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Introduction

Business process management has received considerable attention recently by both business administration and computer science communities.

Members of these communities are typically characterized by different educational backgrounds and interests. People in business administration are interested in improving the operations of companies. Increasing customer satisfaction, reducing cost of doing business, and establishing new products and services at low cost are important aspects of business process management from a business administration point of view.

Two communities in computer science are interested in business processes. Researchers with a background in formal methods investigate structural properties of processes. Since these properties can only be shown using abstractions of real-world business processes, process activities are typically reduced to letters. Using this abstraction, interesting observations on structural properties of business processes can be made, which are very useful for detecting structural deficiencies in real-world business processes.

The software community is interested in providing robust and scalable software systems. Since business processes are realized in complex information technology landscapes, the integration of existing information systems is an important basis for the technical realization of business processes.

The goal of this book is to narrow the gap between these different points of view and to provide a step towards a common understanding of the concepts and technologies in business process management.

The introductory chapter looks at the motivation for business process management from a high-level point of view. The background of business process management is explained, and major concepts and terms are introduced. An example featuring an ordering process is used to illustrate these concepts. The phases in setting up and maintaining business process management applications are discussed. A classification of business processes and an overview on the structure of this book complete this chapter.

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1.1 Motivation and Definitions

Business process management is based on the observation that each product that a company provides to the market is the outcome of a number of activities performed. Business processes are the key instrument to organizing these activities and to improving the understanding of their interrelationships.

Information technology in general and information systems in particular deserve an important role in business process management, because more and more activities that a company performs are supported by information systems. Business process activities can be performed by the company's employees manually or by the help of information systems. There are also business process activities that can be enacted automatically by information systems, without any human involvement.

A company can reach its business goals in an efficient and effective manner only if people and other enterprise resources, such as information systems, play together well. Business processes are an important concept to facilitating this effective collaboration.

In many companies there is a gap between organizational business aspects and the information technology that is in place. Narrowing this gap between organization and technology is important, because in today's dynamic markets, companies are constantly forced to provide better and more specific products to their customers. Products that are successful today might not be successful tomorrow. If a competitor provides a cheaper, better designed, or more conveniently usable product, the market share of the first product will most likely diminish.

Internet-based communication facilities spread news of new products at lightning speed, so traditional product cycles are not suitable for coping with today's dynamic markets. The abilities to create a new product and to bring it to the market rapidly, and to adapt an existing product at low cost have become competitive advantages of successful companies.

While at an organizational level, business processes are essential to understanding how companies operate, business processes also play an important role in the design and realization of flexible information systems. These information systems provide the technical basis for the rapid creation of new functionality that realizes new products and for adapting existing functionality to cater to new market requirements.

Business process management is influenced by concepts and technologies from different areas of business administration and computer science. Based on early work in organization and management, business process management has its roots in the process orientation trend of the 1990s, where a new way of organizing companies on the basis of business processes was proposed.

In their seminal book *Reengineering the Corporation*, Michael Hammer and James Champy advocate the radical redesign of the business processes of a company. They define a business process as a collection of activities that

take one or more kinds of input and create an output that is of value to the customer.

While it has been argued that a radical redesign of business processes is, in many cases, not the best choice and that evolutionary improvements are more promising, the business process definition by Hammer and Champy is a good starting point for our investigations.

This definition puts emphasis on the input/output behaviour of a business process by stating its precondition (inputs) and its postcondition (output). The process itself is described in an abstract way by a collection of activities. Assuming that the term "collection" neither implies an ordering of the activities nor any other execution constraints, the definition by Hammer and Champy is quite liberal with regard to the process aspect.

Execution constraints between activities are identified by Davenport, who defines a business process as "a set of logically related tasks performed to achieve a defined business outcome for a particular customer or market."

The term "logically related" puts emphasis on the process activities, while associating the outcome of a business process with a requestor of a product, that is, a customer. Davenport also considers the relationship of process activities, including their execution ordering, by defining a business process as "a specific ordering of work activities across time and place, with a beginning, an end, and clearly identified inputs and outputs." He continues, "business processes have customers (internal or external) and they cross organizational boundaries, that is, they occur across or between organizational subunits."

Based on these characterizations of business processes, we adopt the following definition.

Definition 1.1 A *business process* consists of a set of activities that are performed in coordination in an organizational and technical environment. These activities jointly realize a business goal. Each business process is enacted by a single organization, but it may interact with business processes performed by other organizations. ◇

After a first consideration of business processes, their constituents, and their interactions, the view is broadened. Business process management not only covers the representation of business processes, but also additional activities.

Definition 1.2 *Business process management* includes concepts, methods, and techniques to support the design, administration, configuration, enactment, and analysis of business processes. ◇

The basis of business process management is the explicit representation of business processes with their activities and the execution constraints between them. Once business processes are defined, they can be subject to analysis, improvement, and enactment. These aspects of business process management will be introduced in Section 1.2.

Traditionally, business processes are enacted manually, guided by the knowledge of the company's personnel and assisted by the organizational regulations and procedures that are installed.

Enterprises can achieve additional benefits if they use software systems for coordinating the activities involved in business processes. These software systems are called business process management systems.

Definition 1.3 A *business process management system* is a generic software system that is driven by explicit process representations to coordinate the enactment of business processes. ◇

The definitions introduced so far are illustrated by a sample business process. Because of its clarity and limited complexity, a simple ordering process is well suited. In the ordering process, an order is received, an invoice is sent, payment is received, and the ordered products are shipped.

This textual representation lists the activities of the business process, but it does not make explicit the ordering according to which these activities are performed. Graphical notations are well suited to expressing orderings between activities of a business process.

The ordering process of a reseller company is shown in Figure 1.1. The process consists of a set of activities performed in a coordinated manner. The coordination between the activities is achieved by an explicit process representation using execution constraints. The process starts with the company receiving and checking an order, followed by activities in concurrent branches. In one branch, the invoice is sent and the payment is received; in the other branch, the products are shipped. When both branches complete their activities, the order is archived, and the business process terminates. At this point in time, the reseller has processed an incoming order, including shipping the product and receiving the payment, which realizes a business goal of the reseller.

While there are several graphical notations for business process modelling, their essence is quite similar. This introductory chapter uses a simplified variant of the Business Process Model and Notation, BPMN. In this notation, activities are represented by rounded rectangles, marked with the name of the activity. Events can be used to mark the start and end of the process. Events are represented by circles. An event can be marked with a symbol indicating the type of the event. In the example, we use a start event with an envelope mark ("message start event" in BPMN) to represent that the process starts on receiving a message. Execution ordering of activities is expressed by directed arrows.

Branching and joining of nodes is represented by diamonds that can be marked with different symbols. In the sample process shown in Figure 1.1, a diamond with a plus sign, a single incoming arc, and multiple outgoing arcs represents a parallel split, which means that the follow-up activities can be executed concurrently. Concurrent activities can be executed in any order, and any overlap in the execution time of concurrent activities is allowed.

The same symbol with multiple incoming arcs and a single outgoing arc is the respective join node, merging the concurrent branches. In the example, this join node makes sure that the archiving of the order can only be started once both concurrent branches have completed. The Business Process Model and Notation will be discussed in detail in Chapter 4.

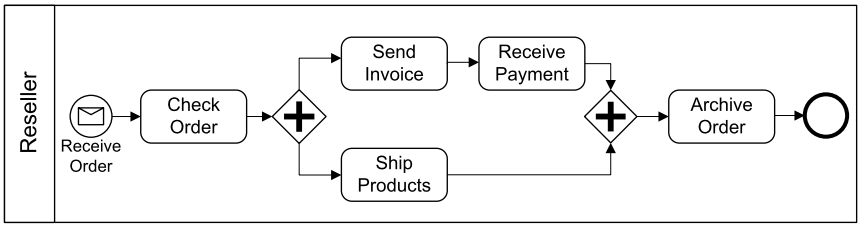

Fig. 1.1. Simple ordering process of reseller

The ordering process shown can be used as a blueprint that allows the reseller company to organize its work. The company will receive many orders, each of which can be processed as described in the blueprint. This observation gives rise to important concepts in business process management: business process models and business process instances.

The blueprint shown in Figure 1.1 is the business process model. Each order that is processed according to this model is a business process instance. Therefore, there is a one-to-many relationship between business process models and business process instances. Conceptual models of business process models and instances will be the subject of Chapter 3.

Definition 1.4 A *business process model* consists of a set of activity models and execution constraints between them. A *business process instance* represents a concrete case in the operational business of a company, consisting of activity instances. Each business process model acts as a blueprint for a set of business process instances, and each activity model acts as a blueprint for a set of activity instances. ◇

If no confusion is possible, the term *business process* is used to refer to either business process models or business process instances. Analogously, *activity* is used to refer to either activity models or activity instances.

Business process models are the main artefacts for implementing business processes. This implementation can be done by organizational rules and policies, but it can also be done by a software system, using a business process management system. In this case, according to Definition 1.3, the software system is driven by explicit process representations.

The business process model shown in Figure 1.1 can be used to configure the process management system accordingly. The resulting system makes sure that all business process instances are executed as specified in the business

process model and that, for instance, after receiving an order, the *Send Invoice* and the *Ship Products* activities are executed concurrently.

Since business processes are performed in a single organization by definition, the ordering of activities can be controlled by a business process management system as a centralized software component run by the reseller company. This centralized control is very similar to a conductor who centrally controls the musicians in an orchestra; therefore, business processes are also called *process orchestrations*. Chapter 4 will investigate languages to express process orchestrations.

The business process model shown in Figure 1.1 represents activities that a reseller performs to process an incoming order. This business process interacts with the business process of a corresponding buyer. The buyer sends an order, receives payment information, settles the invoice, and receives the ordered products.

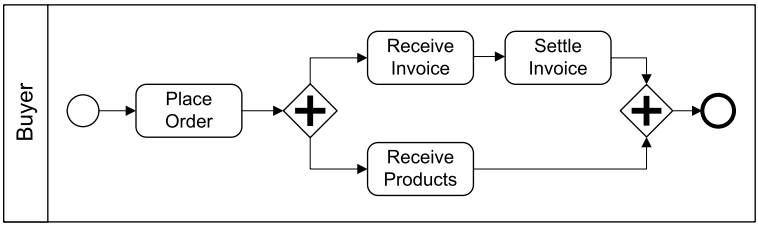

Fig. 1.2. Ordering process of a buyer

The business process of the buyer is shown in Figure 1.2. It starts with its placing an order, before two concurrent branches are opened. In one branch, the invoice is received and the invoice is settled. In the other branch, the product is received. When both branches complete, the business process of the buyer completes.

Definition 1.1 indicates that each business process is enacted by one organization, and that business processes can interact with each other. The business processes of the reseller and the buyer can, for instance, interact with each other in the following way.

1. The buyer sends an order message to the reseller.
2. The reseller receives that message in a start event. The order information is then extracted from the message, and order processing starts.
3. The reseller sends an invoice and ships the ordered products.
4. The buyer receives the invoice.
5. The buyer settles the invoice.
6. Finally, the buyer receives the ordered products.

The interacting business processes are shown in Figure 1.3. Interacting activities of the reseller business process and the buyer business process are related

to each other by dotted arcs, representing the flow of messages. Message flow can represent electronic messages sent and received, but also the transport of physical objects, such as ordered products.

The interactions of a set of business processes are specified in a *process choreography*. The term choreography indicates the absence of a central agent that controls the activities in the business processes involved. The interaction is only achieved by sending and receiving messages. In order to realize correct interactions, the interacting business processes need to agree on a common choreography before they start interacting.

This situation is similar to dancers who need to agree on a common choreography before the show starts. During the performance, however, each dancer behaves autonomously but in line with his or her part in the choreography. Process choreographies will be discussed in detail in Chapter 5.

The representation of the business process choreography is shown in Figure 1.3; it also represents start events and end events of the interacting business processes, marked by circles.

This process choreography allows for multiple concrete implementations, in which the degree of software support can differ. Traditional ways of ordering goods that are not supported by information systems are well captured by this business process interaction. A buyer browses a paper catalogue of a reseller, selects a set of products, fills a postcard with ordering information, and sends the postcard to the reseller.

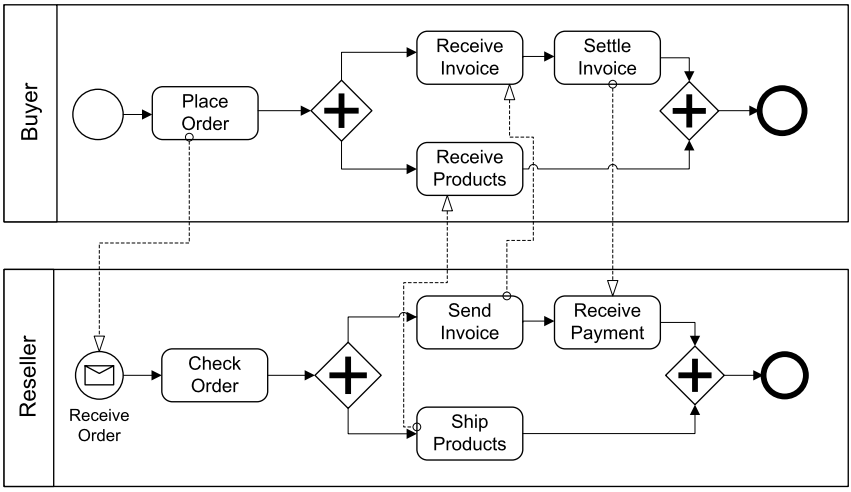

Fig. 1.3. Interacting business processes form process choreography

This postcard effectively implements the message flow from the buyer to the reseller. On receiving the postcard, the reseller sends the products and the invoice. The buyer receives the products and, assuming everything is fine,

settles the received invoice, for instance, by money transfer. Once the money arrives at the reseller, the interacting business processes complete.

Large parts of the interacting business processes shown in Figure 1.3 can also be implemented by software systems. The buyer might use a Web browser to search the online catalogue of the reseller; she fills her shopping basket, provides address and billing information, and presses the submit button.

Pressing the submit button submits the order, that is, it realizes the message flow from the buyer to the reseller. The message flow from buyer to reseller is no longer implemented by surface mail, but by Internet protocols. The buyer's Web browser sends a message to the reseller's Web server, which calls a software module that places the order in the reseller's ordering system.

In case intangible goods have been ordered, such as music or software, sending the products can also be realized by software systems. The same applies for invoicing and billing, where online billing services can be integrated into the business process.

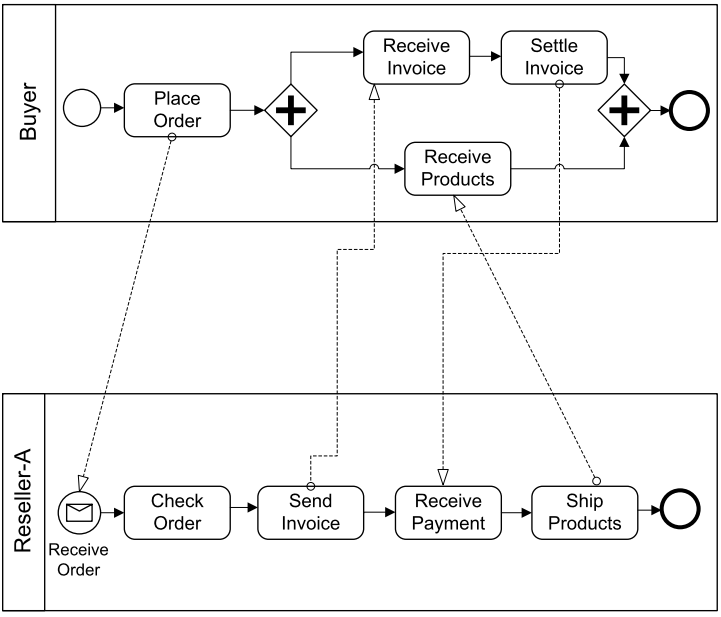

Fig. 1.4. Variant of reseller process with interacting business process

Graphical representations of business processes, as shown in the examples, focus on the process structure and the interactions of the participating parties rather than on technical aspects of their realization. This is an important aspect in business process modelling, since the definition of business processes and their interaction behaviour does not prescribe certain implementation strategies or platforms.

The realization of business processes by participants can change without affecting the externally visible behaviour of the process, that is, without affecting the business process interaction. To illustrate this property, the buyer interacts with a different reseller, called *Reseller-A* in Figure 1.4. The business process of this reseller performs the activities in a sequential order; there are no concurrent activities as in the business process of the original reseller.

Reseller-A realizes the following business rule: a product is sent only after the payment has been received. This is a sensible approach that protects the reseller from fraudulent buyers. The business process of *Reseller-A* also works well with the buyer process, since the concurrent branches allow the products to be received after the invoice is settled. However, overall execution might take longer than in the first case, since fewer activities can be performed concurrently.

The examples discussed so far have shown how to represent individual business processes that realize process orchestrations. We have also looked at interacting business processes that realize process choreographies. These examples focus on the activities of business processes and their relationships and on the business partners involved. The next section will consider the development of business processes and software platforms that realize them by introducing the business process lifecycle.

1.2 Business Process Lifecycle

The goal of this section is providing an overall understanding of the concepts and technologies that are relevant in business process management, using a business process lifecycle. This lifecycle is also useful for scoping the contents of this book.

The business process lifecycle is shown in Figure 1.5; it consists of phases that are related to each other. The phases are organized in a cyclical structure, showing their logical dependencies. These dependencies do not imply a strict temporal ordering in which the phases need to be executed. Many design and development activities are conducted during each of these phases, and incremental and evolutionary approaches involving concurrent activities in multiple phases are not uncommon.

Chapter 8 extends this lifecycle by proposing a methodology for the development of business process applications.

Design and Analysis

The business process lifecycle is entered in the *Design and Analysis* phase, in which surveys on the business processes and their organizational and technical environment are conducted. Based on these surveys, business processes are identified, reviewed, validated, and represented by business process models.

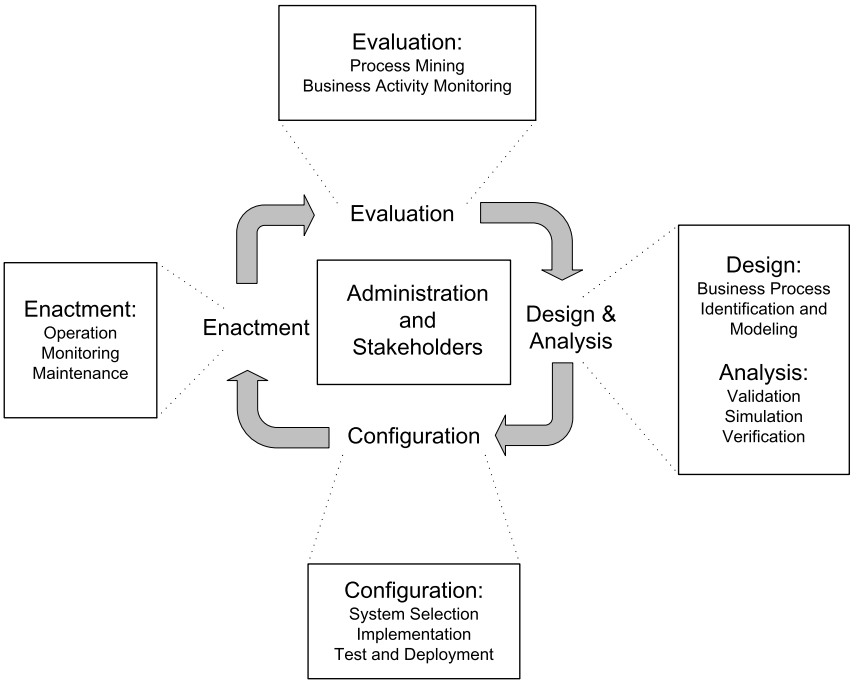

Fig. 1.5. Business process lifecycle

Explicit business process models expressed in a graphical notation facilitate communication about these processes, so that different stakeholders can communicate efficiently, and refine and improve them. Chapter 4 investigates languages to express business process models.

Business process modelling techniques as well as validation, simulation, and verification techniques are used during this phase. Business process modelling is the core technical subphase during process design. Based on the survey and the findings of the business process improvement activities, the informal business process description is formalized using a particular business process modelling notation.

Once an initial design of a business process is developed, it needs to be validated. A useful instrument to validate a business process is a workshop, during which the persons involved discuss the process. The participants of the workshop will check whether all valid business process instances are reflected by the business process model.

Simulation techniques can be used to support validation, because certain undesired execution sequences might be simulated that show deficits in the process model. Simulation of business processes also allows stakeholders to walk through the process in a step-by-step manner and to check whether the process actually exposes the desired behaviour. Most business process

management systems provide a simulation environment that can be used in this phase.

Business processes involving multiple participants play an increasing role to foster the collaboration between enterprises. The design and analysis of interacting business processes is subject of Chapter 5.

Business process modelling has an evolutionary character in the sense that the process model is analyzed and improved so that it actually represents the desired business process and that it does not contain any undesired properties. Deadlock is such a property, in which all activities in a business process come to a halt. Chapter 6 investigates the verification of business process models with respect to correctness properties.

Configuration

Once the business process model is designed and verified, the business process needs to be implemented. There are different ways to do so. It can be implemented by a set of policies and procedures that the employees of the enterprise need to comply with. In this case, a business process can be realized without any support by a dedicated business process management system.

In case a dedicated software system is used to realize the business process, an implementation platform is chosen during the configuration phase. The business process model is enhanced with technical information that facilitates the enactment of the process by the business process management system.

The system needs to be configured according to the organizational environment of the enterprise and the business processes whose enactment it should control. This configuration includes the interactions of the employees with the system as well as the integration of the existing software systems with the business process management system.

The latter is important, since in today's business organizations, most business processes are supported by existing software systems. Depending on the information technology infrastructure, the process configuration phase might also include implementation work, for instance, attaching legacy software systems to the business process management system.

The configuration of a business process management system might also involve transactional aspects. Transactions are a well-known concept from database technology, where a transaction manager guarantees that application programs run as transactions and obey the ACID principle: atomicity, consistency, isolation, and durability. This means that transactions are executed in an atomic all-or-nothing fashion, they transfer a consistent database state into another consistent database state, they do not interfere with other transactions, and transaction results are durable and survive future system failures.

While in business process management database applications with transactional properties play an important role to realize process activities, transactional properties can also be defined at the business process level; a subset

of the process activities form one business transaction, so that either all activities in this set are performed successfully or none is executed, realizing the atomicity property.

Unfortunately, the techniques that guarantee transactional behaviour in database systems cannot be used for business process transactions, since they are based on preventing access to data objects by locking, and locking data objects during process instances is no valid option. Business transactions are currently at the research stage; therefore, this book does not investigate them further.

Once the system is configured, the implementation of the business process needs to be tested. Traditional testing techniques from the software engineering area are used at the level of process activities to check, for instance, whether a software system exposes the expected behaviour.

At the process level, integration and performance tests are important for detecting potential run time problems during the configuration phase. Once the test subphase is complete, the system is deployed in its target environment. Depending on the particular setting, additional activities might be required, for instance, training of personnel and migration of application data to the new realization platform.

The configuration of business process management systems and the respective software architectures are investigated in Chapter 7.

Enactment

Once the system configuration phase is completed, business process instances can be enacted. The process enactment phase encompasses the actual run time of the business process. Business process instances are initiated to fulfill the business goals of a company. Initiation of a process instance typically follows a defined event, for instance, the receipt of an order sent by a customer.

The business process management system actively controls the execution of business process instances as defined in the business process model. Process enactment needs to cater to a correct process orchestration, guaranteeing that the process activities are performed according to the execution constraints specified in the process model.

A monitoring component of a business process management system visualizes the status of business process instances. Process monitoring is an important mechanism for providing accurate information on the status of business process instances. This information is valuable, for instance, to respond to a customer request that inquires about the current status of his case.

Detailed information on the current state of process instances are available in a business process management system. In Section 3.4, the states and state transitions of activity instances are investigated, while Section 3.5 covers process instances. State information can be used to visualize and monitor process instances. Visualization techniques can be based on colours, so that, for instance, an enabled activity is shown in green, a running instance is marked in

blue, and a completed process instance is represented in grey. Most business process management systems provide monitoring information that is based on states of active business processes.

During business process enactment, valuable execution data is gathered, typically in some form of log file. These log files consist of ordered sets of log entries, indicating events that have occurred during business processes. Start of activity and end of activity is typical information stored in execution logs. Log information is the basis for evaluation of processes in the next phase of the business process lifecycle.

Evaluation

The evaluation phase uses information available to evaluate and improve business process models and their implementations. Execution logs are evaluated using business activity monitoring and process mining techniques. These techniques aim at identifying the quality of business process models and the adequacy of the execution environment.

For instance, business activity monitoring might identify that a certain activity takes too long due to shortage of resources required to conduct it. Since this information is useful also for business process simulation, these phases are strongly related.

Similar considerations apply to process mining, which has recently developed into an active field of research. There are different applications of process mining. If the execution logs are generated by traditional information systems, they collectively can be used as a starting point to develop business process models. The evaluation of existing business process models is another application area of process mining. The evaluation phase is not covered in detail in this book; for further information, the reader is referred to the bibliographical notes in the end of this part.

Administration and Stakeholders

There are numerous artefacts at different levels of abstraction in business process management scenarios that need to be organized and managed well. Structured storage and efficient retrieval of artefacts regarding business process models and information on business process instances as well as the organizational and technical execution environment need to be taken into account.

Especially in large organizations with hundreds or thousands of business process models, a well-structured repository with powerful query mechanisms is essential. In addition to business processes, knowledge workers with their organizational roles and skills, as well as the information technology landscape of the enterprise, need to be represented properly.

The business process domain is characterized by several types of stakeholders with different knowledge, expertise, and experience; these are classified into the following roles:

- *Chief Process Officer*: The chief process officer is responsible for standardizing and harmonizing business processes in the enterprise. In addition, he or she is responsible for the evolution of business processes in the presence of changing market requirements. Installing an explicit role of chief process officer acknowledges the importance of business process management at the top level management.
- *Business Engineer*: Business engineers are business domain experts responsible for defining strategic goals of the company and organizational business processes. Often, business engineers have a nontechnical educational background, so that convenient and simple-to-use process modelling notations are required to communicate about business processes with these stakeholders.
- *Process Designer*: Process designers are responsible for modelling business processes by communicating with business domain experts and other stakeholders. Very good analytical capabilities and excellent communication skills are important for a process designer.
- *Process Participant*: Process participants conduct the actual operational work during the enactment of business process instances. They also play an important role during business process modelling, because they are knowledgeable about the activities conducted and their interrelationships with activities conducted by other process participants. It is the task of the process designer to assemble from this information a consistent overall view and capture it as a business process model.
- *Knowledge Worker*: Knowledge workers are process participants who use software systems to perform activities in a business process. Knowledge workers are equipped with detailed knowledge of the application domain, and they can perform activities, or even parts of business processes, autonomously.
- *Process Owner*: Each business process model is assigned an individual who is responsible for the correct and efficient execution of the process. He or she is responsible for detecting inefficiencies in the process and for improving it, in close collaboration with the process participants and the process designers.
- *System Architect*: System architects are responsible for developing and configuring business process management systems so that the configured business process management system enacts the business processes in the context of the information systems infrastructure at hand.
- *Developers*: Developers are information technology professionals who create software artefacts required to implement business processes. The implementation of interfaces to existing software systems is an important area of work for developers.

These different types of stakeholders need to cooperate closely in designing business processes and in developing adequate solutions for enacting them. The business process lifecycle provides a rough organization of the work con-

ducted and the concepts used in this endeavour. In Chapter 8 the specific properties of development methodologies for business process management applications are discussed in more detail.

1.3 Classification of Business Processes

In this section, the main dimensions along which business processes can be classified are investigated.

Organizational versus Operational

Different levels of abstraction can be identified in business process management, ranging from high-level business goals and business strategies to implemented business processes. These levels are depicted in Figure 1.6. At the highest level, business goals and strategies are specified. Business goals refer to the long-term objectives of the company, while business strategies refer to its plans for achieving these goals.

At the second level, organizational business processes can be found. *Organizational business processes* are high-level processes that are typically specified in textual form by their inputs, their outputs, their expected results, and their dependencies on other organizational business processes. These business processes act as supplier or consumer processes. An organizational business process to manage incoming raw materials provided by a set of suppliers is an example of an organizational business process.

Informal and semiformal techniques are used at these high levels. The strategy of a company, its goals, and its organizational business processes can be described in plain text, enriched with diagrams expressed in an adhoc or semiformal notation. A forms-based approach to express organizational business processes is discussed in the next chapter.

While organizational business processes characterize coarse-grained business functionality, typically there are multiple operational business processes required that contribute to one organizational business process. In *operational business processes*, the activities and their relationships are specified, but implementation aspects of the business process are disregarded. Operational business processes are specified by business process models.

Operational business processes are the basis for developing implemented business processes. *Implemented business processes* contain information on the execution of the process activities and the technical and organizational environment in which they will be executed.

As discussed earlier in this chapter, there are multiple ways to implement business processes, ranging from written procedures and policies of the organization to the use of process enactment platforms. In any case, implemented business process refers to a specification that allows the enactment of the process on a given platform, be it organizational or technical.

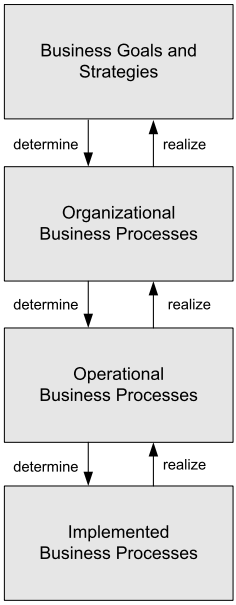

Fig. 1.6. Levels of business processes: from business goals and strategies to implemented business processes

Intraorganizational Processes versus Process Choreographies

As defined above, each business process is performed by a single organization. If there is no interaction with business processes performed by other parties, then the business process is called *intraorganizational*. Most business processes, however, interact with business processes in other organizations, forming process choreographies. The ordering process choreography discussed earlier in this chapter is an example of interacting business processes.

The primary focus of intraorganizational business processes is the streamlining of the internal processes by eliminating activities that do not provide value. The personnel of the enterprise is represented in organizational models used to allocate activities to persons who are skilled and competent to perform these activities. Traditional process management systems can be used to support intraorganizational business processes.

There are a number of issues to address when dealing with interacting business processes, including not only communication aspects related to the process structures, but also legal matters. Interactions between business processes need to be protected by legally binding contracts between the companies involved.

Also, the technical layer requires more thought, since multiple organizations have most likely a heterogeneous software infrastructure that hampers

interoperability in the software layer. Process choreographies are discussed in detail in Chapter 5.

Degree of Automation

Business processes can diverge in the level of automation. There are business processes that are fully automated, meaning that no human is involved in the enactment of such a business process. An example is ordering an airline ticket using Web interfaces. While the process is fully automated on the side of the airline, the customer is involved with manual activities, such as providing address information via Web browser interfaces.

Enterprise application integration is another area where automated business processes can be found. The goal is to integrate the functionality provided by a heterogeneous software landscape. While there are different techniques to integrate enterprise applications, process technology is an important technology, especially since the emergence of service-oriented software architectures that allow composing services to processes.

Many business processes require manual activities; but they also include automated activities. Processing an insurance claim is an example of such a process. Manual activities enter the customer data and determine the settlement of the damage, while automated activities are used to store data on the damage in the software systems of the company.

The interaction with the human user is essential in these settings. Early approaches that prescribe to human users "what to do next" often failed. User interfaces that accept the knowledge worker as an important source to improve and control the process provide more user acceptance.

Degree of Repetition

Business processes can be classified according to their degree of repetition. Examples of highly repetitive business processes include business processes without human involvement, such as online airline ticketing. However, business processes in which humans are involved can occur frequently, for example, insurance claim processing. If the degree of repetition is high, then investments in modelling and supporting the automatic enactment of these processes pay off, because many process instances can benefit from these investments.

At the other end of the repetition continuum, there are business processes that occur a few times only. Examples include large engineering efforts, such as designing a vessel. For these processes it is questionable whether the effort introduced by process modelling does in fact pay off, because the cost of process modelling per process instance is very high.

Since improving the collaboration between the persons involved is at the centre of attention, these processes are called *collaborative business processes*.

In collaborative business processes, the goal of process modelling and enactment is not only efficiency, but also tracing exactly what has actually been done and which causal relationships between project tasks have occurred.

This aspect is also present in the management of scientific experiments, where data lineage is an important goal of process support. Since each experiment consists of a set of activities, an increasing fraction of the experimentation is performed by analyzing data using software systems. The data is transformed in a series of steps. Since experiments need to be repeatable, it is essential that the relationship of the data sets be documented properly.

Business processes with a low degree of repetition are often not fully automated and have a collaborative character, so that the effort in providing automated solutions is not required, which lowers the cost.

Degree of Structuring

If the business process model prescribes the activities and their execution constraints in a complete fashion, then the process is structured. The different options for decisions that will be made during the enactment of the process have been defined at design time. For instance, a credit request process might use a threshold amount to decide whether a simple or a complex credit check is required, for instance, 5000 Euros. Each process instance then uses the requested amount to decide on the branch to take.

Leymann and Roller have organized business processes according to dimensions structure and repetition. They coined the term *production workflow*. Production workflows are well structured and highly repetitive. Traditional process management system functionality is well suited to supporting production workflows.

If process participants who have the experience and competence to decide on their working procedures perform business process activities, structured processes are more of an obstacle than an asset. Skipping certain process activities the knowledge worker does not require or executing steps concurrently that are ordered sequentially in the process model is not possible in structured business processes.

To better support knowledge workers, business process models can define processes in a less rigid manner, so that activities can be executed in any order or even multiple times until the knowledge worker decides that the goals of these activities have been reached. So called *adhoc activities* are an important concept for supporting unstructured parts of processes.

Case handling is an approach that supports knowledge workers performing business processes with a low level of structuring and, consequently, a high level of flexibility. Rather than prescribing control flow constraints between process activities, fine-grained data dependencies are used to control the enactment of the business process. These aspects will be discussed in more detail in Chapter 7.

1.4 Goals, Structure, and Organization

Before the structure of this book is discussed, a summary of the goals of business process management is given.

Arguably, the most important goal of business process management is a better understanding of the operations a company performs and their relationships. The explicit representation of business processes is the core concept to achieving this better understanding.

Identifying the activities and their relationships and representing them by business process models allows stakeholders to communicate about these processes in an efficient and effective manner. Using business process models as common communication artefacts, business processes can be analyzed, and potentials for improving them can be developed.

Flexibility—the ability to change—is the key operational goal of business process management. The subjects of change are diverse. Business process management not only supports changing the organizational environment of the business process, but also facilitates changes in the software layer without changing the overall business process. Flexibility in business process management is discussed in detail in Section 3.10.

A repository of the business processes that a company performs is an important asset. To some extent, it captures knowledge of how the company performs its business. Therefore, business process models can be regarded as a means to expressing knowledge of the operation of a company.

But business process management also facilitates continuous process improvement. The idea is to evolutionarily improve the organization of work a company performs. Explicit representations of business processes are well suited for identifying potentials for improvement, but they can also be used to compare actual cases with the specified process models. While in principle more radical business process reengineering activities can also be supported by business processes, evolutionary measures to improve business processes might in many cases be the favourable solution.

Business process management also aims at narrowing the gap between business processes that a company performs and the realization of these processes in software. The vision is that there is a precisely specified relationship between an activity in the business process layer and its realization in software.

The book is organized into three parts, providing a foundation of business process management, looking at concepts and languages for business process modelling, and investigating architectures and methodologies.

Part I continues with Chapter 2, which looks at business process management from a software systems point of view by investigating the evolution of enterprise systems architectures. The role of business process management systems and the relationships to other types of information systems are highlighted.

Part II covers business process modelling. Chapter 3 presents the foundation of business process modelling by introducing abstraction concepts. It also introduces a way to describe process models and process instances based on fundamental concepts, such as events that occur during the execution of business process instances and their dependencies.

Chapter 4 looks at process orchestrations by first discussing control flow patterns. The meaning of these patterns is expressed by properties of process instances using these patterns. A metamodel is used to specify the semantics of control flow patterns. An important part of this book deals with process modelling techniques and notations. The most important ones are discussed in a concise manner, including Petri nets, event-driven process chains, workflow nets, Yet Another Workflow Language, a graph-based workflow language, and the modelling elements of the Business Process Model and Notation, which are related to process orchestrations.

Process choreographies are covered in Chapter 5. Process choreographies describe the interaction of multiple business processes and, as such, are an important concept for supporting business-to-business collaboration. After introducing high-level choreographies that specify dependencies between interactions of choreographies, service interaction patterns are discussed. Interesting issues occur with regard to the correctness of combined execution when combining multiple business processes. These issues are addressed by discussing the notions of compatibility and consistency. The public-to-private approach is introduced, a concrete technique to develop process orchestrations that are consistent with their behavioural interfaces. This chapter is complemented by introducing language elements of the Business Process Model and Notation that are related to process choreographies.

Properties of business process models are investigated in Chapter 6. Correct data dependencies within a process are a simple type of correctness property of a business process. With object lifecycle conformance, a property of business processes with respect to the data objects they operate on, is introduced. Other correctness criteria have been proposed as different types of soundness criteria. If a business process is sound, then each process instance enjoys certain execution guarantees, for instance, freedom from deadlock. There are different types of soundness properties, each of which takes into account some specific aspect of the business process executed.

Part III investigates architectures of business process management systems and methodologies to develop business process applications. Chapter 7 introduces traditional workflow management architectures and flexible workflow management architectures that allow us to modify processes dynamically. Based on a discussion of Web services as the current implementation of service-oriented architectures, Web services composition is discussed as the mechanism to realize business processes whose activities are implemented by Web services. To ease the composition of services, advanced service composition, which takes advantage of semantic annotations of services, is discussed.

Chapter 7 completes by introducing data-driven process control and its realization in case handling systems.

Chapter 8 introduces a methodology for the development of business process applications involving human users. This methodology provides an understanding of the complexity and of the technical and organizational difficulties in the design and development of business process applications.

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