of building maintenance services, where servitization[5] modules reconfigured to give services to different customers with varying needs of the same type, is applied. Hence, this approach is also applicable in this case in doing detail design of the maintenance service. The economics involved in this case is the reduction of transactions costs due to the standardization of maintenance services components that make feasible to generate a personalized solution for a customer in an agile way, thus making externalization to the electrical company efficient.

The common factor of the cases we have presented in this section is the Capability of dynamic change of service offerings, which is necessary due to the characteristics of the demand of services commented in Chapter 4, when describing BPs.

Design Level ii: Business Service Configuration and Capacity Design

Credit Card Transaction Business Structure Case

For the detail design of the configuration of the business of this case, we use the Architecture and Process Patterns of Chapter 4. Then, we need to map components of Business Design of Figure 5.2 to an Architecture Pattern that is applicable to this case under the rules given in the section "Methodology" of this chapter. Now, the continuous improvement of the

Value Chain implies, according to rule 2 for mapping a BP to architectures, the need for a Macro2 producing Macro1 improvements and changes. Rule 3 also applies, as Macro3, Business Planning, is required to maintain the consistency of innovations in the Value Chain with the Strategy. In addition, since the two Value Streams in Figure 5.2 work with the same customers, suppliers, and information, it is natural to share some of the services. Therefore, the Shared Architecture Pattern of Figure 4.16 is relevant. With these directions, the mapping is shown in the following.

First, we determine the amount of Value Chains, which in this case is only one, since many of the processes of the current configuration will be used by the new Value Stream in Figure 5.2. So, it can be concluded that we have just one Value Chain with one Value Stream that only processes transactions and a new one that manages proactive offerings.

The processes of the Value Chain shared by the Value Streams are determined as: "Shared Sales Management," which has been decided to be common to both flows (design option-based economies of scale and scope) and "Shared Information Maintenance," for the obvious reason that the two flows share the same customer information. These components, with the necessary relationships, define the configuration of Macro1 or Value Chain in this case, which is shown in Figure 5.5.

Now, the mapping of the top four activities of Figure 5.2 must be determined, which are oriented toward generating the new Capabilities that the company will have: generating new offers for banks and new services to the customers of the bank. These activities map directly to the development of new Capabilities (Macro2) in Figure 4.24, which in this case is called "Development of new offers, campaigns, and new Value Streams," as shown in Figure 5.5.

Finally, Business Planning (Macro3) is included in Figure 5.5, since it is clear that the innovations generated in "Development of new offers, campaigns, and new Value Stream" must be aligned with the Strategic Planning of the organization and accepted by the executives responsible for this planning before implementation.

Various design elements of the company shown in the architectural pattern of Figure 5.5 have not been considered to simplify the diagram, such as support resource management and handling. In some cases, these may be relevant and should be included, as well as situations where

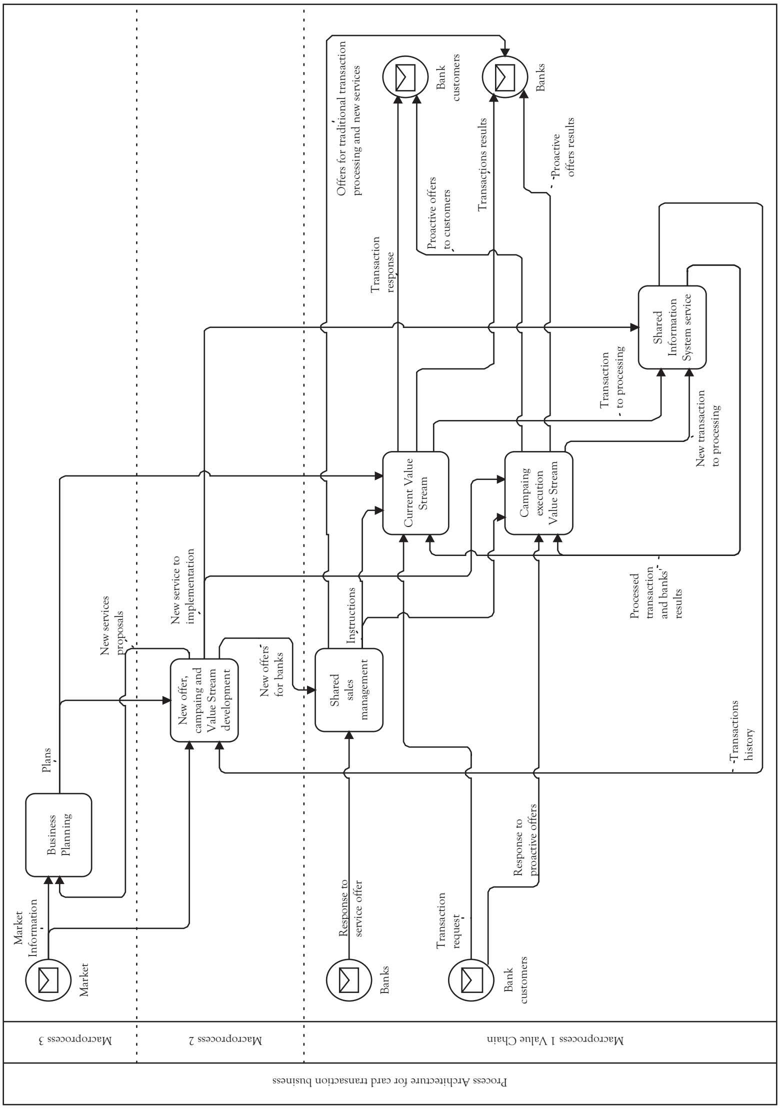


Figure 5.5 Process Architecture credit cards transaction business

outsourcing part of the production of the service and some resources, like people, are a key factor for their provision.

The design continues with the detail design of the processes that will structure the data, develop predictive models based on them, and generate new offers. This was done first with a pilot implementation of this processes that showed the feasibility of the design, which was offered and tested with one bank's client. Based on the pilot, the company decided to invest in the project and with this formal design continued among two lines. First, the processes implemented in the pilot were formalized to be included in "Shared Sales Management," specializing the pattern that applies in this case, which is "Analysis and Marketing " of Figure 4.21. Then, the formal design of the Value Stream "Campaign execution" was done; the main component of this is equivalent to "Service production and delivery" of Macro1 in Figure 4.19, which means we are designing the service in itself, including taking the offers campaigns generated by "Shared Sales Management," identifying the clients to which they apply, then contact such clients through different channels to perform the offer, and finally, do a follow up when necessary. This was done by means of a call center, and in some cases, through the Internet, all these supported by IT systems. The key in the design of this service is the customer experience, since a good one increases the probability of accepting the offer. There are techniques for customer experience design, which we do not present here, but interested readers can find them in the references.[6]

The processes' designs presented have to be performed to put into practice the business design of the previous section, but the Macro2 included in the design implies that there will be new design of the "Shared Sales Management" as new data are determined relevant and new services are incorporated. This means a dynamics that should be considered in the design of the Macro2, which must contain processes that continuously design new Macro1 processes. We will illustrate this idea in the following cases.

The economic justification of this new business configuration design is the provision of a service to banks and their customers at very low transaction costs that make possible the externalization to the transaction-processing company and a high barrier for the banks in trying to replicate the service due to costs of change.

The design presented is working in routine operation with good results, so much that the Board of Directors of the company have formally stated that this is a very promising new line of business, allowing the transformation of the business from a transaction processor to producer of value-added services, and is providing important resources for new developments.

We note that when making business design and configuration, as well as the architecture of the processes we have highlighted, the organizational structure is being redefined and requirements for establishing the IT architecture are given. For example, in the case just presented, the added Value Stream implies an organizational unit, with people and new infrastructure, and implementing Analytics in Macro2 requires the availability of people with new skills and a suitable hardware and software environment to do the work.[7] In other words, we are making EA, as defined in Figure 1.1 and others authors, as it was revised in the section "Enterprise Architecture and Design frameworks" of Chapter 2.

Private Hospital Case

Mapping the BP5 that applies to this case to the processes needed is straightforward, since rules 1 and 2 of the previous chapter apply and "New Capabilities Development" (Macro2) must exist to produce new improvements and "Strategic Planning" (Macro3), to maintain consistency; Macro1 receives the innovations. The mapping is done using the "Process Architecture Pattern for Hospitals," reported by Barros,[8] by specializing it to this case, resulting in Figure 5.6, where the two macroprocesses, "Strategic Planning" and "New Capabilities Development," to be designed are included.

For this hospital, a detailed design was performed, including a formal strategic planning process that provides guidelines for the generation of innovation project proposals that results in the flow "Investment budget, Objectives and metrics" and "Accepted projects" of Figure 5.6. In addition, "New Capabilities Development" was created, which, based on aforementioned guidelines, produces the "Projects implemented" and interacts with "Strategic Planning" by means of the flow "New projects

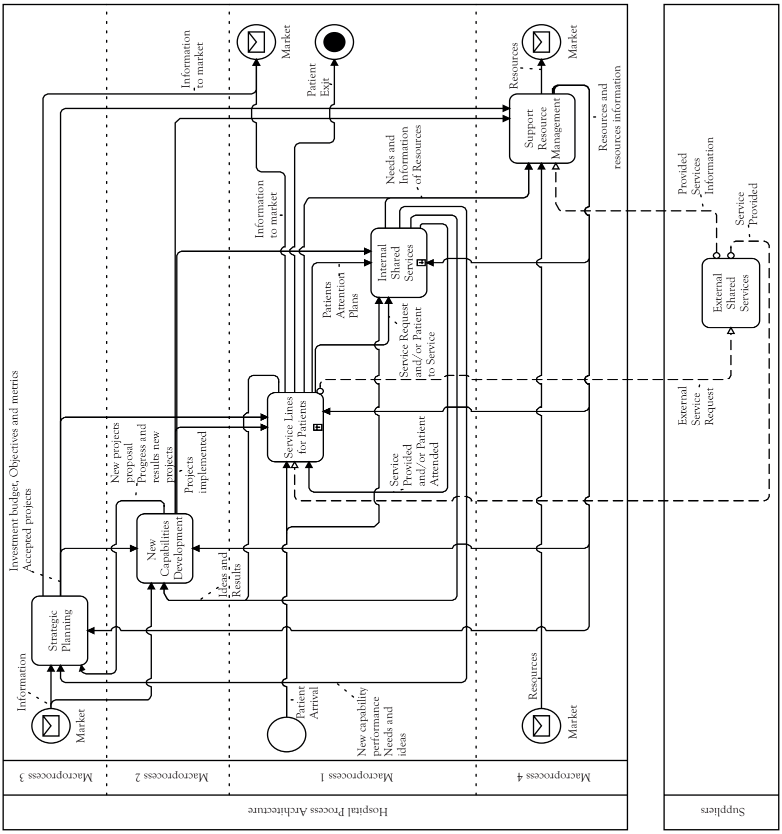


Figure 5.6 Architecture design for the private hospital case

proposal" and "Progress and results new projects." Both of these macroprocesses interact with the other processes in the architecture through "New capability performance" and "Needs and ideas." What we have then is a sequence, which is implicit in Figure 5.6, because it is a nonsynchronous representation, where first "Strategic Planning" will issue guidelines; based on this and "Ideas and results" arising from other processes, "New Capabilities Development" generates new projects ideas that will be submitted back to "Strategic Planning," which will then define the projects to be implemented. Later, projects will be designed and constructed by "New Capabilities Development" and implemented on the other processes. Finally, during all the earlier sequences and after the project are implemented, a monitoring of the progress and result of such projects will be performed. This sequence is formalized and made explicit in the more detailed levels of the design presented next.

To illustrate the following level of design, we use "New Capabilities Development." A general pattern of this macroprocess is shown in Figure 4.24. Such pattern is instantiated for this case, resulting in Figure 5.7, where the first process is "Generation of new projects proposals" that, based on guidelines arising from "Strategic Planning," does a formal definition and evaluation of projects, interacting with the "Other macroprocesses" and acquiring market information; this interaction means an active participation of the Heads of the medical and other services operating units in generating new project ideas. The first result of its effort is "New capabilities ideas" to be considered by "Strategic Planning," in which the projects to be implemented are decided. For such projects, the process "Manage design and construction of new capability" is executed, which generates "Design and construction plans" to be executed by "Design and construction of new capability." The business logic to be executed by these two processes is essentially good project management practices as proposed by the PMBOK.[9] All these processes have feedback flows that allow monitoring and correcting actions, such as "Plan feasibility and resources needs." To provide the adequate system support, there is the process "State updating," where all the information about projects in their various states, plans, and resources are maintained up-to-date.

There are several levels of design details, as it will be exemplified in the next sections, which define the operation of the processes and the business logic that is executed, but are not included for this case.

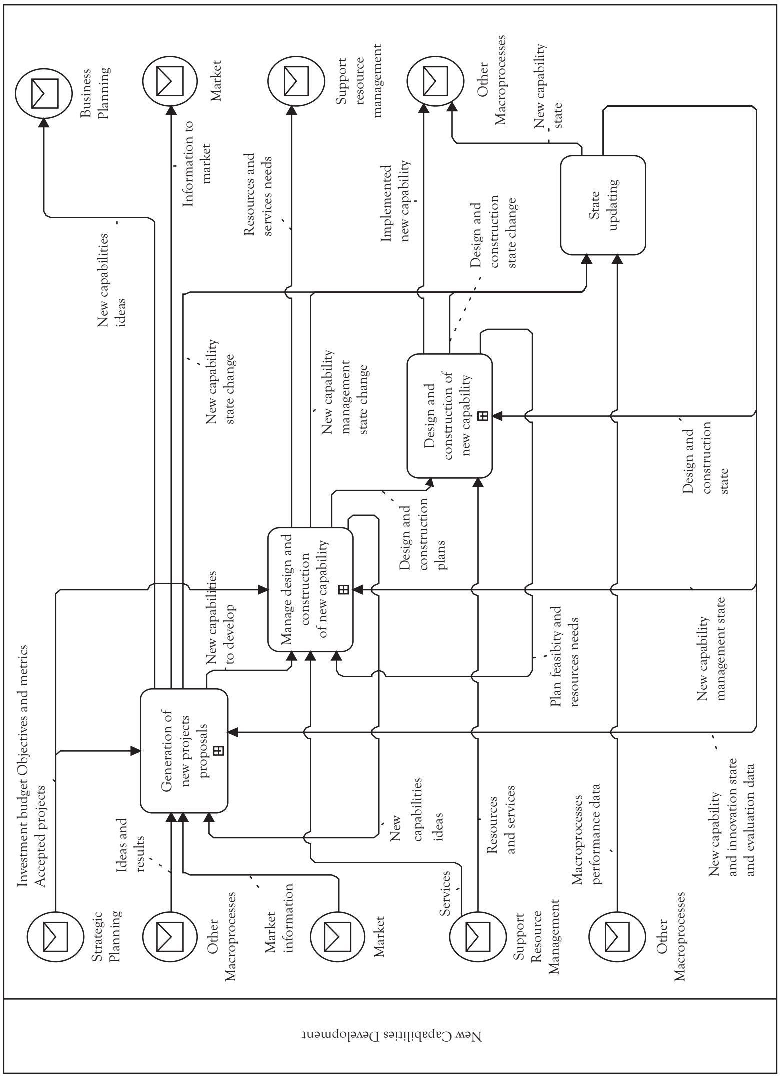


Figure 5.7 "New Capabilities Development" design for the private hospital case

This project was developed during approximately 18 months, where formal processes of planning and management of strategic projects were designed and implemented, which did not exist before this effort, with a custom-made information system support. Moreover, a formal effort was implemented that took care of the factors of change management within the organization. Such effort made a difference in this case, since it is difficult to change management practices in a radical way in a medical environment, where doctors emphasize mainly their discipline. In making the innovations feasible, the support from the Board of Directors and the active participation of the medical unit heads were the key factors. As a result of this design, the visibility of plans and projects' execution was considerably increased; also, the communication between the Directors and the section heads improved. Finally, the results motivated the creation of a Project Management Office that supervises and leads the innovation initiatives. It is convenient to emphasize the enormous cultural change that this project produced in the executives of the organization, including its Board and all the medical unit heads, which had to change their practices of planning and management of projects in a fundamental way, a great merit in a medical atmosphere, where they tend to subvalue the improvement in the management practices.[10] The economics behind this case is an increase in explicit coordination that eliminates waste of slack resources, which more than pay for the increase cost of coordination with new processes and systems. This case proves again that a profound and good business design involves integrated and systemic changes in the structure of the organization, the process architecture, and IT support; that is true EA.

E-Learning Business Case

In this case, the main design is concentrated in the service itself, that is, the production of learning material adapted to a student current knowledge and results from learning evaluations, all this in a continuous process that steadily increases evaluation results. In terms of architecture and configuration, the effort is concentrated in Macro1, and particularly, in the "Service production and delivery" process of Figure 4.19, which determines the design of all the other processes of Macro1. Now, in principle, Macro2 should also exist, since it is the one that does the design of Macro1. But, this is so when the service design will frequently change due to the dynamics of the market. In this case, it is considered that a one-time design, which is the one we will present, is sufficient and only adaptations to take care of curricula changes are necessary.

The design stars with the formalization of the knowledge associated with the high school curricula that will be taught.[11] This is very well defined by Government in terms of content and learning objectives. All this is formalized by means of an Ontology, on which the main component is a Learning Object; this is composed of Content Objects that have associated Content Fragments, as shown in Figure 5.8, which is a simplified representation that omits details. Both of them have many associated slots that define descriptions, keywords, state, and the like, and Subclasses that give content details, such as explanation, demonstration, example, frequent error, experiment, exercise and answer, questionnaire, graphics, text, animation, audio, video, and the like. There is also a Learning Objective associated with a Learning Object, which is also shown in Figure 5.8, having slots similar to the previously exemplified. Then, the teaching domain is defined relating Learning Objects to specific courses students take in high school, which are the ones in which they need help to improve their evaluations. This is shown in Figure 5.9.

Having previous Ontologies instantiated for particular high-school courses and Learning Objects, detail which we will not give here, allows to design the production process that defines how the student will interact with the e-learning software application. This is shown in Figure 5.10.

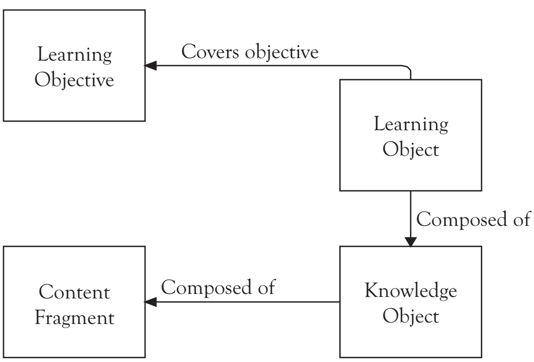


Figure 5.8 First level ontology for Learning Objects

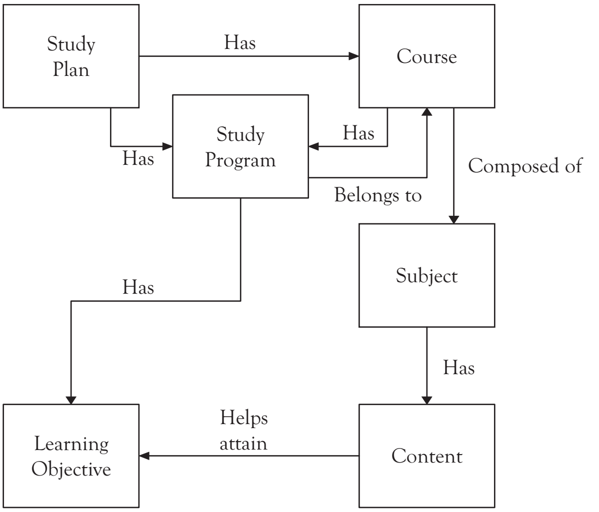


Figure 5.9 Teaching domain and relationship to Learning Objects

The execution of the process in Figure 5.10 needs a logic that relates a diagnosis of the student knowledge state based on evaluations to the learning that should be reinforced. This is done by relating a set of questions for evaluation of a particular topic. If the student fails in a certain percent of the questions, the system should suggest he or she studies certain subjects, ordering them by impact on the learning improvement. The company providing this service has experience with this approach, but the design improves on this by using Learning Objects that allow a more precise suggestion and learning paths for the student to improve. This was tested with good results with a set of specific courses oriented to improve on tests of the national high-school evaluation system for university admission.

Resource Assignment in the Public Health Sector Case

Next, we focus on public hospital business design, where an overall analysis for the public health system in Chile is performed, and a design is developed to promote a coordinated solution for innovation resource assignment. This case illustrates a situation of complex multilevel architecture.

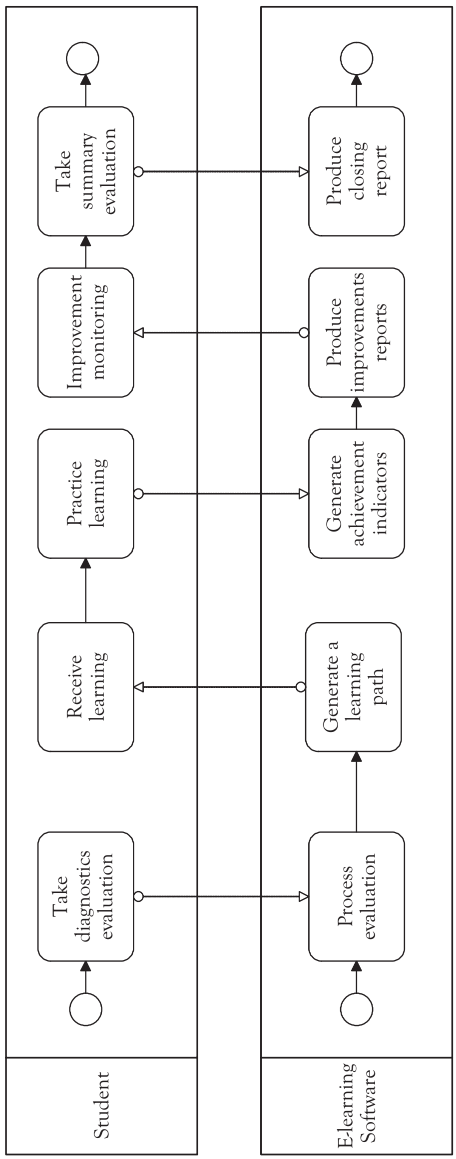


Figure 5.10 E-learning production process

Public hospitals have to usually cope with more demand than their capacity allows, generating waiting lists of patients who cannot be attended immediately; hence, they need to optimize the use of such capacity and must have means to manage priorities, which means efficiency and fairness. In doing this, one of the best possibilities of improvement is to modify the logic behind the decision on the resources hospitals receive. The idea is assign resources in a way that promotes efficiency, and at the same time, improves quality.

The state of the health system in Chile in connection with resource allocation oriented to improve efficiency and fairness of the hospital services is as shown in the following.

For the improvement of the efficiency, the current method of resource assignment to hospitals is primarily historical and includes important distortions related to demand. It is based on the idea of "Management Commitments," which are basically goals measured in quantity of medical interventions of different types that the hospital promises to execute to receive a certain amount of resources in any given year. This method fails on several accounts: (a) failure to set goals that consider the true capacity of the hospitals, (b) within a given type of medical interventions the easier cases are selected to formally meet the goals, (c) there is no measure of quality of the intervention, and (d) no incentive to do more than the goal; in fact, there is a disincentive, since more production than the goal means a higher goal for the following year. Obviously, there is no guarantee that a hospital operates at the "right" efficiency level, according to the resources they have. Furthermore, the objectives of fairness and quality are negatively affected because of the selection of patients with no priority, but easy or no controls on the quality of the interventions.

For the improvement of fairness, the processes and practices that currently govern the management of waiting lists should be reformulated; it is necessary to change from attention according to the order of arrival to one that ensures the timely delivery of the service, considering formal and objective medical criteria. It is also important to discourage the selection of cost-effective hospital treatments, which implies selection of patients who are easier to treat, by transferring the complex cases to other higher-level hospitals; this increases the count to the goals explained earlier with lower costs, but increases the costs of transportation of patients in complex conditions, owing to nonpayment of the hospital transferring the patients.

We now analyze how hospitals should be managed as a system, particularly, in the assignment of resources, to avoid the situations reviewed earlier.

From a strategic point of view, they should follow the positioning of best product and operational effectiveness, as defined by Porter and complemented by Hax and Wilde. This Strategy requires evaluating the services provided, and improving them to provide better quality as well as use the resources in the best possible way to provide such services at the lowest possible cost (efficiency). As for the Business Model, they should provide value to patients (customers) by executing medical services and management processes in such a way as to guarantee the treatments that patients need with the required quality and at the right time (quality and fairness). Here, the ideas of Porter and Teisberg[12] and Christensen et al.[13] can be considered to provide the right value and adapt practices to disease complexity.

Thus, the Capabilities that hospitals need, according to the Strategy and Business Model provided earlier, are to be able to measure current efficiency and quality levels to assign resource in such a way that there is an incentive for the hospitals to improve. This means using Analytics of the DEA type, reviewed in Chapter 4, to rigorously measure efficiency and determine what improvements are necessary to increase it. So, Intelligence Structure II is needed. This, combined with the level i of design we are performing, means that the BP3, "Internal Learning for Process Improvement" apply. BP3 provides the Capabilities to generate new health services that produce better quality and fairness to patients, based on process efficiency. BP3 is also correlated with the proposals by Porter and Teisberg and Christensen et al., since the Capability to innovate on health services provided by this pattern is at the heart of changing medical and management practices that contribute to minimize the cost of the health outcomes and adapting them according to the level of complexity.

We begin by proposing an architecture based on the general architecture for multilevel structures, shown in Figure 4.17, which should exist at the top of the public health system to guide its development with an emphasis on resource assignment for innovation projects on existent hospitals. Hence, we overlook features, such as ordinary annual budgeting, investment in new facilities, health campaigns, and many other activities that are necessary in a centralized country health management, which are summarized in the "Other processes" component of the architecture. We also do not consider the level of Services, which are groups of hospitals managed by a centralized authority, since they play no significant role in resource assignment. Our selection of innovation resource assignment is based on the execution of many projects with hospitals, where the implementation of well-selected projects, which change in a radical way the medical and management practices of services in hospitals, has generated significant social value.[14] Thus, our key idea is to generalize and extend our experience to the public hospitals system.

In the architecture in Figure 5.11, which is an instantiation of the general pattern in Figure 4.17, the main idea is that, besides "Regular planning and budgeting" oriented to continuing operation, Macro3 of the central level includes a new process of "Innovation planning and budgeting." Such process executes a logic, which will be explained later, to determine the innovation projects that are to be executed in selected hospitals in trying to maximize the value associated with the objectives stated earlier. This innovation relates to new Capabilities to be developed for hospitals in a similar way to the previous case of the private hospital; the difference in this case is that we are dealing with all the hospitals in the Chilean health system in a centralized planning approach for this type of innovation. Then, the projects are defined in detail by "Innovation projects organization and monitoring," which determines the budget and the possible external services suppliers that can execute them. Next, the projects are communicated, by means of the flow "Project definition and budget" to the selected hospitals, determined as explained in the following paragraphs, to be defined in detail by them with the collaboration of the "Suppliers Processes," which are academic or consulting services specialized in the types of projects to be defined. The idea behind this proposal is that hospitals do not have health innovation and project management specialists, so, the projects should be executed by means of externalized services, as it has been the case in many historical projects dealing with IT support or process design. In implementing this approach, hospitals need, as shown in Figure 5.11, three new processes:

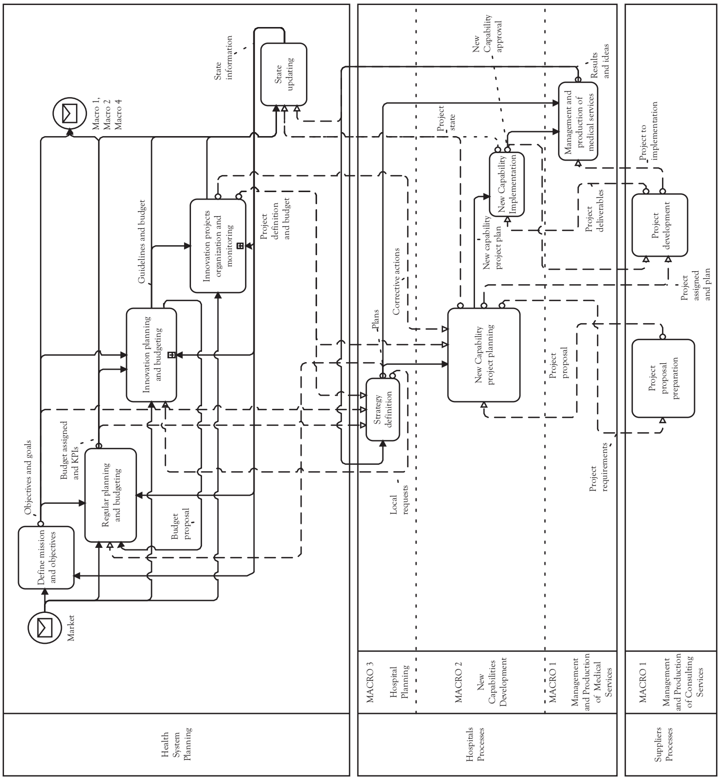


Figure 5.11 Design for "Health System Planning"

(a) "Strategy definition" that, besides doing the current budgetary planning , which includes resources and other medical factors, will perform the overall planning to execute the projects assigned to the hospital; (b) "New Capability project planning" that requests proposals for executing projects from external suppliers, evaluates them, and decides which consulting group will actually develop the project; and (c) "New Capability Implementation" that will coordinate with suppliers and the people from "Management and production of health services," who will execute the new capability, and put the project into practice. Similar examples of such Capabilities will be presented when the logic that defines which new Capabilities are to be implemented is specified. Besides, the processes just explained for "Health System Planning" in Figure 5.11, the design includes "Define vision and objectives" that provides a frame of reference for the rest of the processes and "State updating" that carries out its usual task of keeping up-to-date and reporting the status of the all the processes in the design; in particular, the situation and results of each innovation project.

The key business logic that makes possible the implementation of the preceding architecture is the one that, in "Innovation planning and budgeting," measures efficiency of the hospitals and determines which projects to develop in the less efficient ones to make them improve. Such logic was developed by measuring the efficiency, based on the DEA analysis summarized in Chapter 3, for 40 hospitals, and it is detailed in the follow-up volume *"Service Design with Applications to Health Care Institutions."*

Public Hospital Emergency Configuration and Capacity Determination Case

Here, the strategic issue is to generate the best possible service by having the right configuration and capacity and make the best possible use of the hospitals' resources; the value that can be generated for patients is to improve the service in terms of waiting time and providing the right service. For this, Intelligent Structure II is required, since we need predictive and resource optimization models to provide a required level of service at a minimum cost. Hence, from Table 5.1, BP6, "Optimum Resource Usage" is applicable. Therefore, from this, we design a new architecture configuration for the service that reduces waiting time and improve service, besides evaluating them for a forecasted demand. Such design is based on representing the design problem by means of a process architecture. To do this, the Shared Services Architecture Pattern, adapted to hospitals as in Figure 5.6, is used. To exemplify this design of configuration and capacity, we concentrate on the "Services Lines for Patients" in the figure, detailed in Figure 5.12, selecting the "Demand Analysis and Management" process in relation to the "Emergency Medical Service." This process needs the subprocess of "Demand Forecasting and Characterization," including business logic, which will be detailed in what follows.

To be able to forecast effectively, one of the key factors is the quality of historical data. In addition, the hospital operating conditions and environment should remain relatively stable for the data to be representative. This work focuses on two public pediatric hospitals: from now on referred to as HLCM and HEGC, and a general purpose hospital, HSBA. On arrival at the emergency facilities, each patient is registered, including personal data, time of arrival, diagnosis, and classification according to the severity of illness. All the historical data for the three hospitals were obtained for the purposes of this work and are as follows:

- HLCM: from January 2001 to December 2009
- HEGC: from January 2001 to July 2009
- HSBA: from January 2000 to December 2009

Since these hospitals could provide high-quality data regarding their emergency operation, we could infer historical demand with forecasting Analytics. We used the monthly aggregated demand as a basis to construct predictive models.

However, to convert historical data into useful input information for the forecasting models, further analyses and a series of transformations were necessary. By analyzing the demand that arrives at the emergency department, outliers were detected, as shown in Figure 5.13. Visual inspection of the aggregated demand as shown in such figure for one of the hospitals reveals a strong seasonal pattern. We observed a low demand during the summer months (December, January, and February in the Southern hemisphere) and a high influx of patients during the

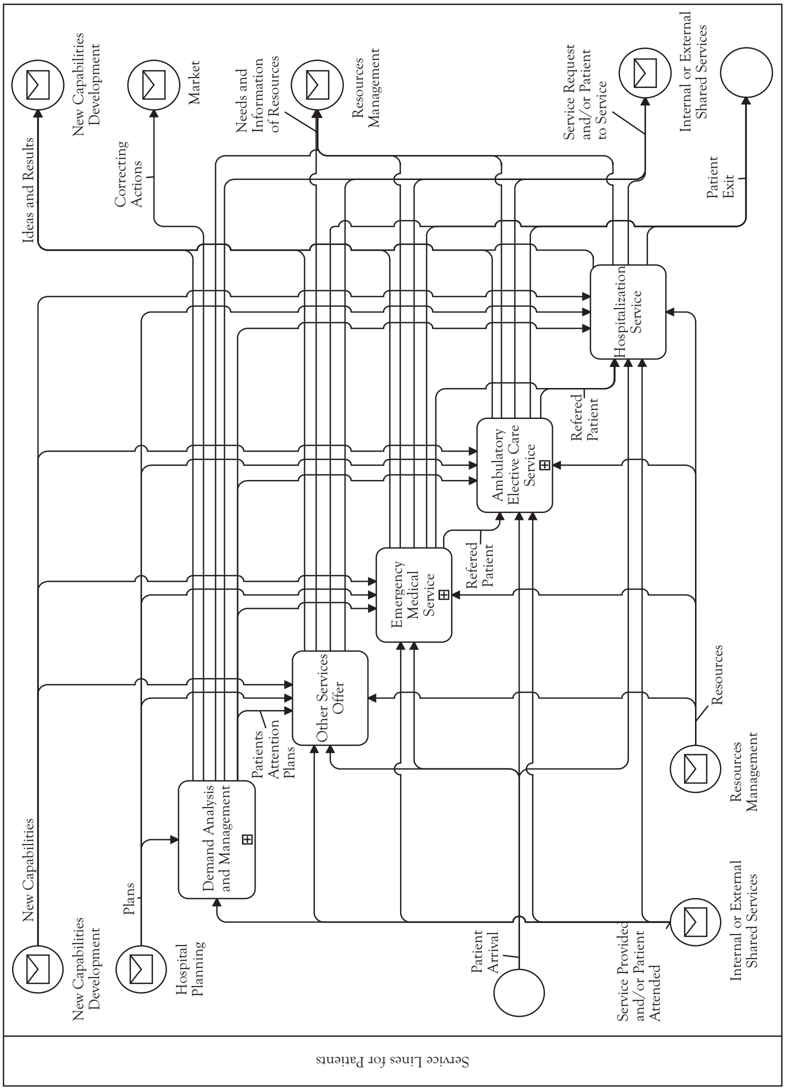


Figure 5.12 Detail of "Services Lines for Patients"

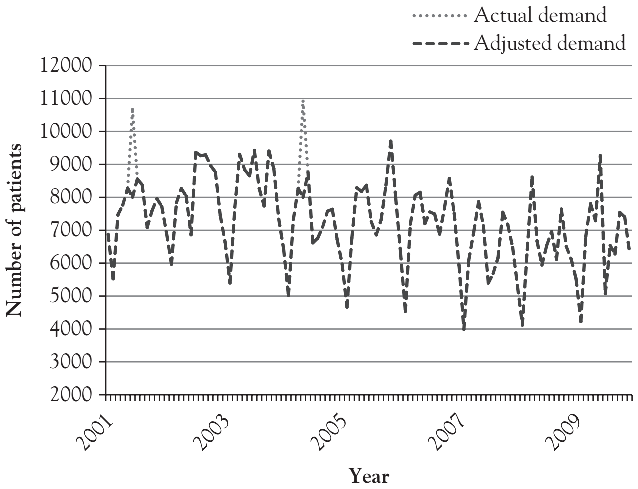


Figure 5.13 Actual versus adjusted demand per month in HLCM

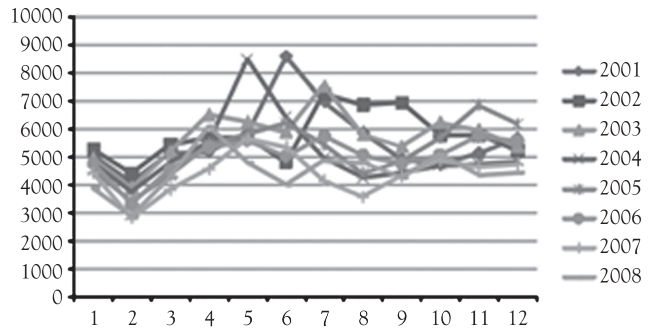


Figure 5.14 Medical demand for HLCM

winter season (May, June, and July). In general, a downward trend can be observed over the years.

When data are disaggregated by pathology type, we notice huge differences, as shown for medical and surgical demand in Figure 5.14 and Figure 5.15. The first is much more volatile over the years since it depends on factors such as temperature and flu-like illness rate, while the second is more stable over the years. We also conclude that medical demand comprises 70 percent of the emergency cases and surgical demand corresponds to 30 percent of the cases.

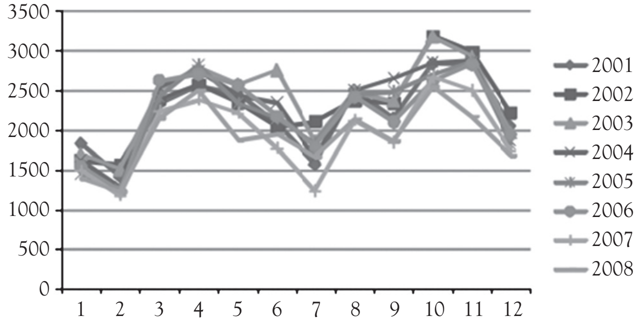


Figure 5.15 Surgical demand for HLCM

The demands at HEGC and HSBA show behaviors that are very similar to the demand at HLCM. Four forecasting methods are applied: Linear Regression, Weighted Moving Averages, Neural Networks, and Support Vector Regression (SVR). The first two are well-known techniques used for forecasting and described in the literature;[15] Neural Networks and SVR are techniques that are increasingly used for forecasting. We used Mean Absolute Percentage Error (MAPE) and Mean Square Error (MSE) as performance measures to determine model accuracy.

For the Linear Regression, Weighted Moving Average, and SVR, the same inputs as the ones described for the Neural Network are used. The results obtained using these four methods for the validation sets of all hospitals are shown in Table 5.2. As observed in this, in five out of seven cases, best results are obtained with SVR, when using MSE as a criterion to compare the different models' performance. When using MAPE as a criterion for comparison, SVR appears as the best option for demand forecasting in all cases.

Given the results described earlier and based on the fact that SVR is built on a solid theoretical foundation, we conclude that it is the most appropriate method for predicting demand in emergency rooms. For practical use, we recommend to additionally consider using simpler methods, which produce results that can be acceptable under certain conditions.

Just having a forecast for the number of patients arriving at emergency services is not sufficient for capacity management; also needed are the different kinds of resources necessary to attend the patients. Following the healthcare conventions used in Chilean hospitals, patients are classified into four categories according to the severity of their illness, as shown in

Table 5.2 Forecast errors on validation sets (best results in bold)

	Linear regression		**Weighted moving average**		**Neural network**		**SVR**	
	MAPE (%)	**MSE**	**MAPE (%)**	**MSE**	**MAPE (%)**	**MSE**	**MAPE (%)**	**MSE**
HLCM Medical Demand	12.67	150,68	7.53	**144,72**	7.45	161,68	**5.61**	154,86
HLCM Surgery Demand	6.54	27,097	7.36	**20,137**	8.99	22,947	**5.09**	25,199
HEGC Medical Demand	15.91	3,114.3	16.5	1,978.3	7.7	1,043.7	**6.86**	**606,32**
HEGC Surgery Demand	8.55	14,302	8.96	11,730	8.3	12,155	**5.88**	**8,120**
HEGC Orthopedic Surgery Demand	8.41	35,940	8.60	28,247	5.12	29,851	**4.44**	**25,460**
HSBA Medical Demand	8.27	3,125.07	11.83	850,342	7.9	1,226.16	**6.97**	**643,98**
HSBA Maternity Demand	10.54	23,738	6.98	12,408	10.6	38,629	**3.24**	**7,867**

Table 5.3. Each category is associated with different uses of the medical resources, as explained in the following section.

As shown in Figure 5.16, the illness severity distribution varies over different months of a year. Nevertheless, the severity distribution per month remains relatively stable over the years. Therefore, in the following calculations, each month will be considered to have a deterministic distribution of patients for each category.

Given the emergency patients forecast and the illness severity distribution, the expected number of patients per category can be calculated. To determine the number of doctors required to attend such demand, the next step is to characterize the behavior of the attention time for each category. For this purpose, a representative sample of C1, C2, C3, and C4 individuals was used.

Table 5.3 Category types and description

Category	Description
C1	Extreme-risk patient
C2	High-risk patient
C3	Low-risk patient
C4	No risk patient

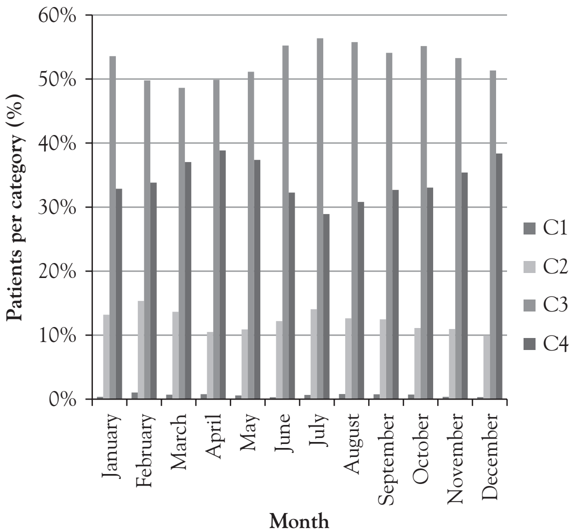


Figure 5.16 Monthly categorization distribution

Each C1 patient is referred to the reanimation room for resuscitation, upon the patient's arrival to the emergency service. When this occurs, and depending on the complexity of the surgery or diagnosis, between one and three of the doctors currently working in the attention cubicles immediately set aside their activities to focus on the extreme risk patient. After the medical attention, the time required to stabilize and treat the C1 patient is registered in a logbook, along with the names of the doctors who performed the medical procedure.

Using this information, we run a *Kolmogorov-Smirnov* (K-S) test to determine the distribution of the C1 patients' attention time. We concluded that it has a log normal distribution with a mean of 108 min and a standard deviation of 121 min. We also noticed that the number of doctors required to attend these patients had a highly concentrated distribution in two doctors; therefore, this value was used for the following calculations.

When trying to characterize the consultation of C2 patients, the data used did not provide enough information to determine a distribution of the attention time. However, in a discussion with the doctors, a consensus was reached where the average time to attend C2 patients is 60 min, with a standard deviation of 20 min. A normal distribution was chosen to represent the behavior of this attention time.

Finally, and with a high level of confidence, we determined the distribution of the attention time for C3 and C4 patients as log normal with means of 10 and 7 min, and standard deviations of 7 and 3 min, respectively. All non-C1 patients are attended by only one doctor.

The time distributions presented earlier provide a basis to estimate the time that doctors will spend to attend the patients from each category, expected to arrive to the emergency room. A summary of the attention time distributions found for the different severity categories and the number of medical doctors required to attend each patient per category is presented in Table 5.4.

An analysis of patient arrivals at different times of the day was performed, as shown in Figure 5.17. This study concluded that 59 percent of the patients arrived at the emergency service between 12:00 hours and 20:00 hours. Using a representative sample, we found that this distribution does not vary significantly among different days of the week or

Table 5.4 Distribution of attention time and number of physicians per category

Category	Distribution	Mean (min)	Standard deviation (min)	Physicians required
C1	Log normal	108	121	2
C2	Normal	60	20	1
C3	Log normal	10	7	1
C4	Log normal	7	3	1

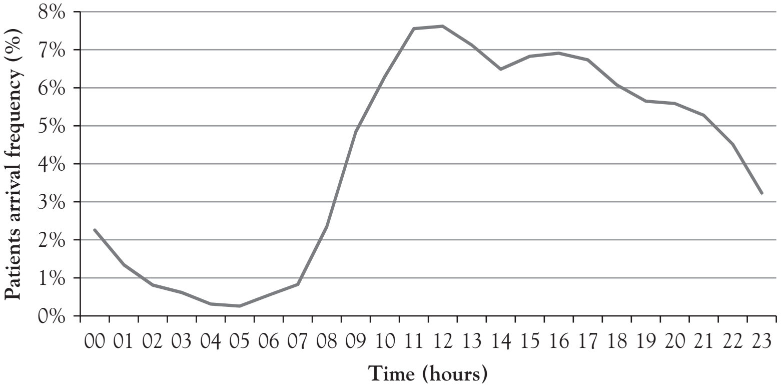


Figure 5.17 Patients arrival distribution per hour

among the same days of different weeks. Therefore, this distribution is considered as fixed for every day of the year.

Now, given a forecast, the subprocess "Capacity Analysis" for the configuration design within the "Demand Analysis and Management" process in relation to the "Emergency Medical Service" in Figure 5.12 is needed, as explained next.

In the literature, several proposals for the configuration of emergency services are defined,[16] of which we selected the option b in Figure 5.18, which considers a Triage, for patient pre-evaluation, and a fast-track line for patients that according to evaluation are more critical; this was complemented with parallel medical facilities for less urgent patients. For such a configuration, we developed a simulation model, shown in Figure 5.19, which evaluates waiting time for a given demand. The simulation model

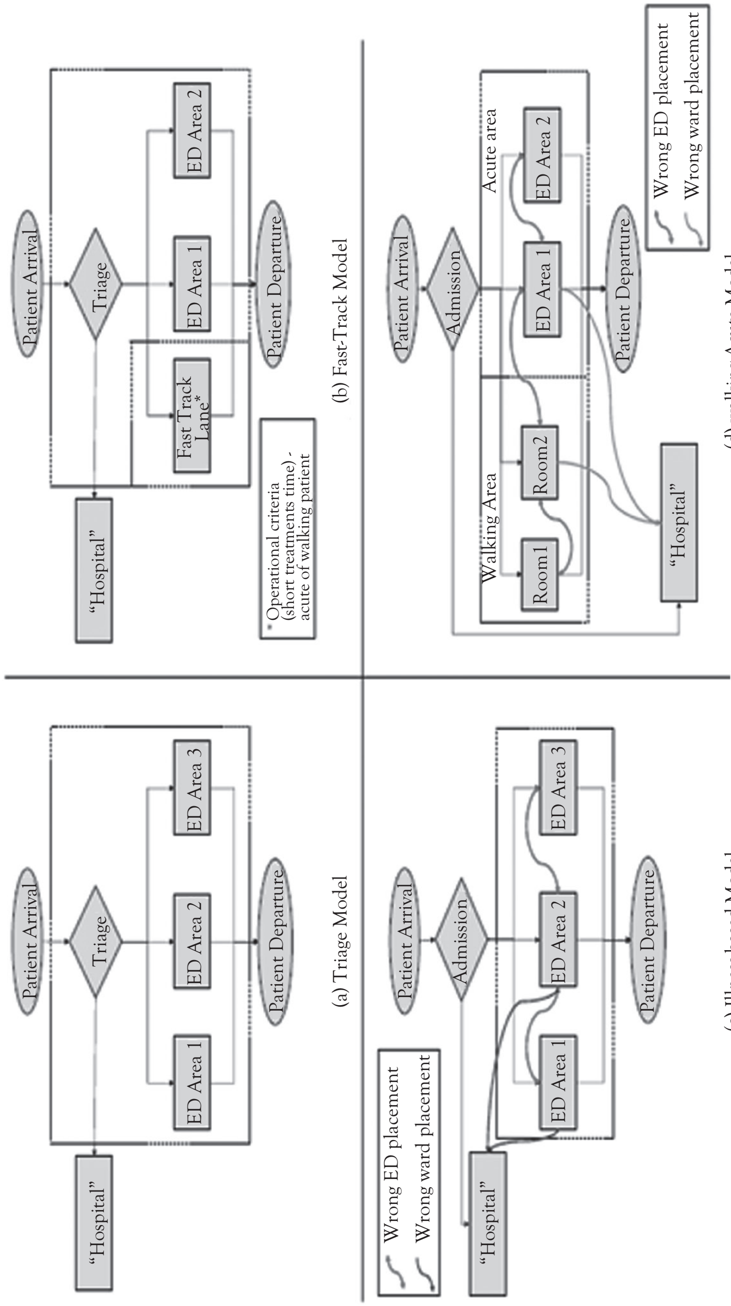


Figure 5.18 Alternative configurations for emergency services

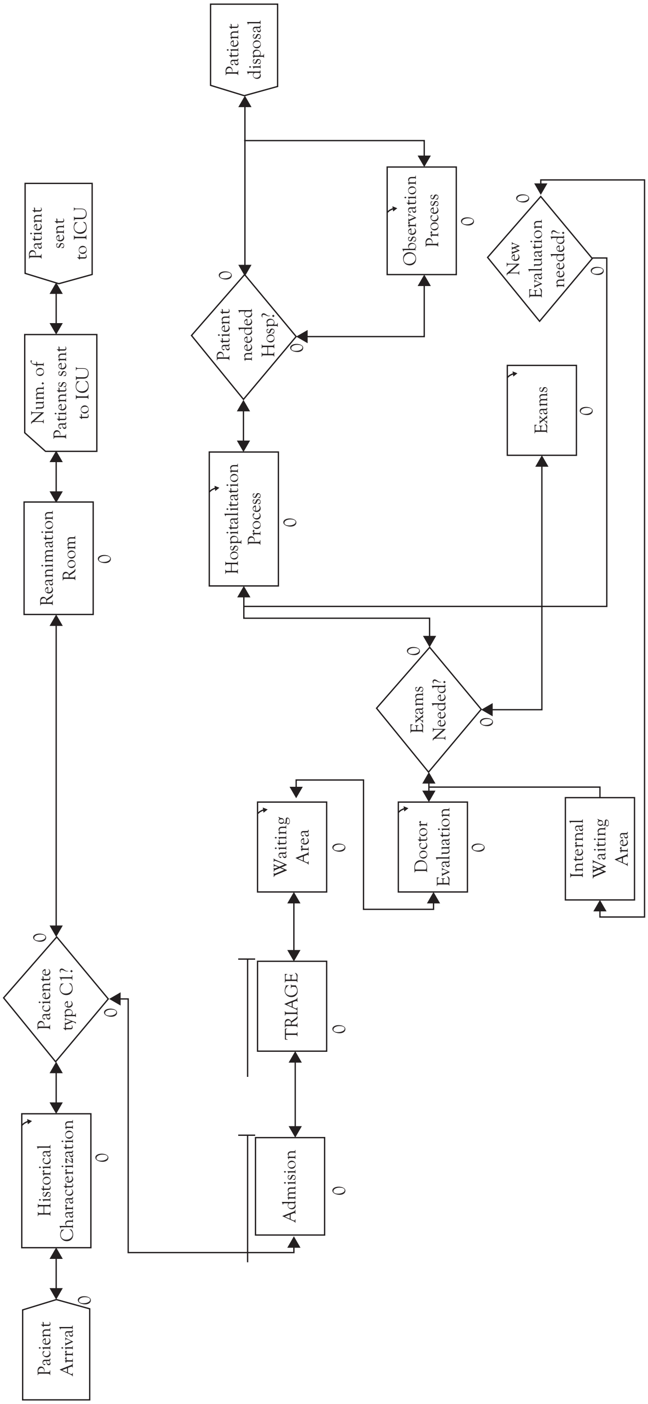


Figure 5.19 Simulation model for capacity analysis

incorporates the stochastic behavior of the demand. Since the waiting time and length of lines have shown to be significantly higher for medical attention, the simulation will be performed for these patients only. The forecast has an error with a normal distribution. To simulate the different demand scenarios for each month, the forecast was adjusted several times by different values sampled from the normal distribution of the error. Due to the stability of its daily behavior, the demand of each scenario was distributed uniformly across every day of the month. The daily demand was further disaggregated into hourly demand. As a consequence, we were able to generate several scenarios of monthly demand disaggregated per hour. Using the hourly forecasted demand from each of the scenarios generated as described earlier, the average forecasted demand was calculated for each hour of the day. We assumed that the hourly demand arrives according to a Poisson process; then, this average corresponds to the mean of the Poisson distribution per hour.

On their arrival at the emergency service, patients are categorized and served according to the time distributions, which are also stochastic. Now that the stochastic behavior of the demand and the medical attention have been incorporated into the problem, we will discuss the construction of the simulation model and its role in the management of hospital capacity. In capacity configuration management, we want to determine how different designs of the hospital facilities, which determine the production process, may affect the quality of service, measured in length of wait (LOW) before the first medical attention. The simulation model allows us to observe how the expected flow of patients will use the different services offered in the facilities of the hospital, and how the available capacity performs when attending such demand. As a consequence, capacity can be redistributed or adjusted with the objective of eliminating bottlenecks and reducing idle resources. This provides a powerful decision tool for managing capacity in such a way that a given service level can be guaranteed at minimum cost.

As stated earlier, the average LOW will be used as the main criterion to compare the performance of the system designs. This metric was calculated weighing the demand per category by its respective average LOW. The results for this metric for the Base and Fast Track simulated configurations are presented in Table 5.5.

Table 5.5 Simulated LOW of different emergency service configurations

Configuration	Avg. (min)	Std. Dev. (min)
Base Case	64.2	1.2
Fast-Track with Triage	57.3	0.9

Table 5.6 Base Case/Fast-Track configurations comparison

Comparing configurations	Avg. (min)	Std. Dev. (min)	Lower bound 95% (min)	Upper bound 95% (min)
Base Case/Fast Track with Triage	6.9	1.5	3.9	9.9

On the basis of the scenarios run in the simulation, a 95 percent confidence interval was generated for the LOW of each configuration. The intervals obtained were (55.5, 59.1) and (61.8, 66.6) for the Base Case and Fast Track with Triage, respectively. To test if the LOW differs significantly between these two configurations, we applied the procedure proposed by Law and Kelton.[17] This comparison is established based on the difference of their respective statistical distributions, as displayed in Table 5.6. Since the confidence interval does not contain the value 0, we confirm that the difference shown is statistically significant.

On the basis of the results presented in Tables 5.5 and 5.6, we observe that:

- The simulation model resembles the actual behavior of the system, since current average LOW is within the confidence interval of the simulated Base Case.
- The main bottleneck occurs in the medical consults and during the day shift.
- The Fast-Track Box with Triage reduces the average LOW in 6.9 min, which corresponds to a 10.8 percent reduction of the current average waiting time.
- Hence, it was decided to implement the Fast-Track Box with Triage configuration, and it is the one currently used in the

hospital where work was performed. Another hospital is replicating the forecasting and simulation-based processes, due to the good results obtained in the first hospital.

It should be remarked that the process designed, with the imbedded Analytics and Information System support, is not a one-time effort. In fact, it is designed for periodically executing the whole process under changing conditions, such as unexpected demand, for example, epidemic episodes and new campaigns, which require adapting capacity. So, a Macro2 to do this is necessary.

We also notice that the process design presented includes the relationships to the other components of the hospital architecture. Thus, the relationship to the organizational structure is included in the process definitions, such as shared services, which is the case of "Demand Analysis and Management" of Figure 5.12, which was presented for Emergency, but needs to be coordinated with ambulatory and hospitalization and other shared services, such as surgery. We did not go into such coordination, but in a complete design, it should be taken into account. If this is done, it means that we are redesigning the organization as well as design the processes. Also, the relationships to the systems architecture and IT infrastructure should be taken into account, since the data come from current systems and the process design should be integrated with such systems. Furthermore, new technological tools, such as Analytics packages should also be integrated into the design.

Design Level iii: Resource Management Process Design

Public Hospital Emergency Resource Management Case

The resource management process will be exemplified with the "Emergency Medical Service," for which the relevant pattern is also, as in the previous section, "Demand Analysis and Management" in Figure 5.12, performed at a lower level of detail. In the previous case, we considered the aggregated demand for configuration (which also implies service production) design, and in this case, we must use the disaggregated demand to define resources needed and assign them to process operation.

For forecasting demand in the first subprocess of Figure 5.12, the same models are used as in the previous section, but at a more disaggregated level. Then, a capacity analysis has to be executed. Here, the key resource is availability of doctors, since they are the ones who diagnose and provide treatments for emergency patients. Hence, demand has to be converted into medicals hours needed of different specialties, which were determined through technical coefficients. Comparison with available resources defines lack or excess of resources, which is the basis for the determination of correcting actions; of course, there may be a feedback among these activities in order to analyze resources for given correcting actions, such as changing number or schedules of doctors. We then evaluate the impact that redistribution, reduction, or addition of medical resources would generate on the performance of the system. The resource management analysis, then, will be performed for the Fast Track configuration only. The same simulation model of the previous section, shown in Figure 5.19, is then run for several assignments and number of doctors per shift under the Fast Track configuration with Triage and assuming a stochastic demand.

If the current structure of two 12-hour shifts is maintained, an initial scenario would consider only redistributing the doctors available in a different manner. Given the greater arrival of patients during the day, a possible redistribution could include the reassignment of doctors from the night to the day shift. As a consequence, more doctors would attend during the day shift than at night. The average LOW of this scenario would be 45.1 min. Further, resource management considerations may determine the addition or reduction of medical hours for attending the patients. Since these resources are known to be quite expensive, the different scenarios were simulated by changing the existing capacity in 0.5 doctor intervals. The extra half doctor interval was included through the creation of a new shift of 6 hours, from 12:00 to 18:00, which is precisely the period in which most patients arrive at the service. Thus, the number of 6.5 doctors available means that 4 doctors attend on the day shift (8:00 to 20:00), 1 doctor on the half shift (12:00 to 18:00), and 2 doctors at night (20:00 to 8:00). The average LOW obtained with this configuration is 40.5 min. The simulation was run using from 5 to 7 doctors within 24 h, and distributed as explained earlier. The idea behind analyzing the reduction of the current number of doctors is to assess whether the performance of the system is affected in a significant manner when these resources are lacking, either by management decision or by absenteeism. The average LOW for different numbers and assignments of resources are summarized in Figure 5.20, including the 95 percent confidence interval for each of the points.

As expected, the addition of medical resources improves the service quality, measured in average LOW. The interesting result is that the average LOW decreases dramatically when increasing the number of medical resources from 5 to 5.5 doctors, while it decreases more gradually when new resources are added. To test whether the LOW difference between all the scenarios included in Table 5.7 is statistically significant, we applied again the procedure proposed by Law and Kelton. Table 5.7 shows the confidence intervals when comparing the LOW of these scenarios. As

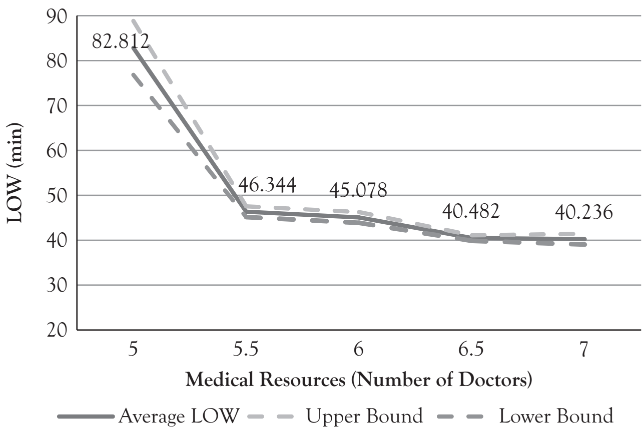


Figure 5.20 Average LOW and confidence intervals for different numbers of doctors

Table 5.7 Confidence intervals for compared scenarios

Comparing scenarios	5.5	6	6.5	7
5	[30.4; 42.6]	[31.6; 43.9]	[36.3; 48.3]	[36.5; 48.7]
5.5	-	[-0.4; 3]	[4.5; 7.2]	[4.4; 7.8]
6		-	[3.3; 5.9]	[3.1; 6.5]
6.5			-	[–1.1; 1.6]

it can be observed, increasing from 5 to 5.5 doctors provides a significant improvement in the performance of the system, while the change between 5.5 and 6 doctors does not. Nevertheless, increasing from 5.5 to 6.5 doctors does show statistical significance.

The previous analysis of the system performance provides hospital managers a decision tool for determining the number and distribution of medical resources on the emergency service, based on a cost and benefit analysis of resources and service improvement. The preceding results were used to assign doctors to the different kind of boxes and define their work schedules and also to assign additional doctors. Each of the activities of the process "Demand Analysis and Management" in Figure 5.12 has computer system support, as exemplified in the model in Figure 5.21 for "Capacity Analysis," which uses the Business Process Management Notation (BPMN) notation. Notice that, in order to use these tools routinely, one has to embed the models and the application logic we have described in the supporting system to the actors of the process as specified in the design of such figure.

As already commented in the previous case, this type of design clearly includes organizational design, since the roles in the lanes of Figure 5.21 have been assigned specific tasks in the execution of the process. Also, IT support is specified in a very precise way as data processor, and more importantly, as a container for embedded logic that allows optimizing resource assignment.

Design Level iv: Operating Management Processes Design

The fourth design level refers to the management processes necessary for the day-to-day operation of the business' Value Chain, in connection with customer relationship, suppliers' relationship, and production management and execution, as modeled in Macro1. Also, there is operations design in connection with Macro4 supporting processes, such as financial and human resource management. To illustrate this type of design and the use of Analytics, we will present several cases in the private and public sectors.

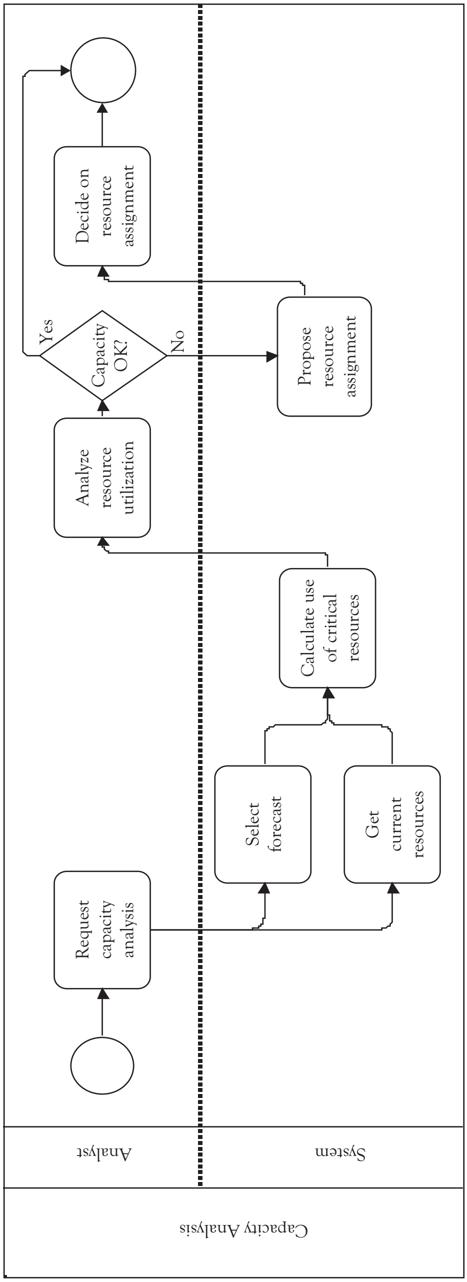


***Figure 5.21* BPMN for "Capacity Analysis"**

International Seller of Office Equipment

This case deals with an international company that sells office equipment, documents solutions in general, which defined a Strategy oriented to give integral services to clients, and a Business Model based on the proactive selling of value-added services adapted to clients' needs. This needs Capabilities of structuring internal customer information and develop predictive models to generate proactive value-added offers, so that Intelligence Structure II is the one that should be used. Since we have a level iv design, this is consistent with selecting BP1, "Client's knowledge based selling," as stated by Table 5.1.

The application (specialization) of BP1 to this situation is shown in Figure 5.22, where what is more relevant to this case is detailed. In particular, focus is concentrated on "Data mart creation and client' clustering," where sales history is structured with an appropriate technology, and a Data Mining tool is applied to discover patterns through clustering and binary trees. Moreover, "Clustering characterization and generation of sales campaigns" are important, since it is here where, based on the clusters, groups of clients with particular needs are discovered and specific customized offers are defined, which are implemented by means of campaigns. The key idea of this proposal is to implement the Capability that make it possible to go from passive selling of office equipment to proactive selling of document solutions, and eventually, business solutions that provide high-value services for clients.

This is an example of a *local design case*, which, as opposed to the previous cases presented using a top-down global business design approach, concentrates on just the Value Chain. It is also consistent with the rule 1 of Chapter 4 for mapping from BP to process architecture, which states that BP2 "Client knowledge based selling," the one that has been used in this case, implies a redesign of Macro1, as the only component of the architecture. Then, we first concentrate on the "Customer management" process of Macro1, modeled in Figure 4.20, which shows how the Capabilities required by such design get implemented at a higher level of detail. In particular, illustration of the Analytic Capabilities necessary to understand and characterize clients for proactive selling are designed at the operating level and explained in this case.

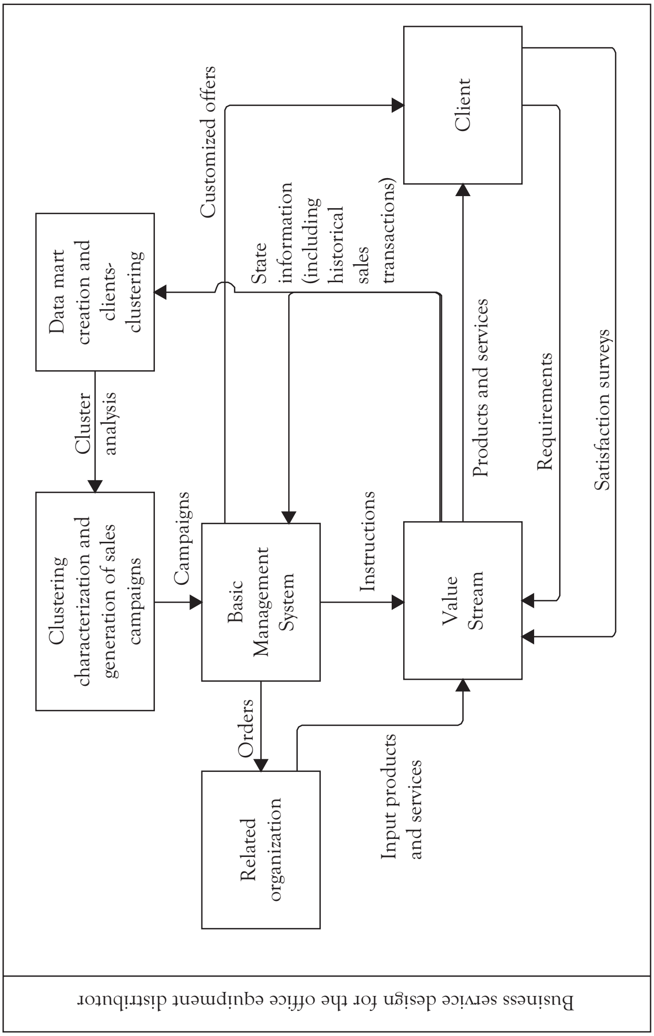


Figure 5.22 Business service design for the office equipment distributor

In the model in Figure 4.20, we concentrate on "Analysis and Marketing," detail of which is presented in Figure 4.21. The specialization of this pattern to this case is shown in Figure 5.23, using the first style of process modeling mentioned earlier.

This process has been fully redesigned, as compared to the current operation, by introducing a process, as the pattern suggest, of "Customer behavior analysis and segmentation," which did not formally exist before this project. The new process focuses on dynamically identifying the characteristics and behavior of the clients of the firm, by using Data Mining techniques. In addition, this characterization is the basis to perform the process of "Marketing actions definition," also in Figure 5.23, in order to provide instructions and leads to the process of "Selling and customer request processing" and also to "Sales planning," which will execute the marketing actions. Notice that all the design ideas come directly from Macro1.

A fundamental organizational change in this design is to group all the marketing functions, which were dispersed in different units, to coherently decide the marketing actions and the clients to which they will be oriented. This, again, shows that in-depth process design implies organizational design; also, there is IT design involved, since the technology of Data Mining will be introduced, including the design of a client's Data mart.

On a lower level of design, we show a full BPMN model, in what we called the second style of process modeling in the "Process modeling" section of Chapter 3, for "Customer behavior analysis and segmentation" of Figure 5.23, which is included in Figure 5.24. In this process, we show the logic of how the data related to the behavior of the client will be analyzed, using Data Mining techniques, to segment the clients and to obtain the profiles of the different segments with the purpose of being able to better satisfy their needs. The process begins with the recovery, from internal databases and external information, of the data related to the clients' behavior. To avoid incorrect data being used later in the analysis, it is reviewed and cleaned and loaded into a Data mart; an analyst checks that the data is correct and the load has been made in a satisfactory way. With the data already loaded, it is prepared for the execution of the

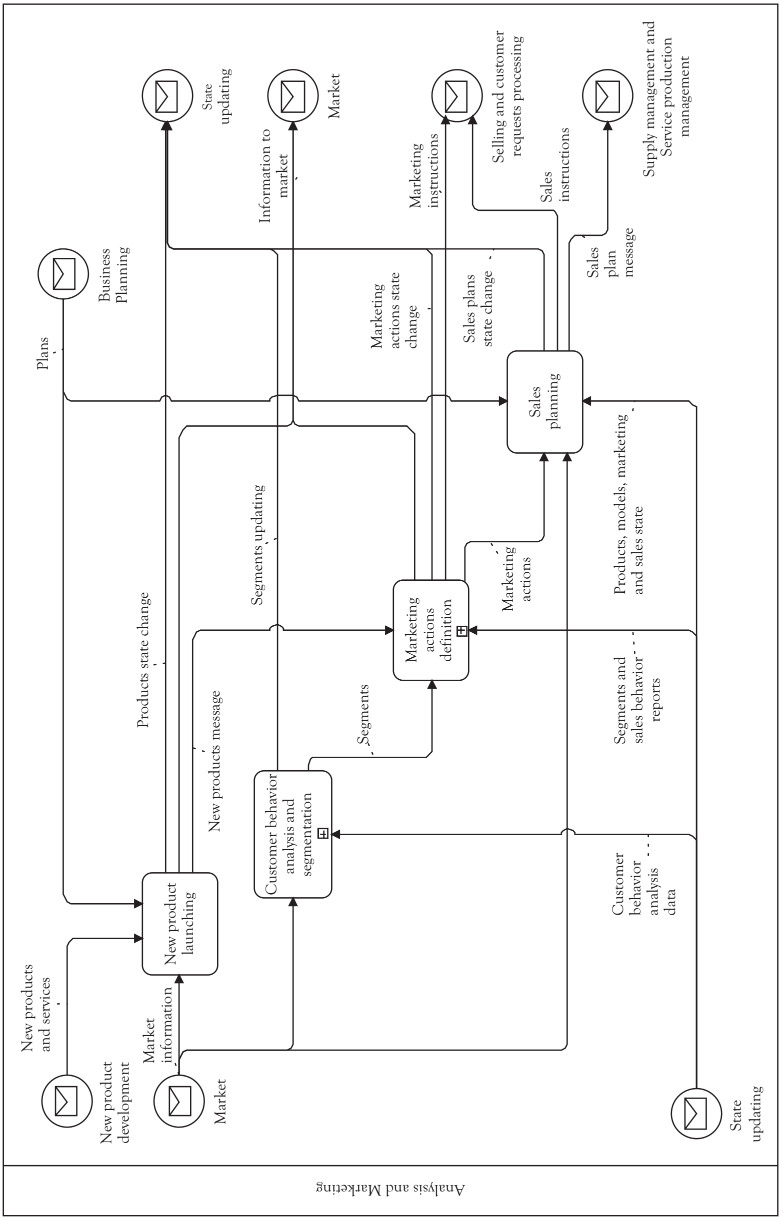


Figure 5.23 ***Design (specialization) for "Analysis and Marketing"***

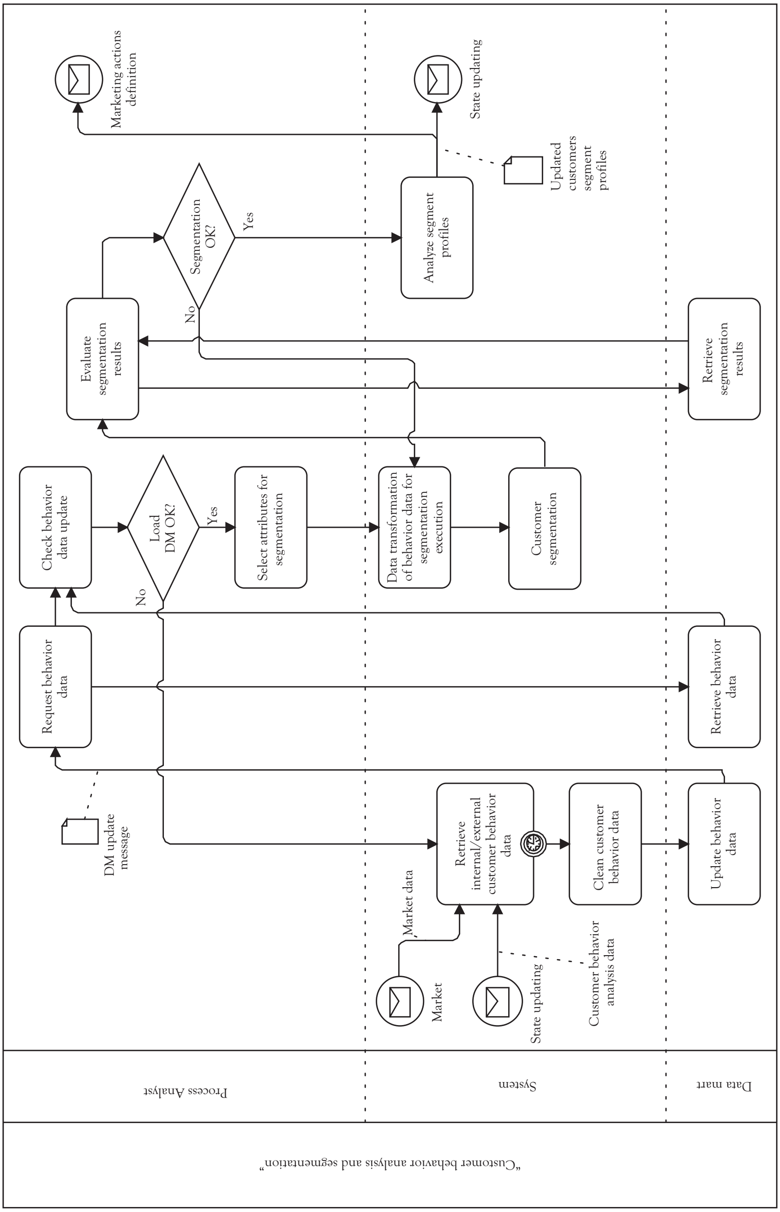


Figure 5.24 "Customer behavior analysis and segmentation" design

segmentation. This step is necessary since the data must be normalized and transformed, so that the segmentation algorithm can use it.

The segmentation algorithm is within the developed application (System). This way the process is simplified, and it is not required to generate connections to external systems. The results of the segmentation must be evaluated by the analyst, and if found satisfactory, they are stored for their diffusion and use. The last stage of the process consists making an analysis of the segments and to determine which of their characteristics and profiles are and to leave the results of these analyses available for "Marketing actions definition" of Figure 5.23.

We give further details of the logic involved in some of the activities of the process just described, which are based on a clustering algorithm and binary trees.

The proposed segmentation (clustering) algorithm consists finding groups between a set of individuals. The segmentation technique used is the partition method k-Means, which was explained in the "Analytics" section of Chapter 3. For the evaluation and profiling of the segments found, the following clients' attributes are used:

- Number of equipment by client
- Equipment lines distribution in the client's facilities
- Quantity and characteristics of prints in rental equipment
- Number of visits and hours used in technical support
- Quantity of accessories
- Quantity of parts, software, and supplies delivered to the client
- Accumulated invoicing to the client
- Number of months with invoicing
- Number of invoices
- Equipment bought
- Lines of product bought

With the data for these attributes, cleaned and complemented by statistical analysis, the algorithm k-Means was applied. The parameter k was determined with a method provided by Rapid Miner,[18] which led to 6 segments, as follows:

1. Stable with middle expansion, 30 percent total clients
2. Stable without expansion, 28 percent
3. Stable with low expansion, 23 percent
4. Stable with continuous expansion, 7 percent
5. Lost clients, 6 percent
6. New clients under development, 6 percent

Segments were checked by evaluating cohesion and degree of separation among the segments and found of good quality; they were characterized by means of profiling using variables such us regularity of invoicing, amount of invoicing, degree of rental and characteristics of equipment used, degree of use, and frequency of acquisition. Then, a classification based on binary trees was performed; an example of the results is given as follows for the clients in segment "stable with middle expansion," which define then according to the following rules:

Days in which last machine was acquired <9
- Color printings <=3891.5
  - Printings BW >143.5
    - Lectures taken <=206.5
      - Fraction total color printers acquired <=0.5
        - Color printings <=254.5

These rules apply to 96 percent of the members of this segment.

Now, we present the detailed BPMN design of the process "Marketing actions definition," as shown in Figure 5.25. In this process, the strategies are elaborated and will be applied to the different segments found in the process "Customer behavior analysis and segmentation," explained earlier.

The actions are generated or modified by the process analyst and are approved by the commercial manager. In this stage, the objective is to design actions, based on the characteristics of the found segments, which allows satisfying the needs of various clients and permit the organization to reach its objectives. In producing such strategies, the following four steps are executed:

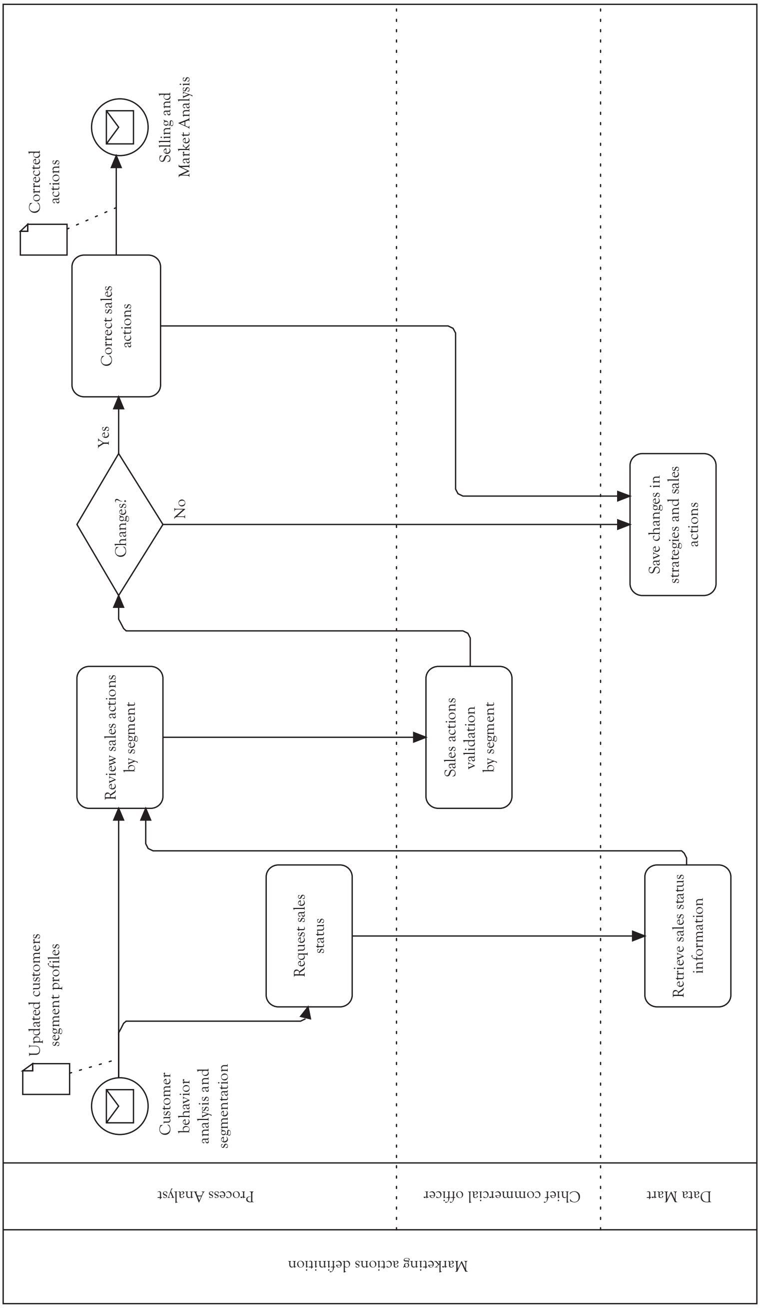


Figure 5.25 "Marketing actions defnition" design

1. To identify the clients' segments
2. To evaluate the position of the segments
3. To perform a cost–benefit analysis to prioritize the actions by segment
4. To construct and to provide different actions based on two generic strategies: retention and development

These steps were applied to all the segments resulting in well-defined marketing and sales actions for each of them.

This design has been fully implemented and is currently operating successfully; some of the results obtained so far are an 18 percent increase in business leads as compared with the previous situation and a success rate of 42 percent for the proactive leads generated by the new Capabilities.

Food Production and Distribution Case

Next, we present another case in sales management, which is done according to the business design summarized in the corresponding section. Such design pointed toward strengthening the Competitive Advantage of the business, which consisted supplying most of the small food retail shops in the country with its products, through a large force of salesmen who periodically visit such shops. The challenge was to manage the growth of the portfolio of clients with quality. To increase the number of clients, and simultaneously, to improve the service to retain them seem opposed objectives in a portfolio of more than 40,000 clients. On the other hand, the market served demands the actual visit of the salesman, but each client buys a small amount per visit. Therefore, it was concluded that the success factor was to optimize the field work of the salesman: to visit more clients and be more effective. The daily plans of visits for the salesman, to be generated in the way explained as follows, should assure a maximum numbers of clients (yield), and that all the clients will be taken care of some day of the week (service).[19]

In Figure 5.26, the decomposition of "Selling and customer requests processing" of Figure 4.20 is specialized to this case, using the first process modeling style. The model in the figure includes three subprocesses:

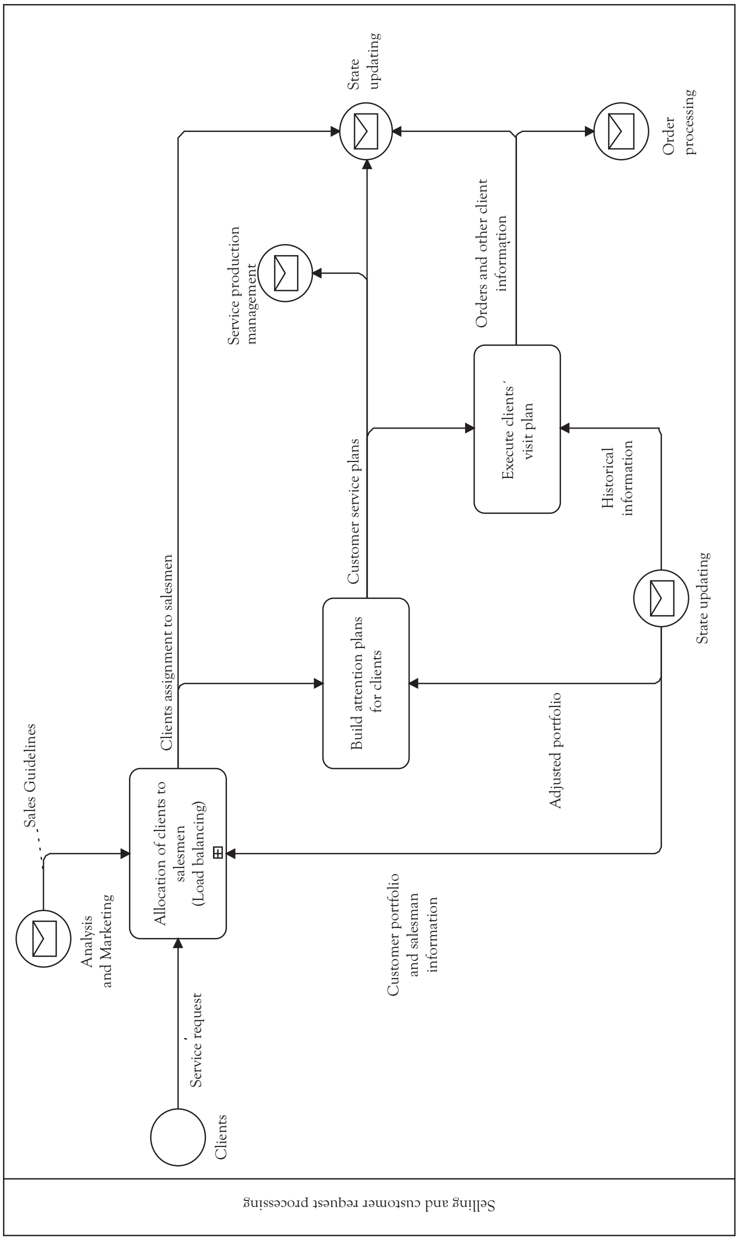


Figure 5.26 Decomposition of "Selling and customer requests processing"

1. Allocation of clients to salesmen: it corresponds to the objective of the optimization of the clients' service by assigning clients in a balanced way as we explain as follows.
2. Build attention plans for clients: determines when and as part of which route each client will be visited, also detailed as follows.
3. Execute clients plan visits: carrying out the visits according to designed routes and collecting orders from clients.

In Figure 5.27, the detail design of "Allocation of clients to salesmen" is shown using a BPMN model with the second process modeling style. The execution of the model gives as a result a balanced portfolio of clients for each salesman, considering variables such as total number of clients, average sale per month in weight and value, real frequency of visits, actual frequency, and number of daily visits. The following definitions and criteria are used in the model:

1. The regions and counties of the country will be used as geographic divisions to be assigned.
2. A polygon is a geographic area that is derived from a county depending on the number of clients it contains. There are two possible cases: it includes a complete county or a partition of it, as shown in Figure 5.28, for the second case.
3. A polygon must be assigned only to a portfolio.
4. A portfolio is a geographic area, including one or several polygons.

In Figure 5.27, the business analyst uses two systems to execute the process: SugarCRM system, an existing software, and System TRIO, a software developed for this case. The first provides the required data, so that the system TRIO operates on it and generates the portfolios.

The process begins with the selection of the parameters that identify the geographic zone to work, that is to say: region of the country and county. The system TRIO extracts the data from the CRM to calculate the key variables of the process: clients, kilos, amount, real frequency, and visits per day. In addition, it presents the list of the suggested polygons. All this information is complemented with a geographic visualization in

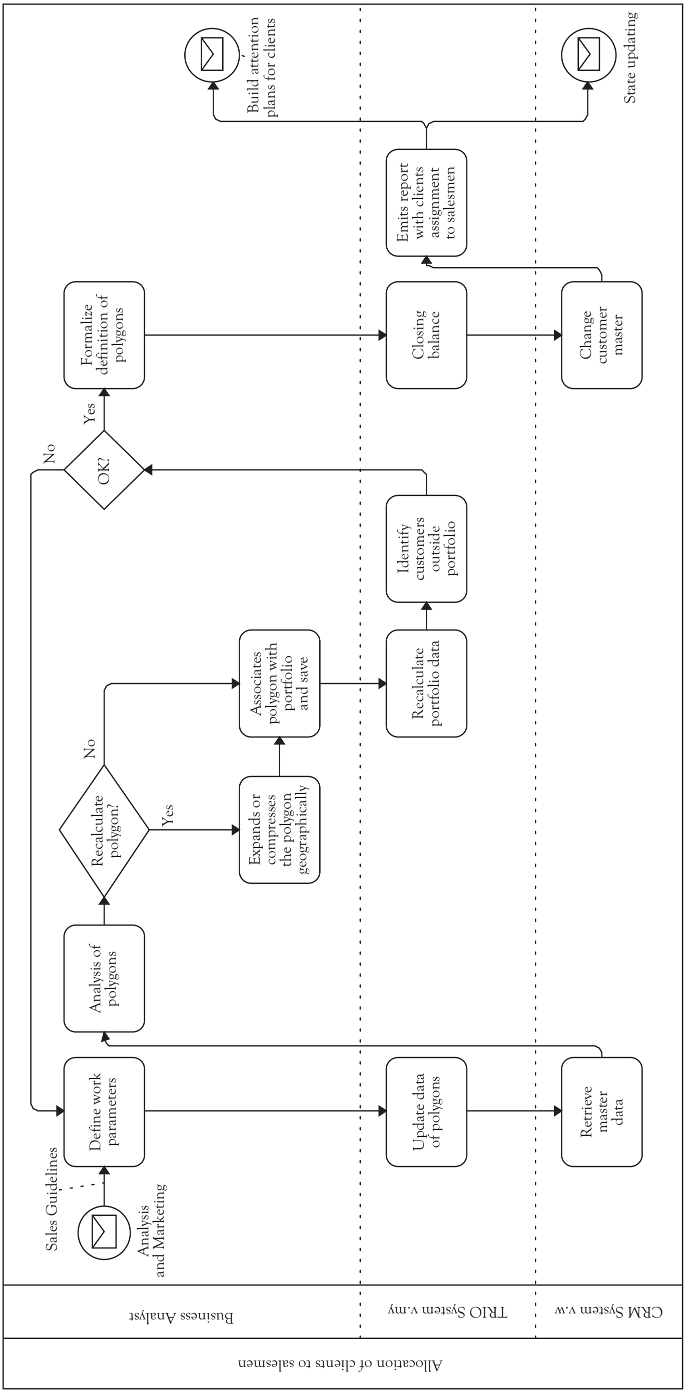


Figure 5.27 "Allocation of clients to salesmen" design

Sub county:

A county has too many clients and must be divided in several polygons (geographical clusters)

Figure 5.28 Examples of counties with several polygons

Google Maps, in which it is possible to identify each client. The business analyst reviews the displayed data, and has the option of modifying the suggested polygon based on his or her experience. It can change the borders of the polygon by expanding it or compressing it, removing or adding clients. Once this action is completed, the polygon associates with a portfolio, and at the same time, updates the system and recalculates the data of the portfolio. If in the process of polygon adjustment, there are clients left without assigning, the system aids the analyst to identify them, continuing with the adjustments until all the clients belong to a polygon. This sequence can be repeated until he or she considers that the definition of the portfolio is adequate, according to the variables used to define it, to be assigned to a salesman.

Now, we explain the Analytics embedded in the business logic the system executes to recommend polygons. The proposal is based on the amount of clients that a county has. If the polygon is for less than a county (the county has more than 300 clients), each polygon is the result of application of the clustering algorithm k-Means, explained in the "Analytics" section in Chapter 3, to group 200 clients in each one by location proximity. If the county has less than 300 clients, the proposed polygon is equal to the county. In formalizing the balance process, two key parameters for each portfolio are due to define:

1. Type of initial routes: routes may be by sectors or weekly (will be reviewed in detail in the process). A portfolio will have initial routes by sectors when there is a high density of clients or a high frequency of attention, usually in urban areas. A weekly initial route is defined when the density of customers or customer service frequency is low, for example, in rural areas. Thus, it directly depends on the presence of the company in the area and the distances between clients and the company.
2. Frequency target is the frequency that is defined commercially if it is possible to reach this target. This logic is detailed as follows.

One parameter necessary for the following calculation of routes is the frequency of weekly visits for each client. This represents the particularity of each client in their need for attention. A single criterion or a unique way to calculate it for all customers was considered to be inappropriate, so three simple ways of defining the frequency were identified:

Case 1: Calculation of the frequency according to the actual frequency of historic purchase in past 12 months

Case 2: Calculation of frequency by portfolio goal, where visits are determined by a frequency target, which is defined to attain an objective growth of sales in a given portfolio

Case 3: Customer frequency defined by the analyst.

So, this logic is applied to all regions of the country, where the company is present. The logic has been kept as simple as possible; since it is the first time that what was tacit is being formalized. Then, the logic will be adjusted according to experience.

Next, we present the design of "Build attention plans for clients" of Figure 5.26. The result of this process is the plan of work per day of the week (6 days) for each salesman; that is to say, each portfolio will have six visit plans, and in each one, the list of clients to visit is included according to a calculated sequence to minimize crossings. This information is downloaded to a Blackberry, which allows taking digital orders while visiting clients. The BPMN diagram of this process is presented in Figure 5.29.

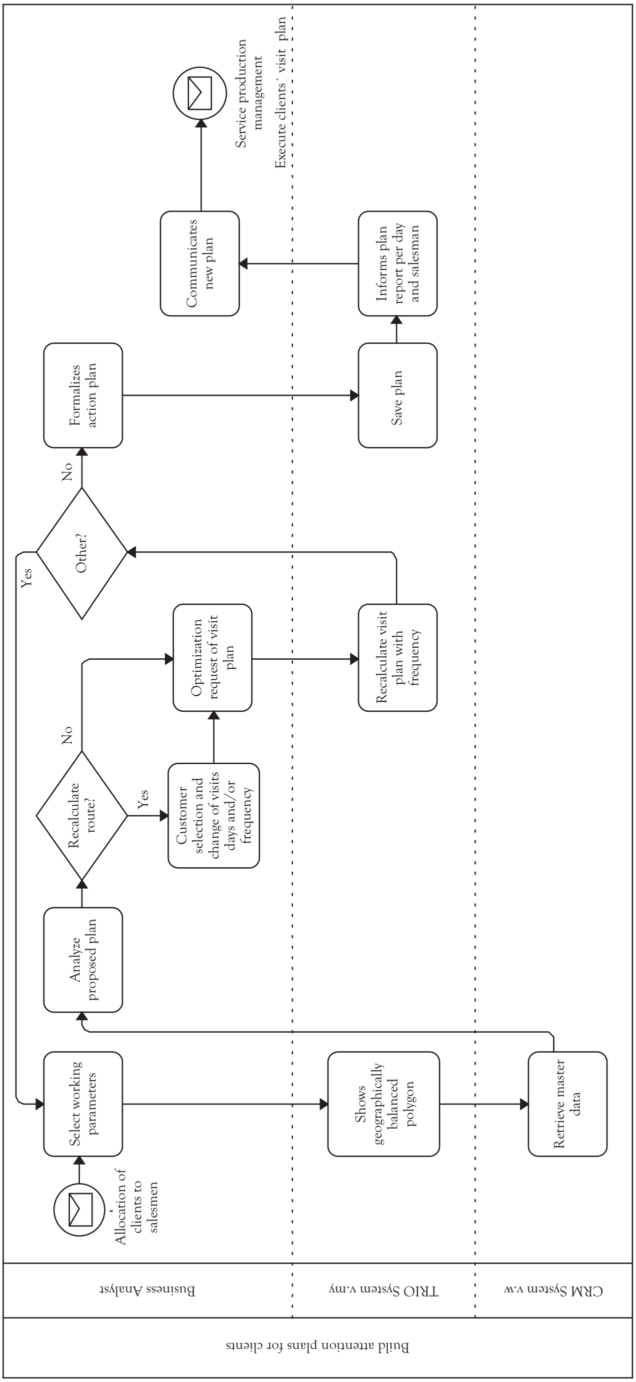


Figure 5.29 "Build attention plans for clients" design

The business analyst selects the region where there is a portfolio of clients for which a visit plan will be optimized. Then, the system displays a proposal of an initial detailed plan of visits for every day of the week. The data are displayed in a tabular way and geographically. The proposal of the displayed plan is calculated for a week and sector, depending on the identification that was made of the portfolio in the balance process. If, when analyzing the route of a day it is discovered that it is possible to improve it, then the analyst can select the client in the map and change his or her visit day.

The Analytics are used as follows in this process: a portfolio of clients is determined by sector and routes designed to visit them within a week. The objective of the algorithm to do this is to select attention routes that include geographically closed clients. In doing this, the following steps are executed:

1. Each portfolio is divided in three sectors by geographic clustering (k-Means with k = 3), as shown in the example of Figure 5.30; k = 3 is applied because each cluster represents a pair of days of the week for the attended sector; thus, it could be defined: A = {Monday and Thursday}, B = {Tuesday and Friday}, and C = {Wednesday and Saturday}.
2. Allocation of the type of visit; the type of visit corresponds to the alternatives for visiting clients, for example, every day, or once or twice per week.
3. On the basis of the type of visit, each cluster and each client is assigned to a given day of a six-day week, where the objective is to meet the visit frequency for each client, previously determined.

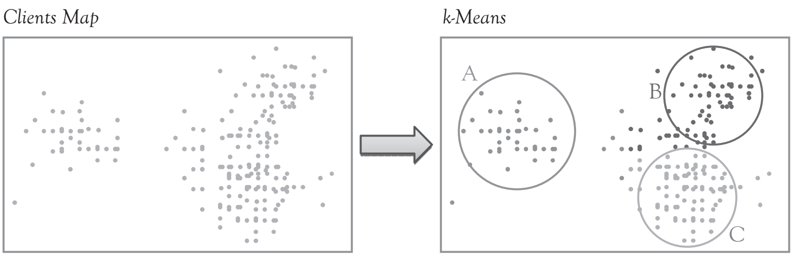


Figure 5.30 Sectors defined by clustering

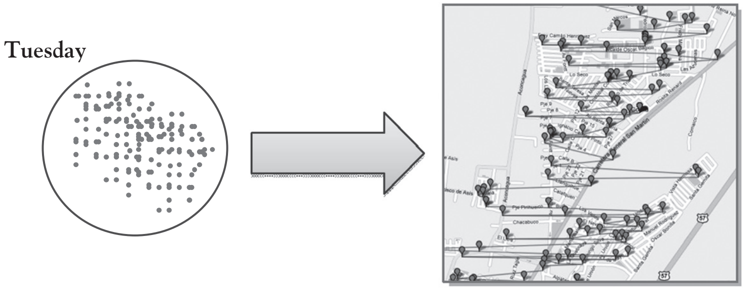


Figure 5.31 Route for a day and cluster

4. Each cluster is mapped to a daily route.
5. Route optimization.

Finally, each daily route is processed with an algorithm that solves the traveling salesman problem through a heuristic based on Sierpienski curves,[20] which was mentioned in the "Analytics" section of Chapter 3 and gets close to the sequence that minimizes the total distance to visit all the clients. For example, in Figure 5.31, there is an actual case of route optimization for a given date and cluster.

The new process of sales and the computing support were implemented in a region of the country with the following results:

1. The commercial pilot region represents 4 percent of the total company sale.
2. The income of accumulated sales from January to October in the region of the pilot increased between 20 and 40 percent with respect to equal months of the previous year.
3. The amount and frequency of purchase by client increased and the loss of clients diminished.

The process is under implementation for the rest of the company.

Production Management Case

Now, we present a case of production management in a cardboard manufacturing plant of a leading international pulp and paper company in

Chile,[21] which is also a local case. The Strategy for this plant is obviously of best product with an emphasis on low cost due to local comparative advantages of faster (twice) pine growth rate in the location where its forests are located, as compared with competitors with plants in countries such as Scandinavia and Canada, which means a low cost for pulp and cellulose. In addition, pine as raw material requires less quantity for the same paper strength than eucalyptus, which is used by competitors as Brazil. Additionally, it wants to be distinguished by its products' quality, which is adapted to customers' requirements, and service excellence in orders fulfillment. Finally, the plant wants to reinforce the earlier mentioned advantages with the best use of its production facilities. Regarding clients, who are spread worldwide, the commercial strategy of using sales representatives in markets where they compete, has allowed this company to have a thorough knowledge of its customers, with products specialized to their needs. This closeness creates a cost of change for customers, but can be overcome through competitors by providing the same services; therefore, the conclusion is that the product is relatively standard and other competitive advantages are necessary. Then, complementary to what is stated earlier in this best product strategy, this plant has extended the service provided to the key variable of delivery time of products, and given the large distance to its main markets, has extended its logistics network and installed warehouses in Europe and the United States. Subsequently, the Business Model is based on the value provided by low-cost products adapted to customer requirements and delivered according to their needs. Besides, the obvious technologically state-of-the-art production processes that reinforce the comparative advantages due to natural factors stated earlier, this plant needs a Capability for a production scheduling process that allows to use capacity as much as possible and to prioritize and monitor customers' orders to assure service; so, an Intelligent Structure II is needed within a BP6, "Optimum Resource Usage." This solution is included in Macro1 within the BPP in Figure 4.19, since in the decomposition of "Service production management," there appears the scheduling of resources for the execution of the service in processing a given demand in the activity "Service production planning."

The project focuses on the task of load assignment to the cutters of the conversion manufacturing process, specifically in the selection of the cutter used to manufacture the cardboard orders, since each of these is requested in piles of a nonstandard dimension that suits customers' needs. This is an activity of great complexity, and today it is performed by professional schedulers. The task is complex because the assignment requires the analysis of at least ten variables per order to schedule, and there are approximately 80 orders daily processed in 7 cutters; also, two new cutting machines will be added soon. The production process is supported by a two million dollar Enterprise Resource Planning (ERP), specialized in paper plants, which does not have the required algorithm to program the cutters. However, it manages all the information such algorithm needs to run. Therefore, the key idea is to superimpose an intelligent analytical process over the ERP, which is a type of solution we have implemented in many cases. As a matter of fact, in the previous case of the food processing company, an intelligent process was also superimposed over an existent CRM. Both cases illustrate the use of the Intelligence Structure II.

The incorrect selection of a cutter can decrease production rates significantly, as also a good and systematic selection can bring the levels of production above today's standards. Hence, an intelligent scheduling process based on job shop heuristics, as the ones described in the "Analytics" section of Chapter 3, is proposed, which will not assure a "perfect" solution, but under certain conditions, gets close to the optimum.

The process to be designed is "Resource scheduling," included within "Service production planning" of Figure 4.22, and it is decomposed and specialized in Figure 5.32. It begins with the subprocess "Programming of paper machine for direct rolls" that defines the cardboard rolls to be manufactured to comply with customers' requests, starting with the information provided through "Orders to be processed and transport availability" messages, which define priorities and shipping capacity. Once the programming is done, it is registered in "State updating," including the status of orders that were scheduled.

Next, the subprocess "Programming of paper machine and Conversion Room and load release" is performed, where the work of selecting the cutter in which the rolls in each order will be cut to the required size and work load will be released. It is executed by using a heuristic that has an objective to select the cutting machine in which each order is to be processed, and then the release (timing) of the load to the chosen machine,

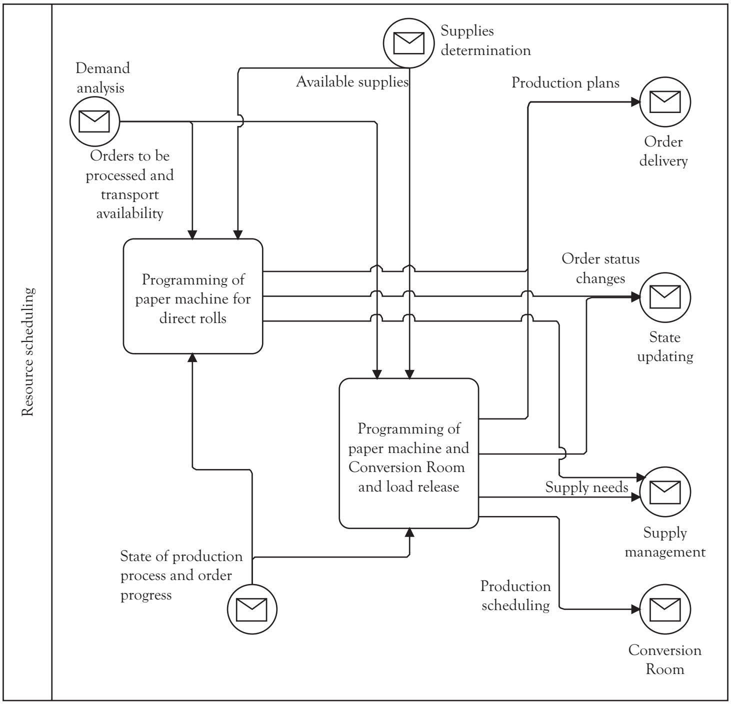


Figure 5.32 Decomposition and specialization of "Resource scheduling"

minimizing the total time for the production of all orders. This activity also updates the status of the production program and orders and the load (schedule) of the Conversion Room.

Next, in Figure 5.33, the detail design of "Programming of paper machine and Conversion Room and load release" in BPMN is presented, using the second modeling style.

The process begins when the "Production Scheduler" requests the system "Inimajiq," which is built for supporting this process, to select data from OptiVision, the existent ERP, to start programming for certain defined conditions; the most important data are paper, paper machine time block, and type of orders to schedule (direct or semifinished rolls to conversion). In the case of conversion, the scheduler reviews the data and then calls the execution of the heuristic, which appears as a separate track, since it can be a web service, also written for this particular process. When it delivers the results to the "Production Scheduler," they are analyzed; if

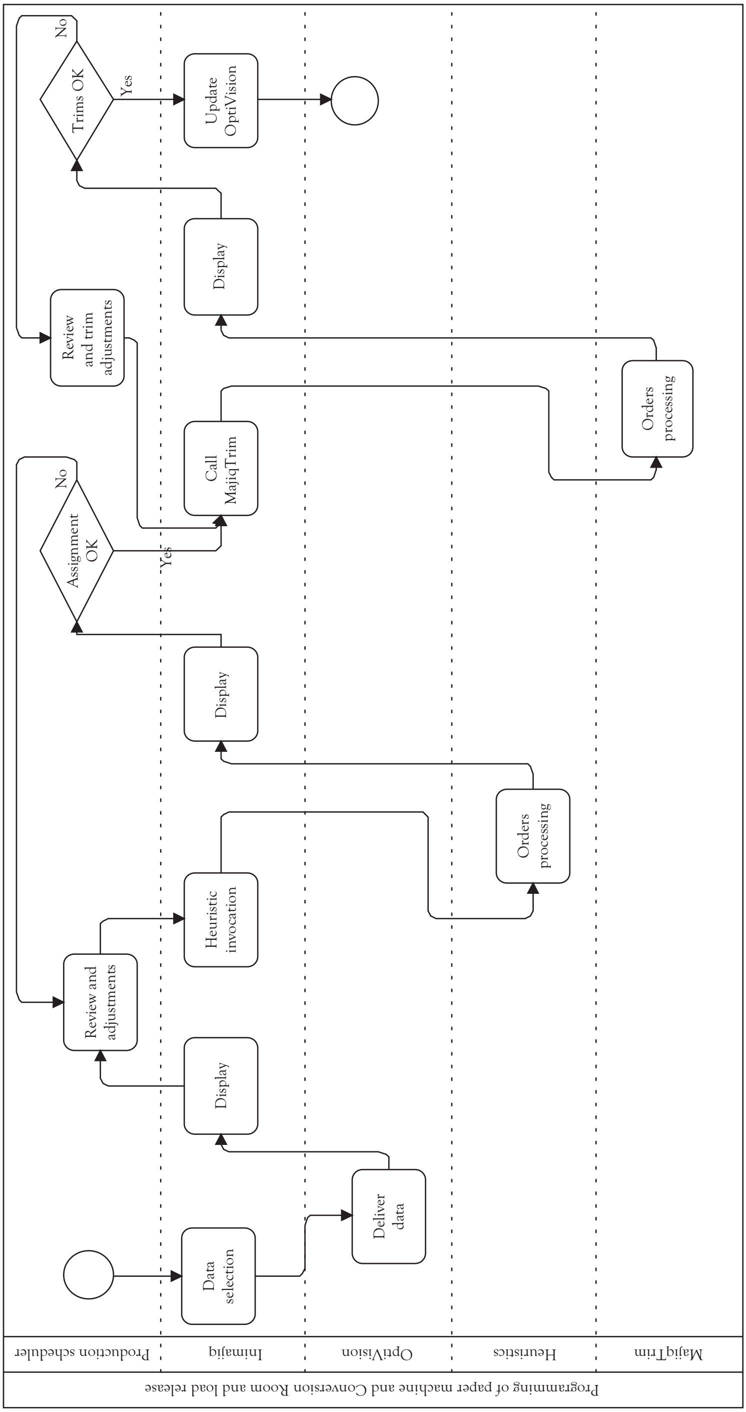


***Figure 5.33** Design for "programming of paper machine and Conversion Room and load release"*

the allocation of machines is correct, the scheduler requests the generation of trims through "MajiqTrim." This is a program that assigns orders to a roll to minimize waste (unused roll material). Once "MajiqTrim" has delivered trims, the programmer reviews several results, the most important being the quantities the routine has proposed to manufacture for each order and the waste generated; then, the programmer decides to make adjustments such as how to incorporate new orders, add stock orders, or set parameters on the optimization routine. Finally, and usually after some iterations in this routine, it sends the trims to OptiVision, where they are made available for manufacturing.

Now, the heuristic used in the preceding BPMN is explained. As we mentioned earlier (the "Analytics" section, Chapter 3), the resolution of the job shop problem can be performed using several techniques or types of algorithms; the most popular are branching and pruning, Tabu search, genetic algorithms, and search in directed graphs. After analyzing the different alternatives, it was opted for the search in the directed graphs as a method of solution, mainly because it is less complex and more accessible to the operators of the process; furthermore, the test performed with the method showed good fit to the problem faced and provided good results.

To obtain a good load allocation, it is necessary to define what will be the objective function, variables, constraints, and policies to include, where these last ones correspond to particular requirements that customize the resolution of the job shop problem to the reality of production scheduling in a cardboard plant. The objective in applying a heuristic is to minimize solution make span, that is, minimize the total time of processing of orders in machines.

The problem in this case is defined by the following facts, constraints, and policies:

1. There exist orders (P) that must be scheduled to be processed in the cutters. There are M unrelated cutting machines in parallel, where each machine has scheduled stopping times.
2. Cutters have different speeds depending on the length of the sheet on the order.
3. Cutters have different efficiencies (number of cuts), depending on the width of the sheet on the order.

4. Each cutter can manufacture an order at a time.
5. Not all orders can be manufactured on all machines.
6. The total execution time may not exceed 24 hours.
7. Minimize the gaps, that is, trying to use machines as much as possible.
8. Each order is manufactured in just one machine.
9. Give priority to large order on faster machines.

Additional points which should be considered in the heuristic are:

1. Setup between orders for a machine have been ignored or considered to be zero.
2. Selection of orders to incorporate in the process is made by the person in charge of scheduling, based on priorities and other technical factors.
3. The objective function of the job shop problem is to minimize total make-span.

Figure 5.34 presents a simple example of use of the scheduling for three orders (P1, P2, and P3) and two machines (M1 and M2), which shows a graphical solution.

In Figure 5.34, each node represents an assignment of orders P to machines M, and in this simple case that allows an enumeration of all the possibilities, once completed the last level of the tree, the last node with minimum processing time should be selected.

Evidently, if P and M are large, the quantity of nodes that can be generated is also very large. So, the heuristic has to define criteria to continue branching on the nodes that hold promise in terms of finding possible good solutions and disregard the ones which do not. In a tree like the one in Figure 5.34, each level represents an order that is incorporated into the analysis, each node has a total execution time (make-span) and in its creation defined policies can be applied, in addition to validating constraints.

To understand how the proposed heuristic works, some of the criteria used in generating the tree are specified:

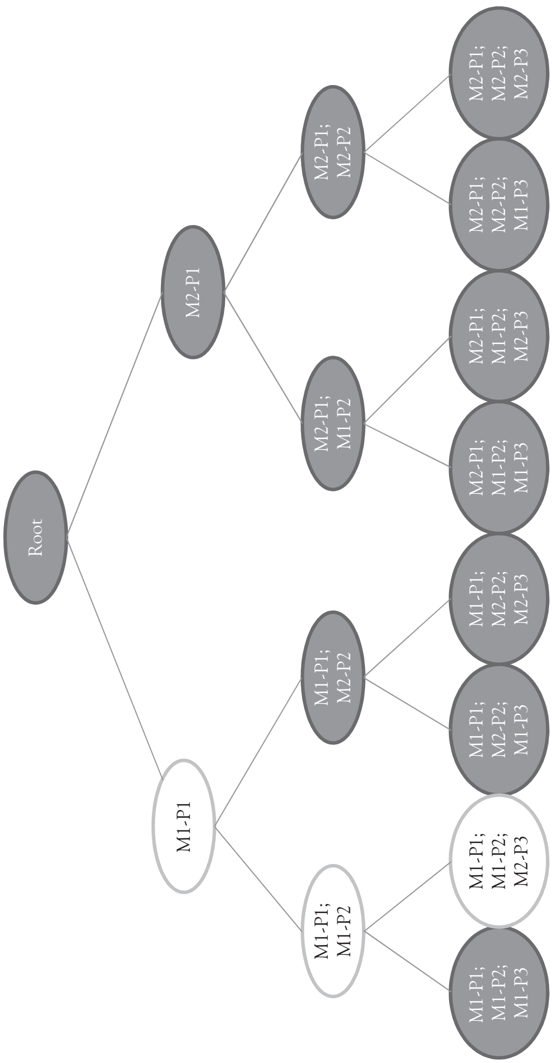


Figure 5.34 Sample scheduling tree

1. Everything starts with a root node.
2. Sort orders from major to minor, whereupon the solution space tends to prefer the larger orders in the machines that process faster.
3. In each level under consideration, search all those nodes which have not been analyzed for exploration.
4. Calculate the make-span of each node and verify if it exceeds the time limit of manufacture; this means that the solution that passes through a node that exceeds such limit is not viable and no further branching from it is necessary.
5. Create a node, which adds to the path a new step with an order and a machine not previously considered; calculate and store the make-span of the node.
6. Sort the tree by placing nodes with lower make-span to the left.
7. Prune or remove nodes that are on the right side of the tree from a certain number onward, which do not promise good solutions.
8. Select the best node by identifying the one with smallest make-span and check the standard deviation in the use of the machines. It has been empirically proven that the node with better make-span always tends to keep all machines busy.

The renewed scheduling process, outlined earlier, for which the most important innovation is it includes a heuristic that allows generating the work load on the machines, executed with the support of a computer application, which tries to maximize production, meeting constraints, has been implemented at the plant. This new process has produced the following results:

1. At the fifth month of operations of the new process, an output of 4,000 additional tons and an estimated income increase of $1.2 million have been achieved; extrapolating this to future operation, and considering a learning effect, means a yearly extra income for this company in the order of tens of millions of dollars.
2. The definition of an explicit and formal allocation and release of load to the machines activity has enabled better communication, less conflict between areas, and better use of installed resources.

3. The problem solved by this project is similar to the problems encountered in other productive plants, including ones of the same company, that have a production process of semifinished products and then a process of termination. This means that the solution can be extrapolated with some adjustments to other productive processes.

Public Service Case

Finally, we consider a local design case in a public service related to the control of labor laws, such as those related to work contracts, benefits, working hours, and the like. The unit that performs this control has as objective to assure that organizations comply with these laws and reports to the Labor Minister. It has a staff of hundreds of inspectors who hear complaints from workers, verify the work site for an actual violation of the law, and if there is, they have the authority to propose a fine to the company as default. In parallel, the inspectors visit companies according to a schedule to review the situation of their workers and possibly find violations. The schedule of visits does not have any rationality behind it and is close to random; furthermore, it has a very low success rate in finding law violators, and hence inspectors' time is wasted. Therefore, the opportunity here is to analyze the behavior of companies and sectors and try to find patterns that indicate what companies or sectors are most likely to be violators, which should be more controlled to correct such violations. This approach is presented as follows.[22]

In this situation, it is intended, from the strategic point of view, a best product approach in the variant of operational effectiveness. The value that is to be generated for clients is to provide attributes for the service that are appreciated by them, such as low cost for companies by avoiding unnecessary inspections and better quality of service to workers by solving or avoiding labor law violations.

The Capability that is needed for such Strategy and Business Model needs Analytic to model companies behavior with internal data, so Intelligent Structure II is required; this is aligned with BP3, "Internal learning from process improvement," which, in this case, requires being able to use Analytics to systematically process hard data to determine the origin and possible solutions for process problems related to inspections. This should lead to very efficient processes, which are also convenient for the stakeholders. The design problem is then centered on Macro1, and within it, in "Service production management" of Figure 4.19, which should perform the analyses of labor violations behavior, and based on this, generate cost-effective inspection plans. The other relevant process in this case is "Service production and delivery," which executes the inspection plans and generates the data (inspection results) that allows continuously evaluating inspection effectiveness, re-evaluating behavior models, and improving inspections plans. On the basis of these ideas, a first level design for "Service production management" is presented in Figure 5.35, based on a specialization of the model in Figure 4.22. In this figure, the first process is "Analyze behavior of sectors," which is constantly monitoring law violations and developing various models of segmentation and classification that will form the basis for determining the needs for inspection (demand). This process uses historical information of the various productive sectors with detailed audits, complaints, fines, and infringements of each company. "State updating" provides all the relevant data that are required in this activity: attributes or input variables and current models that will be monitored. The output of this process is "Behavior models" that will be used for inspection planning. The second process is "Plan inspections," where the planning of the audits is done based on the behavior of the different economic sectors and companies. The process has as an input the available models and generates the "Inspection plans" that will determine inspection visits in the process "Service production and delivery." The third process is "Inspection control" where the executions of the inspection plans will be reviewed and analyzed to find deviations or unexpected results that signal the need for model correction or replanning.

Next, we present the details of the design of "Analyze behavior of sectors" of Figure 5.35, including BPMN diagrams and Data Mining methods included in the process' execution logic. As it is typical in these types of analytical models, there are two subprocesses that can be clearly defined: Segmentation, which is basically clustering, and Classification, where predictive models are developed. Details of a previous data collection and preparation activity will not be explained here.

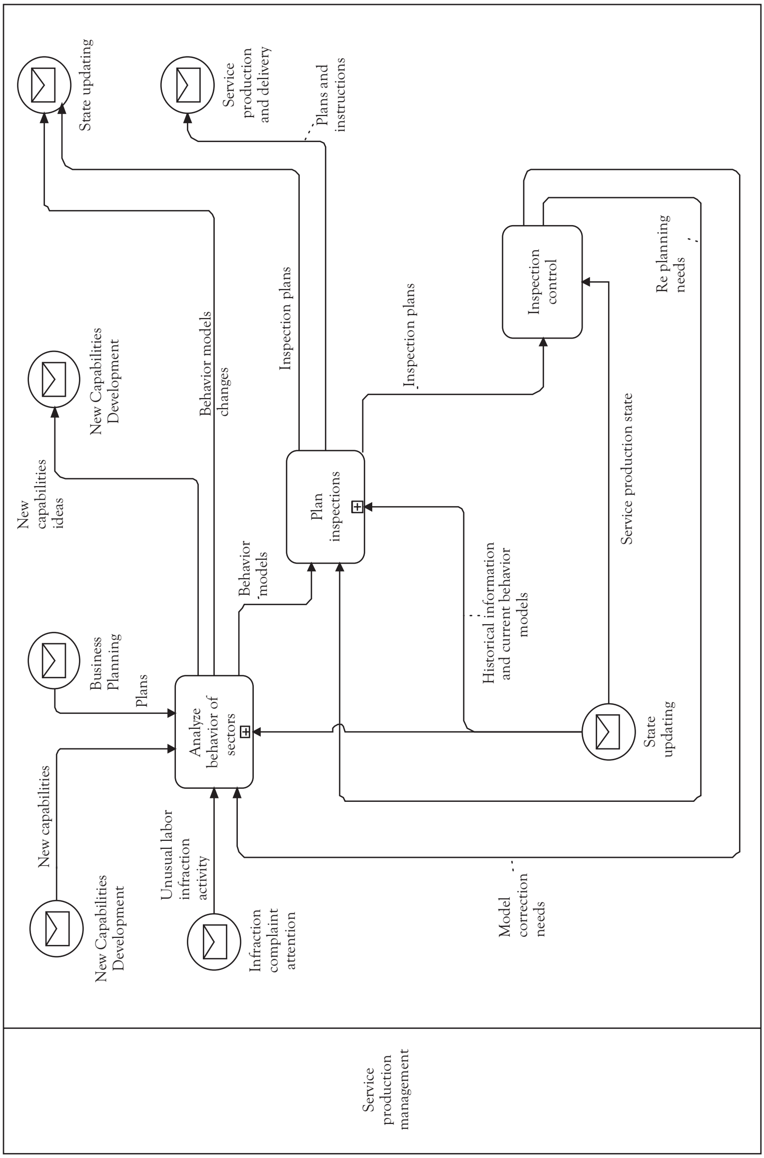


Figure 5.35 Decomposition and specialization of "Service production management"

In Figure 5.36, the Segmentation BPMN is presented, which operates as follows.

In the Segmentation process, the central idea is to use Data Mining tools to group companies. Activities begin when the "Model Analyst" requests from the "System," a supporting computer application, available segmentation algorithms and attributes of the available data. The System delivers the requested information for the analyst to examine if the attributes are suitable for clustering through the selected segmentation algorithm. If they are not appropriate, he or she has the option of requesting new statistical analyses for modification or selection of new attributes. If the attributes are appropriate, he or she proceeds to the configuration of the new grouping model chosen according to the selected attributes. The "System" runs the newly configured model and delivers numerical and graphical results. Then, the analyst, with the help of more specialized inspectors, examines groupings delivered by the model in order to find consistent patterns that explain these segments. It is often the case that, in this type of models, the first groupings are not clearly different, so, various numbers of segments are tested until adequate results are obtained. He or she may also vary the attributes used in the generation of the segments. The process is repeated as many times as necessary, until groupings that explain clearly the behavior of companies are found, which are registered in "State updating." The next step is to generate the Classification models that predict the behavior for the identified segments. Classification models consist of a series of patterns that are useful to distinguish classes with rules that define their behavior, which usually take the form of Decision Trees. Once a model has been generated, it can be used to predict the class of other nonclassified records, since models are only made with a sample of data from the total number of companies. The BPMN that defines how to derive the classification is given in Figure 5.37.

The process begins with the "Model Analyst" requesting an analysis of previously developed models and the new attribute data available for a particular segment. Then, the analyst decides if new attribute data are required, and if necessary, he or she initiates an application that searches for it. If there are enough data, he or she instructs the system to prepare training and test samples and defines the attributes for the system to train the model and generate the classification error based on the test data.

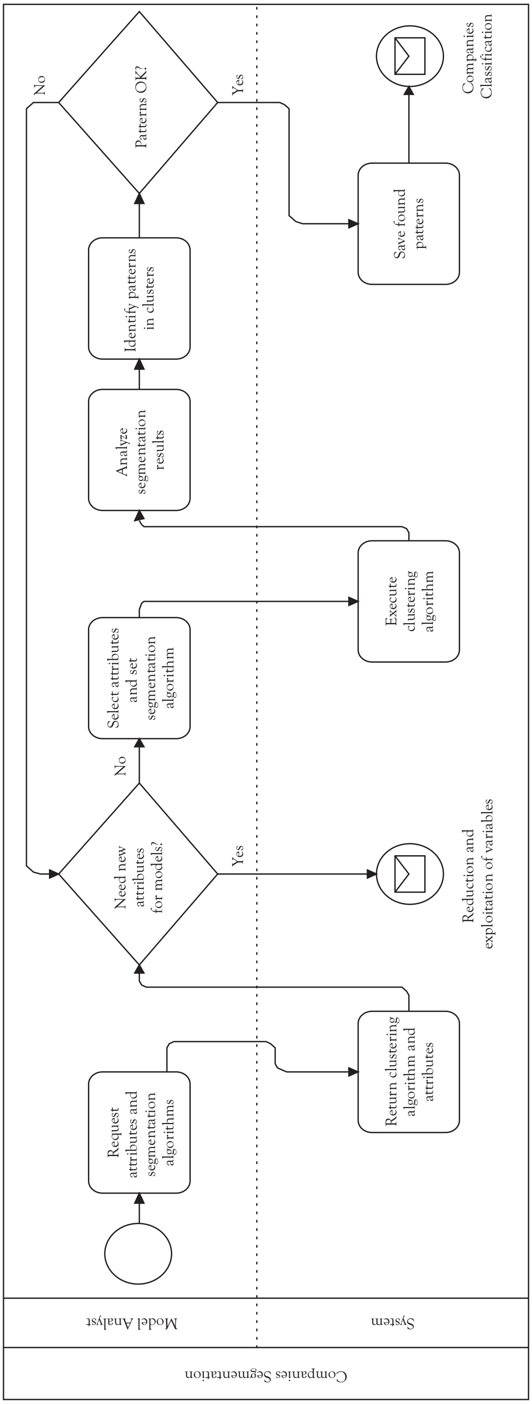


Figure 5.36 Companies segmentation design

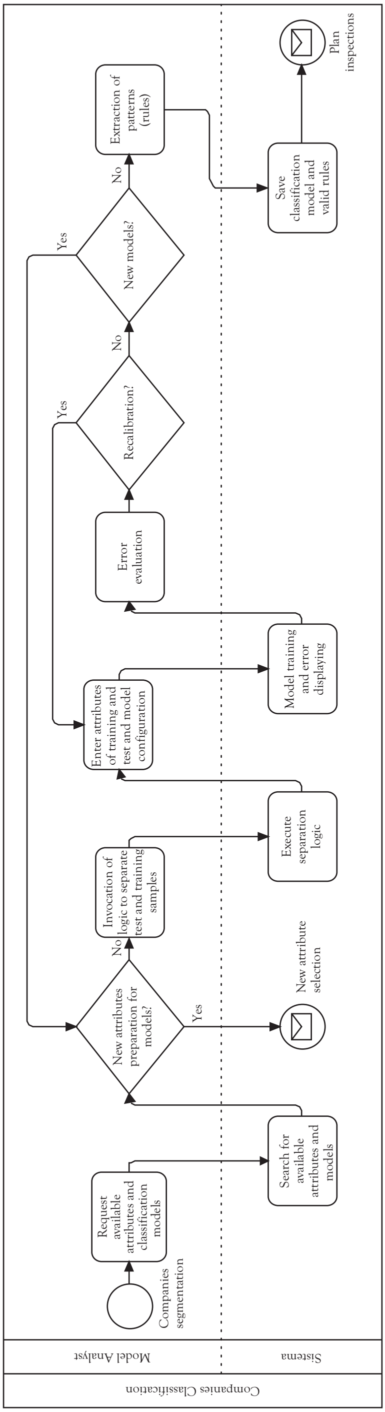


Figure 5.37 Design for companies classification

With these results, he or she evaluates the model performance and decides to accept it or to recalibrate it, including the possibility of generating a new one from scratch. The last step is the identification of patterns in the form of rules that can be derived from the model for a better understanding by the persons responsible for interpreting the results.

Next, some results of the application of the processes Segmentation and Classification are presented using the clustering and Decision Trees analytical methods, previously described in the "Analytics" section of Chapter 3, and their actual application to generate inspection plans for companies.

The information on which the results are developed contains 1,119,642 inspection records, from which a sample of 200,000 is taken; they contain diverse denunciations, reclamations, fines, conciliations for companies as well as basic data for them, as type and size. The total number of attributes per company is 13. Examples of these are: total number of inspections, number and amount of fines, infraction subjects (e.g., nonpaid overtime), number of workers affected, company type, and location. Several common statistical analyses, such as population stability, outlier's consideration, and null values fixing, were performed in order to prepare the data for the processing described as follows.

For Segmentation, the k-Means algorithm, described in Chapter 3 and used in other two cases in this section, is applied. For this, k = 4 is selected, and the open software Weka[23] that runs the algorithm is integrated into the System that supports the process. The results of the determined clusters are as follows.

For example, using the attribute "Number of fines," the results in Figure 5.38 signal that clusters 1 and 3 are the ones with more infractions, companies in these clusters having fines for more subjects in default.

Similarly, all the variables can be used to generate clusters that illustrate which companies are more likely to generate infractions and under what conditions. This was done for this case, arriving at the following conclusions:

1. Companies that belong to cluster 1 should always be inspected, since they have a high rate of infraction to the labor code.

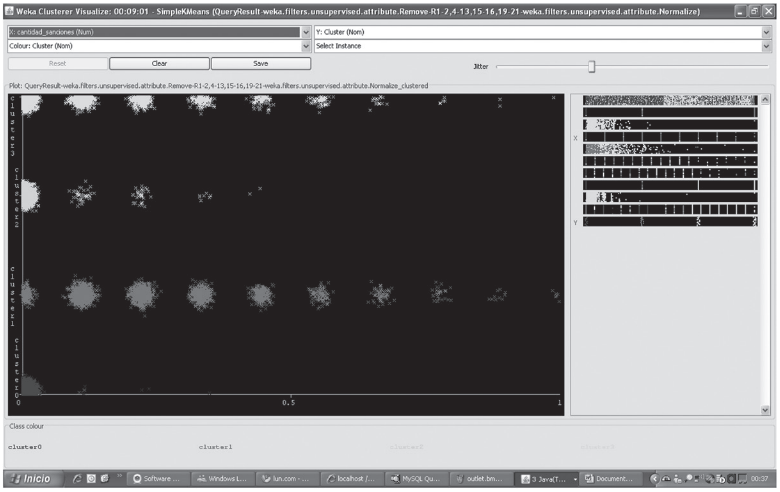


Figure 5.38 ***Clusters according to "Number of fines"***

2. In the companies of clusters 3 and 0, inspections should be random, although they do not have a high number of inspections with fines, they have many denunciations and infraction subjects involved, situation that merits a review.
3. In the companies that belong to cluster 2, there is an extremely favorable situation, while they have been controlled, no infraction to the labor code has been found, reason that suggest they must have a special treatment due to the good practices with their employees.

Once the companies have been classified, it is necessary to extract the rules where the rest of the companies can be assigned to a cluster (0 to 4), and so, define the way they are to be inspected. Therefore, the induction of rules through a supervised Decision Tree model is necessary. To elaborate these rules, the same software used for clustering was adopted. The software implements an algorithm that uses a dataset to determine the binary tree that defines how to assign a company to a cluster and another, for which it is known the cluster to which they belong, that it used to test the quality of the prediction of the tree. The final form of the tree in this case is shown in Figure 5.39, to determine to which cluster a company belongs, which has not been part of its construction; a path of the tree is

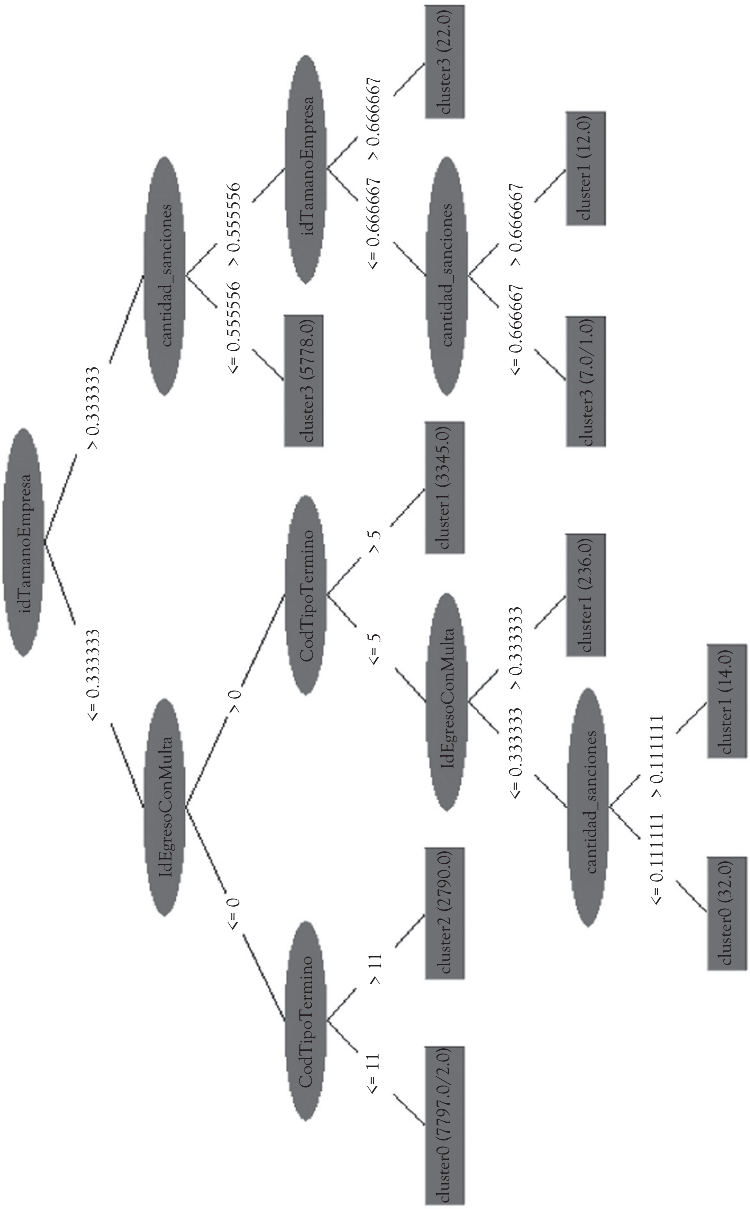


Figure 5.39 Binary tree for determining rules for a company's cluster

to be followed applying the rules it defines, using the value of a certain variable of the company to select which branch of the tree should be taken. Doing this one variable at a time and in the order in which they are in the tree, in the final node, the classification of the company is found. It is clear that the tree can be transformed into a set of embedded rules that can be applied automatically to determine the classification of a company.

The quality of the prediction of the binary tree can be tested with a dataset that was not used in its construction, for which we know the cluster each of the companies in it belongs to. These companies are part of the previous Clustering procedure. This was done for the data previously described, and it was found, by means of an statistical analysis (Confusion Matrix) that the prediction of a company belonging to cluster 1, which is the most important due to its high rate of labor infractions, has a precision of 71 percent. Hence, it is good enough to serve as a basis for inspection programs. This was the case in the public service we are presenting, where the rules derived are being used routinely to improve the rate of success of inspections and contribute to diminish labor laws infractions, and hence improve the quality of work situation in companies.

CHAPTER 6

Conclusions

General

As proposed by Spohrer and Demirkan,[1] the idea of "integrating scientific, engineering, and management disciplines to innovate in the services that organizations perform to create value for customers and shareholders that could not be achieved through disciplines in isolation" produces impressive results when there is an approach that orchestrates innovation and value generation. Our version for this integration is what we call Business Engineering, which is a hierarchical top-down approach, allowing a systemic design of a complete enterprise, or part of it, starting from Strategy and Business Model, putting them into practice by determining the needed Capabilities and Business Design, and finishing with processes and Information Technology (IT) support design that make the whole innovation operative. The proof that this approach works is empirical, with its application to many real cases, successfully implemented, in very different situations in manufacturing, distribution, financial services, government services, and health, both private and public.

Another important conclusion is that it is possible to continously formalize and structure design experience in patterns—business, architecture, and processes—that provide innovation design ideas at different levels of the proposed design hierarchy. We have shown in all the cases presented that innovations are accelerated when a design pattern is used, specializing it to the particular situation, which is much more efficient and effective than to start design from scratch or from so-called "as is" models.

The use of a hierarchical design approach based on patterns has also the advantage of allowing to position at the right place the integration of Spohrer and Demirkan's disciplines when performing service innovations. Thus, for example, as we have presented in this book, quantitative marketing—with the tools of Data Mining—is used to model customers' needs and options; Management Science allows characterizing providers' logistic; the Economics theory permits to model competitors' behavior; knowledge management and change management define people's roles in service change; Industrial Engineering and Information Sciences provide the tools for information analysis and supporting IT tools definition; and all these disciplines as well as Strategic Planning, Analytics—as Optimization Models and Business Analytics—process modeling and design, project management, and others serve as a basis to generate ideas to produce and implement a design that realizes and innovation that generates value for the customers and stakeholders.

Students at the Master in Business Engineering (MBE) at the University of Chile develop projects as part of their thesis, then all the knowledge and experience gathered from the cases, some of which have been reported in this book, are being continuously incorporated into existing patterns as well as new specialized ones for domains such as health. This means that the reuse of knowledge incorporated into the patterns is increasingly used in areas of new applications, and this produces a virtuous circle, because new knowledge generated enrich the patterns and permit generating new ones. Additionally, this creates the possibility that, when very detailed patterns exist in a domain, general software solutions can be developed to support the detailed process patterns. Subsequently, general flexible solutions—including business, processes, and software design—can be developed for a domain, which can be specialized to particular cases. The advantage of this approach, as compared to Enterprise Resource Planning (ERP), is in allowing to customize the whole design, from business to software, with reasonable effort, especially when this is combined with process execution, using Business Process Management Notation (BPMN) models and a Business Process Management Suits (BPMS). We have already shown that this approach is feasible in the health domain.[2]

One last general conclusion concerns the power of a well-defined design approach as the one we propose, with appropriate tool support, to make possible that students with little or no experience generate solutions in complex cases in a short period of time. This has been the situation in all the cases in the health sector as reported, with results that will be elaborated later. We should clarify, though, that most of the cases in Chapter 5 have been developed by professionals sent to the MBE by the companies for which they work.

Results from Cases

In terms of value generated with the implementation of the approach in private businesses, the results in most of the cases are outstanding. What other adjective can be used for the successful innovation in products and services implemented in the cases of the credit card transaction service and the Scientific Information Publishing multinational organization presented in Chapter 5, which are producing millions of dollars every year from the new businesses for these organizations. It is equally impressive that the office equipment distribution firm and the company in the food production business, with cases also detailed in Chapter 5, have been able to importantly increase their sales by customized and proactive offers to their customers and optimized selling processes. Furthermore, the case of the cardboard manufacturing plant shows a very high potential of value generation in the more traditional area of resource optimization, generating more output with the same resources, hence increasing productivity; for example, millions of dollars of additional production per year in the case of the cardboard plant without additional investment.

All the private businesses exemplified earlier have a further value, which is to induce a closer relationship with customers, by giving integral services, which eventually has a lock-in effect that make it less attractive for them to look for other suppliers. In better understanding the clients' needs and providing services according to this, we are clearly aligned with Davenport's ideas.[3]

Another interesting observation about the projects developed in this type of business is the impact the design approach has had in making possible innovations that otherwise were unfeasible. The power of the approach is that it is normative and is well-defined as to what design steps should be taken. Typically, it is observed that an initial blueprint of the design in the project facilitates the participation of executives and operation people affected by such design. This is provided in our approach by Business and Architecture Patterns that allow a creative interaction with such people. Early design also allows identifying key work that should be prioritized in order to make the project feasible and provides hard information about benefits. Since, as stated several times in this book and illustrated in the cases, we believe that Analytics is a key component to produce true innovation, and early proof that it will generate value. Hence, early testing of the relevant analytical methods with data is a must to convince people involved that the project will generate value. This has been the standard approach in all the cases presented in the book; for example, doing Data Mining in the credit card transaction service and international firm that sells office equipment and testing optimizations models in the cardboard manufacturing plant and the company in the food production business. Once hard data furnished from the models testing shows clear benefit potential, the project increases its priority and change management gets less complicated. There is not more convincing arguments for change than there is a sure possibility of generating value, especially for executives.

The case of the private hospital in Chapter 5 reinforces the conclusion that there is a large potential for service innovation in all kinds of businesses. In fact, the hospital in this case, which is recognized as one of the best in Latin America, completely reformulated its Strategy and investment initiatives generation and evaluation by means of a design that assures developing new services that maximize value for the stakeholders. Thus, the hospital maintains its competiveness by the continuous services innovation that is generated by well-designed processes and supporting systems.

In the public hospital cases, presented in Chapter 5, value has been generated in several dimensions: quality, efficiency, and fairness. These objectives, defined in detail in the same chapter, are related to ideas proposed by Porter and Teisberg and Christensen et al.[4] The important result here is the proof that very significant improvements can be obtained in all these objectives by using the approach we propose for service design. In particular, we have stressed the increase in quality and fairness that can be generated in public hospitals, with no additional resources, by designing service to patients taking into account all the relevant variables, as opposed to the current emphasis on the reduction of waiting lists ordered by time of first medical service request. We have proved that this is basically a wrong approach, in which government has wasted tens and possibly hundreds of millions dollars to reduce such lists, by giving extra resources, which can be spent in private hospitals, to eliminate the patients who have waited a longer time since they entered the lists, that is a first-in-first-out (FIFO) rule. Other cases that have provided more quality and fairness are the ones that have allowed designing hospital-right configuration of services and capacity to insure a predetermined service level for patients. This was done for emergency services. Behind these cases, the idea is also of optimizing the level of resources by providing what is strictly necessary to give the desired service level. The results on the efficiency objective are extremely important, since we have been able to show that there is a high potential for productivity improvements in public hospitals.

A complementary factor to the objectives stated earlier has been relevant, which is the speed with which solutions can be developed. For example, important innovations in the private hospital case, the credit card transaction business and the equipment distribution firm have been developed in about 18 months. In public hospitals, we have been able to generate proposed designs for key parts of health service in a couple of months and implemented solutions in less than six months.

The cases for hospitals have been expanded to many other situations, such as efficiency measurement for hospitals using Data Envelopment Analysis for resource assignment for innovation projects; management of geographic hospital groups; operating room capacity analysis, assignment and scheduling; emergency monitoring; and online monitoring of chronic patients. This will be presented in the follow up volume *Service Design with Applications to Health Care Institutions*, which is being published by this same editorial.

Notes

Prolog

1. Information about the Master in Business Engineering can be obtained at its website MBE (2016), where there are links to Facebook, LinkedIn, and Twitter; also the blog, Barros (2016b), contains books, papers, and theses related to the MBE.
2. Brocke and Rosemann (2010).
3. Alexander (1964).
4. Gamma et al. (1995).

Chapter 1

1. IBM Research (2004).
2. Chesbrough and Spohrer (2006); Spohrer et al. (2007); Spohrer and Maglio (2008); Maglio, Kieliszewski, and Spohrer (2010).
3. Porter (1996); Hax and Wilde (2001); Hax (2010).
4. Johnson, Christensen, and Kageman (2008); Osterwalder and Pigneur (2009).
5. Barros (1998b, 2004, 2016a).
6. Barros and Julio (2011); Barros, Seguel, and Quezada (2011).
7. Barros (2016a).
8. Barros (1998b, 2000, 2004, 2007, 2016a).
9. Davenport (2006); Davenport and Harris (2007).
10. Barros (2004, 2016a); Barros and Julio (2011); Barros et al. (2015); Barros, Seguel, and Quezada (2011); Barros and Aguilera (2015).
11. White and Miers (2009).
12. Pant and Juric (2008); Barros, Seguel, and Quezada (2011).

Chapter 2

1. Chesbrough and Spohrer (2006); Spohrer and Ricken (2006); Spohrer et al. (2007); Spohrer and Maglio (2008); Maglio, Kieliszewski, and Spohrer (2010).
2. Tien and Berg (2003).
3. Bullinger, Fähnrich, and Meiren (2003).
4. Johansson and Olhager (2004).

5. Reijers (2002).
6. Hill et al. (2002).
7. Gasevic and Hatala (2010).
8. Groop (2012).
9. Ricketts (2007, 2010).
10. Patrício et al. (2011); Voss and Hsuan (2009) have made proposals centering on the design of the user experience.
11. Kalbach (2016); Polaine and Løvlie (2013).
12. Baines et al. (2007).
13. Hwang, Gao, and Jang (2010).
14. Min and Yih (2010).
15. Marmor et al. (2009).
16. Samaha, Armel, and Stark (2003).
17. Rojas and Garabito (2008).
18. Khurma and Bacioiu (2008).
19. Maglio et al. (2010).
20. Rouse and Compton (2010).
21. SEBoK (2016).
22. White House Executive Office. (2014).
23. Barros and Julio (2009, 2010a, 2010b, 2011); Barros and Julio (2011).
24. SCOR (2013).
25. APQC (2016).
26. White House E-Gov (2013).
27. Chervako et al. (2005).
28. Sessions (2007).
29. Ross, Weill, and Robertson (2006).
30. Zachman (1987).
31. This is a commercial study “Hype Cycle for Enterprise Architecture” conducted by Gartner in 2011, which is not publicly available, but can be bought, Garner (2011a).
32. This is a commercial study “Enterprise Architecture Priorities for 2012 through 2013 in Chile” conducted by Gartner in 2011, which is not publicly available, but can be bought, Gartner (2011b).
33. Barros (1998b, 2000).
34. Adams et al. (2001); IBM (2010).
35. Fowler (2011).

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2. Hax and Wilde (2001).

3. Rohwedder and Johnson (2008).
4. Farhoomand, Ng, and Cowley (2003).
5. Katz and Shapiro (1985); Klemperer (1987).
6. Kaplan and Norton (2001).
7. Johnson, Christensen, and Kageman (2008); Osterwalder and Pigneur (2009).
8. Farhoomand, Ng, and Cowley (2003).
9. Johnson, Christensen, and Kageman (2008).
10. Farhoomand, Ng, and Cowley (2003).
11. Johnson, Christensen, and Kageman (2008).
12. Osterwalder and Pigneur (2009).
13. Barros (1998b, 2000, 2004).
14. Barros (1988, 1990, 1991, 1993, 1994a, 1994b, 1995, 1996, 1998a).
15. Pekkaninen and Ulkuniemi (2008); Dorbecker and Bohman (2013).
16. Meyer, Jekowsky, and Crane (2007); Barros (2016a).
17. Meyer, Jekowsky, and Crane (2007).
18. Pekkarinen and Ulkuniemi (2008).
19. Voss and Hsuan (2009).
20. We present a summary of the structure; full detail in Pedersen (2010).
21. We present a summary of the structure; full detail in Soffers et al. (2014).
22. Presentation based on Pekkaninen and Ulkuniemi (2008).
23. Voss and Hsuan (2009).
24. Meyer, Jekowsky, and Crane (2007).
25. Pekkaninen and Ulkuniemi (2008).
26. Voss and Hsuan (2009).
27. de Blok et al. (2010).
28. Sheng, Wang, and Sun (2012).
29. Chilecompra (2016).
30. Miozzo and Grimshaw (2005).
31. Davenport, Cohen, and Jacobson (2005).
32. Davenport (2006); Davenport and Harris (2007).
33. Rud (2009).
34. Der Aalst and Van (2011); Liu (2007); Witten, Frank, and Hall (2011).
35. Davenport (2013).
36. McKinsey (2011a).
37. McAffe and Brynjollfson (2012).
38. Dell (2014).
39. Barros (2016a).
40. Davenport (2013).
41. Tsiptsis and Choriannopoulos (2009).
42. Lloyd (1982).

43. Alsabti, Ranka, and Singh (1997).
44. This topic is covered in detail in Tsiptsis and Choriannopoulos (2009).
45. This case is based on the MBE thesis.
46. SPSS Modeler (2016).
47. Rapid Miner (2016).
48. Pentaho (2013).
49. Castellano et al. (2009).
50. Pant and Juric (2008).
51. Der Aalst and Van (2011).
52. LeCun, Bengio, and Hinton (2015).
53. McAffe and Brynjolfsson (2012).
54. LeCun, Bengio, and Hinton (2015).
55. Sherman and Zhu (2013).
56. Barros and Aguilera (2015).
57. This section on forecasting is based on the paper by Barros et al. (2015).
58. Adya and Collopy (1998) for a discussion of overfitting on this type of models.
59. Chen, Lin, and Schölkopf (2005); Smola and Schölkopf (2004).
60. Vapnik (1995).
61. Smola and Schölkopf (2004).
62. Vapnik (1998).
63. Cherkassky and Ma (2004).
64. The presentation of this model is based on the work by Monica Cortez as her thesis for the Master's in Business Engineering, where she applied the type of solutions that are summarized to a company in the food production and distribution business. The thesis is available in MBE (2016).
65. Applegate et al. (2006).
66. Johnson and McGeoch (1995).
67. Platzman and Bartholdi (1989).
68. Kuhn (1955).
69. Burkard, Dell' Amico, and Martello (2009).
70. Applegate and Cook (1991).
71. McKinsey (2011b).
72. Der Aalst and Hee (2004).
73. Based on a thesis of the MBE by C. Carrasco. It can be found at www.tesis.uchile.cl
74. Le Clair and Miers (2014).
75. White and Miers (2009).
76. OMG (2016).
77. IDEF0 (1993).
78. Barros and Julio (2011).

79. Barros et al. (2015).
80. Barros and Quezada (2015).
81. The problem of different levels of design and appropriate representation by using BPMN constructs is discussed in Barros and Julio (2009) and Barros et al. (2011).
82. Langerstrom et al. (2013); MacCormack et al. (2015).
83. Barros (2016a).
84. Glasner (2009).
85. Barros (1990, 1991).
86. Barros (1995, 2000, 2004).
87. Gailbraith (1977).
88. Malone and Crowston (1994).
89. Williamson (1981).
90. Arrow (1985).
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3. Barros (2004, 2016a).
4. Kaplan and Norton (2001).
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6. Barros et al. (2015).
7. Cito Research (2015).
8. Abu-Mostafa (2012).
9. Davenport, Mule, and Lucker (2011).
10. McAffe and Brynjollfson (2012).
11. Porter (1996).
12. This is an adaptation of ideas from TOC to services as proposed by Ricketts (2007, 2010).
13. Hax and Wilde (2001); Hax (2010).
14. Davenport (2011).
15. Hax and Wilde (2001).
16. Barros and Aguilera (2015).
17. Garretson and Harmon (2005).
18. Kaplan and Norton (2001).
19. This case is based on the MBE Thesis by L. Montero. It can be found at www.tesis.uchile.cl

20. Barros (1998b, 2000, 2004, 2005, 2007); Barros and Julio (2010a, 2010b, 2011).
21. Porter (1996).
22. This is unpublished information, which was presented at the BPM Workshop III, October 2000 in Chile, by Paul Harmon, editor of BPtrends.
23. SCOR (2016).
24. APQC (2016).
25. eTOM (2016).
26. Ross, Weill, and Robertson (2006).
27. Barros and Julio (2009, 2010a, 2010b, 2011).
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29. Barros and Aguilera (2015).
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32. Barros and Aguilera (2015).
33. Brocke and Rosemann (2010).
34. Barros (2000, 2004, 2016a).
35. Barros (2005, 2007); Barros and Julio (2009, 2010a, 2010b, 2011).
36. Manyika, Roberts, and Sprague (2007).
37. Manyika, Roberts, and Sprague (2007).
38. The case of IBM and the other innovation cases are presented in Fingar (2006).
39. Barros (2000, 2004).

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1. Hax (2010).
2. This section is based on the thesis of P. Carroza at the Master in Business Engineering; it is available at MBE (2016) and www.tesis.uchile.cl/
3. This section is based on the thesis of M. Cortes at the Master in Business Engineering; it is available at MBE (2016) and www.tesis.uchile.cl/
4. This section is based on the thesis of G. Jofre at the Master in Business Engineering; it is available at MBE (2016) and www.tesis.uchile.cl/
5. Sheng, Wang, and Sun (2012).
6. Patrício et al. (2011); Polaine and Løvlie (2013).
7. A paper that comments on the problem of skills to perform Analytics is Lambrecht and Tucker (2016).
8. Barros and Julio (2010b, 2011).
9. PMBOK (2016).

10. This section is based on the thesis of P. Anguita at the Master in Business Engineering; it is available at MBE (2016) and www.tesis.uchile.cl/
11. This section is based on the thesis of L. Montero at the Master in Business Engineering; it is available at MBE (2016) and www.tesis.uchile.cl/
12. Porter and Teisberg (2006).
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14. Barros (2016a), and see the follow up volume *Service Design with Applications to Health Care Institutions*.
15. For example, Armstrong (2001).
16. Barros et al. (2015).
17. Law and Kelton (2001).
18. Rapid Miner (2016).
19. This section is based on the thesis of Monica Cortes at the Master in Business Engineering; it is available at MBE (2013) and www.tesis.uchile.cl/
20. Platzman and Bartholdi (1989).
21. This section is based on the thesis of R. Rivera at the Master in Business Engineering; it is available at MBE (2016) and www.tesis.uchile.cl/
22. This case is partially based on the work done by J. Araya in a thesis at the Master in Business Engineering; it is available at MBE (2013) and www.tesis.uchile.cl/.
23. Pentaho (2013).

Chapter 6

1. See the Systems-Discipline Matrix in the Prolog of this book.
2. Barros and Quezada (2015).
3. Davenport, Dalle Mule, and Lucker (2011).
4. Porter and Teisberg (2006, 2007); Christensen, Grossman, and Hwang (2009).

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