

# Secondary Publication



Ferstl, Otto K.; Sinz, Elmar J.

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Date of secondary publication: 26.08.2024

Accepted Manuscript (Postprint), Conferenceobject

Persistent identifier: urn:nbn:de:bvb:473-irb-975563

### Primary publication

Ferstl, Otto K.; Sinz, Elmar J. (1997): „Flexible organizations through object-oriented and transaction-oriented information systems“. In: Hermann Krallmann (Ed.), *Wirtschaftsinformatik '97 : internationale Geschäftstätigkeit auf der Basis flexibler Organisationsstrukturen und leistungsfähiger Informationssysteme*, Heidelberg: Physica-Verl., pp. 393–411, doi: 10.1007/978-3-642-57737-6\_24.

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# **FLEXIBLE ORGANIZATIONS THROUGH OBJECT-ORIENTED AND TRANSACTION-ORIENTED INFORMATION SYSTEMS**

O. K. Ferstl, E. J. Sinz

Information systems are a critical success factor for flexible organizations. Starting with behavioral and structural characteristics of flexible organizations, the paper introduces an architectural framework for the specification of flexible organizations. This framework shows model layers for (1) enterprise plan, (2) business processes, and (3) personnel and machine resources for business processes. All three layers prove to be crucial for flexible organizations. The paper concentrates on layers (2) and (3), examining the potential of distribution and virtualization. Both layers are specified as distributed systems and are connected among one another by flexible relationships. The object-oriented concept of autonomous, loosely coupled components which cooperate using transaction-oriented coordination mechanisms is used as a fundamental modeling technique. Based upon the idea of setting-up a flexible organization as a system of virtual business processes, the role of business information systems within flexible organizations is investigated. Finally, some key concepts for the automated subsystems of an information system, the business application systems, are examined. The paper focuses on the question: How can object-oriented and transaction-oriented information systems contribute to establish flexible organizations?

Informationssysteme stellen für flexible Organisationen einen kritischen Erfolgsfaktor dar. Ausgehend von Verhaltens- und Strukturmerkmalen flexibler Organisationen führt der Beitrag einen Architekturrahmen für die Spezifikation flexibler Organisationen ein. Dieser Rahmen unterscheidet Modellschichten für (1) Unternehmensplan, (2) Geschäftsprozesse und (3) Personal sowie maschinelle Ressourcen zur Unterstützung von Geschäftsprozessen. Alle drei Schichten erweisen sich als kritisch für flexible Organisationen. Der Beitrag konzentriert sich auf die Schichten (2) und (3), wobei speziell das Potential von Verteilung und Virtualisierung untersucht wird. Die beiden Schichten werden als verteilte Systeme spezifiziert und untereinander durch flexible Beziehungen verknüpft. Als grundlegender Modellierungsansatz wird das objektorientierte Konzept autonomer, lose gekoppelter Komponenten genutzt, welche auf der Basis transaktionsorientierter Koordinationsmechanismen kooperieren. Aufbauend auf dem Ansatz, eine flexible Organisation als System virtueller Geschäftsprozesse zu begründen, wird die Rolle betrieblicher Informationssysteme in flexiblen Organisationen untersucht. Schließlich werden einige Konzepte für die automatisierten Subsysteme eines Informationssystems, die betrieblichen Anwendungssysteme, betrachtet. Im Mittelpunkt des Beitrags steht die Frage: Wie können objekt- und

transaktionsorientierte Informationssysteme zur Gestaltung flexibler Organisationen beitragen?

## 1 Introduction

Setting-up flexible organizations is one of the big challenges in business and management for the next years (Bahrami 1992). Information systems play an important role in achieving this goal.

In the following, the term (business) information system denotes the whole information processing sub-system of an organization. It includes all information processing tasks of an organization as well as the information relationships between these tasks. Actors of the information system are persons and application systems. Personnel and machine actors communicate while carrying out the information processing tasks.

The main purpose of the information system is to control the organization. In some respect, the information system can be considered the nervous system of an organization. It plays the same role as the nervous system does in an organism.

An organization and its sub-system information system have to meet equivalent requirements. As we will show in this paper, distribution of components is a key prerequisite for flexibility of a system. As organizations need to be distributed to obtain flexibility, information systems have to be distributed as well.

In the OEVIS project (object-oriented development of distributed information systems; see remark 1) we investigated methodical concepts for distributed information systems. The results of the OEVIS project have been reported in several papers (see e.g. Ferstl/Sinz 1994b, Ferstl u.a. 1994). The project showed, how object-oriented concepts of autonomous, loosely coupled objects combined with transaction-oriented concepts for the coordination of the objects can establish a solid platform for distributed information systems. The methodical concept behind the OEVIS project is the SOM approach (Semantic Object Model), a comprehensive approach for enterprise modeling (see e.g. Ferstl/Sinz 1990, Ferstl/Sinz 1991, Ferstl/Sinz 1995). The SOM approach comprises business process modeling as well as information system and application system modeling. During the OEVIS project the SOM approach has been detailed and extended. In this paper, we look at the OEVIS results from an organizational viewpoint. We ask the question: How can object-oriented and transaction-oriented information systems contribute to establish flexible organizations? In the following chapters, we examine this question and try to give some answers.

## 2 Flexible Organizations

Throughout this paper, the term organization is used to denote any kind of socio-technical system with goals and objectives (see remark 2), e.g. companies, business units of companies, administrations, and cooperating companies. Thus, the term organization is not restricted to a company's boundary. To investigate the requirements on flexible organizations, we distinguish between behavioral and structural characteristics. In the following, some of these characteristics which are fundamental to the SOM approach will be outlined.

*Behavioral characteristics* of flexible organizations are discussed currently from the viewpoint that organizations have to go through major transformations, caused by environmental shifts like new international distribution of production sites, and caused by technological breakthroughs centered around the new communication networks (see e.g. Picot/Reichwald 1994, Picot u.a. 1996). Characteristics to meet these changes will be categorized by the aspects evolution of an organization, organization as a viable system, organizational learning and virtual organization:

- *Evolution of an organization:* Looking at an organization from the outside, this term means rather small sized steps of smoothly changing an organization to adapt to modified environmental conditions and to modified organizational goals. Many organizations have to learn that conditions and goals are changing continuously and therefore require continuous evolution. Interesting problems from this viewpoint are to find out relevant environmental changes and sensory methods to anticipate these changes.

Looking at an organization from the inside, the term evolution describes strategies and conditions of organizations to survive in the world they are living in. Which measures have to be taken to adapt the structure and the behavior of an organization to keep it alive?

- *Organization as a viable system:* Meanwhile, there is more understanding that an objective like maximization of profit is a formal measurable sub-objective of the objective maximization of viability. This objective is based on the view that an organization is an organism which tries to survive in its environment. Applied to organizations, the model of viable systems shows two architectural features of a viable system: autonomy and recursiveness (Beer 1981). Autonomous systems should be able to survive on their own. For this ability they include all necessary functions like input/output transformation, power supply, maintenance functions, communication and sensory functions, and systems management to coordinate all these functions. A recursive system consists of sub-systems with features equivalent to those of the whole system, i.e. an autonomous recursive system consists of autonomous systems.
- *Organizational learning:* One of the major problems in the transformation process of an organization is to adapt the staff to new tasks or to a new organizational culture (Senge 1990). The traditional way goes top down: The first step is to develop plans and strategies derived from organizational goals

and objectives. The next steps are training courses for the staff to meet the requirements derived from the plans. The staff is considered a rather passive group which has to be trained to adapt to new requirements.

Learning organizations also have goals, plans and strategies. But the staff is now in a self-learning situation. The staff as a group and each member have to decide on their own which is the best way to adapt to a new situation and which learning steps are necessary to go this way. The self-learning situation may include corporate planning and thus enable (1) a better adjustment of planning and of the training phase, and (2) faster adaptation to environmental changes affecting the organization. Integration of planning and learning allows an early and organization-wide examination of the validity and feasibility of corporate plans.

- *Virtual organizations*: Real organizations have real attributes. They have real (i.e. physical) locations and exist continuously in time. They use long term actors as well as long term equipment and plants. Their input/output procedures and transformation procedures are maintained permanently during life-time. Property rights, social institutions and so on are based on this understanding of organizations. Virtual organizations also include input/output procedures and transformation procedures, management and actors, all of these oriented toward the goals of the virtual organization (see e.g. Arnold/Härtling 1995, Griese 1994, Olbrich 1994, Mertens/Faisst 1994, Scholz 1994). However, they implement these features by adopting them from real organizations which are short-term or long-term members of the virtual organization. Virtual organizations should be able to achieve higher degrees of adaptation and less consumption of resources. However, they need new management techniques and especially new communication procedures to overcome the problems of restricted stability in terms of location and availability of resources.

*Structural characteristics* of flexible organizations are considered here mainly from a designer's viewpoint who is interested in the degrees of freedom of an organization's design. They are categorized by the aspects degree of automation, distributed system, sphere of control and architectural framework:

- *Degree of automation*: An organization is a socio-technical system which pursues goals and objectives by carrying out tasks. Actors of the tasks are persons and machines. Because of the explicit differentiation between a task layer and an actor layer it is necessary to assign tasks to actors. The result of this assignment is indicated by the degree of automation which describes the set of tasks assigned to machines. Flexible organizations use dynamic assignment to exploit the special skills and potentials of persons and machines. Examples for fast and frequent changes of assignments are communication tasks within organizations. They are now strongly supported by the ubiquitous computer networks.
- *Distributed system*: In general, a distributed system shows the following properties (see also Enslow 1978):

1. From an outside view, the system is a black box, pursuing a set of joint goals.
2. The inside view shows of a distributed system shows multiple autonomous components which cooperate in pursuing the goals. There is no component which has global control of the system.

These minimum features will be supplemented to apply the concept of distributed systems to organizations:

3. The distribution of the multiple components of the system is invisible from an outside view. This feature is called transparency of distribution.
4. The components of a distributed system are loosely coupled. Each component is autonomous and encapsulates its states and the transitions defined on it.

Organizations are an important class of distributed systems. Here, components are autonomous organizational units. Their separation into a task layer and an actor layer increases the complexity of the control problem within this type of distributed system. However, there are a lot of advantages of distribution. The separation offers clarity and enables to explore possible solutions of the assignment problem between the task layer and the actor layer.

Virtual organizations as a special class of organizations also are distributed systems, designed for highest degrees of flexibility. As outlined in chapter 4 they consist of virtual organizational units which are mapped onto real organizational units. Distribution features have to be described for the virtual and the real layer. The complexity of the control problem in virtual organizations is increased again, as it is through the separation of the task layer and the actor layer.

- *Sphere of control*: From the viewpoint of information systems sciences the management of an organization is part of the organizational sub-system which deals with information processing in general and which is called the information system of an organization. All relevant states and transitions of an organization have to be recorded and supervised by the information system which in general is decentralized. The increasing degrees of freedom in flexible organizations require new strategies for information systems to control an organization. These new strategies have to take into consideration the behavioral and structural characteristics outlined in this chapter. Among the most important solutions for this problem are the implementation of nonhierarchical coordination mechanisms according to the concept of autonomous components in distributed systems (Ferstl/Sinz 1995), intensive usage of network services for implementing world-wide information systems or the implementation of learning processes in organizations.
- *Architecture*: Real organizations may include thousands of persons and machines. The spectrum of goals, tasks and membership of an organization comprises a large variety. Analysis and design of an organization is a complex problem which needs methodical support. Important design principles are to

distinguish between an outside and an inside view of a system, or the separation of the task layer and the actor layer as already mentioned. The appropriate way to handle such complexity is to build several models, focusing different features and levels of abstractions while observing integrity constraints between the models. Additional views on the models help to understand and examine the models. A systematic approach to integrate different design principles leads to an architectural framework which is explained in the following chapter 3.

### 3 An Architectural Framework for Flexible Organizations

To understand a complex system such as an organization, a comprehensive model of the system is required. In general, this model is very complex as well. In order to deal with the complexity of the model, it is divided into several model layers, each of them focusing on a special view on the system. This leads to an architectural framework for organizations, which we call enterprise architecture (fig. 1).

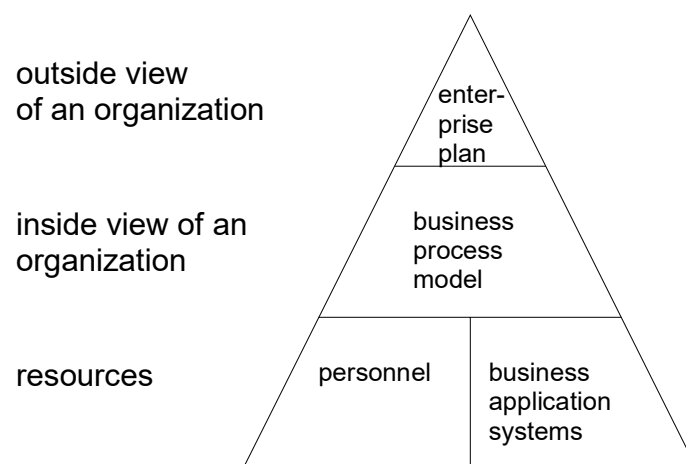


Figure 1: Enterprise architecture

The enterprise architecture structures a comprehensive model into three layers (Ferstl/Sinz 1995):

- *Enterprise plan*: The enterprise plan constitutes an outside view on an organization. It focuses on the global task of an organization. First, this task

has to be marked off from its environment and then has to be specified. The specification includes the universe of discourse, the goals and objectives to be pursued, and the services to be produced. The relationships between the enterprise task and its environment are further characterized by an analysis of chance and risk, as well as strength and weakness. The specification of the procedure of the enterprise task includes product/market strategies, strategic actions, and rules. Last but not least the resources which are necessary to carry out the task are specified roughly.

- *Business process model*: The business process model constitutes an inside view on an organization. It specifies main processes and service processes. Main processes contribute directly to the goals of the organization, service processes provide their outcome to main processes or other service processes. Relationships between business processes follow the client/server concept. A client process engages a service process to deliver a certain service. Because business processes are autonomous components which cooperate in pursuing joint goals and because no business process has global control on the whole organization, the system of business processes establishes a distributed system.
- *Specification of resources*: Personnel and application systems are regarded as resources for carrying out the business processes. The enterprise architecture treats personnel and application systems as independent resources. This means that the relationships between persons and application systems is characterized by a partner/partner relationship rather than by a person/tool relationship. This kind of relationship conceptually allows to substitute persons and application systems as actors of given business tasks, thus improving synergy to a high potential.

Why does an enterprise architecture like this help to establish and manage flexible organizations? There are several reasons:

- Inside view, outside view, and resources of an organization are specified separately in different model layers.
- The relationships between the layers are specified explicitly.
- Each layer employs autonomous and loosely coupled components.

Any model of an organization has to be balanced within and between the three layers of the enterprise architecture. In contrast to a single-layered monolithic model, a multi-layered, differentiated model allows local changes without affecting the whole. For example, it is possible to improve a business process model (inside view) yet retaining goals and objectives (outside view), at the same time replacing actors of one type by other ones.

The underlying methodical concept of the enterprise architecture is a general architectural framework shown in fig. 2 (Sinz 1995b, Sinz 1996). In general, the architectural framework divides a complex model into several model layers, each of them specified according to a corresponding meta-model. To manage complexity, convenient views are defined on each model layer. Moreover, each layer is associated with a particular set of design patterns, providing modeling

rules and heuristic knowledge applicable to this model layer. The concept of design patterns applies the idea of object-oriented design pattern (see e.g. (Gamma et al. 1995)) to each model layer of the architectural framework. Relationships between different model layers are specified by relationship meta-models. Relationship patterns may be provided to support the connection of different model layers with transformation rules and other knowledge.

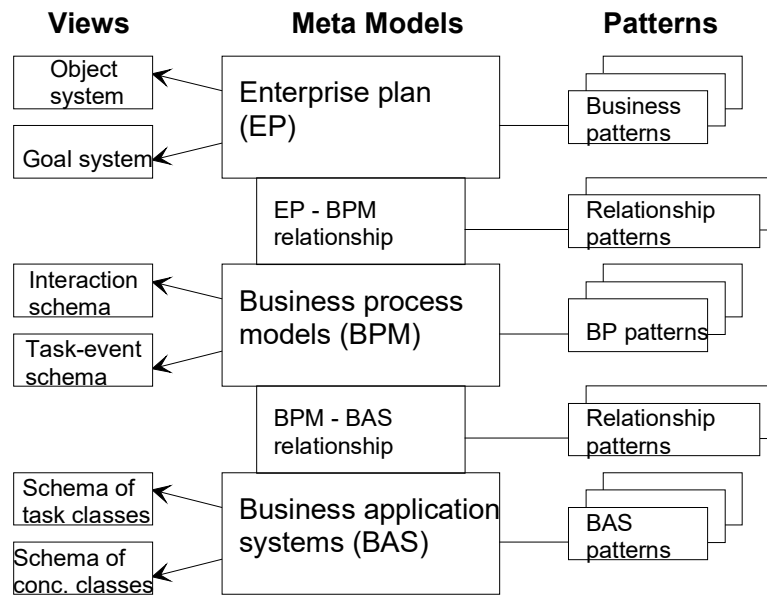


Figure 2: Architectural framework for business system modeling

In fig. 2 the architectural framework is instantiated with the domain-related layers of the SOM approach. The three model layers match with the enterprise architecture in fig. 1. However, the third layer is limited to application systems. This is because personnel tasks are frequently ill structured and therefore less convenient for formal modeling. In the following chapters we will refer to some specific components of the architectural framework.

## 4 Object-Oriented and Transaction-Oriented Business Process Models of Flexible Organizations

In literature and practice, there are several approaches to business process modeling (see e.g. Vossen/Becker 1996). Most of them look at a business process as a sequence of activities (also called steps, process elements, functions), which have to be performed when carrying out a business process and which are provided with resources when being performed.

In contrast, the SOM approach to business process modeling considers three different characteristics of a business process (Ferstl/Sinz 1993, Ferstl/Sinz 1995). Following this approach, a business process model specifies for each business process the following attributes:

1. *Production and delivery* of one or more services (the term service includes products, goods, and payments as well),
2. *Coordination of the business objects* which are involved in the production and delivery of these services, and
3. *Sequence of tasks* which are to be carried out when performing a business process.

Service relationships connect different business processes and link business processes to the environment of the universe of discourse.

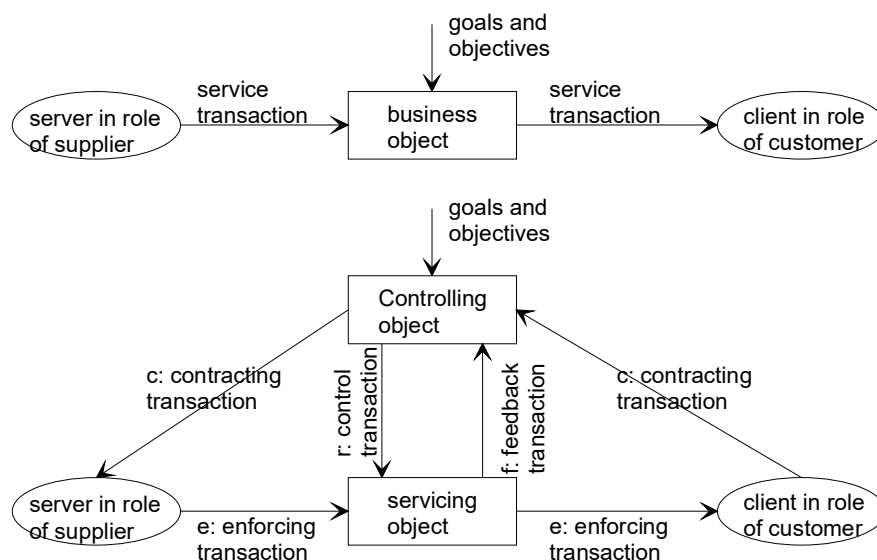


Figure 3: Basic building block for business process models

The business process model in fig. 3 shows a simple business process and its first decomposition. This business process model is used as a basic building block for the more complex business process models of flexible organizations. This building block will be explained now according to the characteristics given above. We concentrate on (1) services and (2) coordination. The sequence of tasks (3) is not relevant here and is therefore omitted.

According to its goals and objectives, the business object in fig. 3 produces a service and delivers it within a service transaction to a client in the role of a customer. Input services which are necessary to produce this service are delivered by a server in the role of a supplier. To uncover the coordination of this business process, the service transactions as well as the business objects are decomposed. Two basic principles are used for decomposition (Ferstl/Sinz 1995):

- Following the *negotiation principle*, the service transaction is decomposed into three subsequent transactions: (1) an initiating transaction, where the business object and its client/server learn to know each other and exchange information on deliverable services, (2) a contracting transaction, where both objects agree to a contract on the delivery of services, and (3) an enforcing transaction, where the objects exchange the service. To simplify matters, we assume that the objects already know each other and will omit the initiating transaction in the following discussion.
- Applying the *feedback control principle*, a business object is decomposed into a controlling sub-object and a servicing sub-object as well as a control transaction and a feedback transaction. These components establish a feedback control loop. The controlling object prescribes objectives or sends control messages to the servicing object via the control transaction. Conversely the servicing object reports to the controlling object.

By means of fig. 3, the object-oriented and transaction-oriented modeling technique of the SOM approach becomes clear. Each business object encapsulates its states and the operations defined on them. The business objects are loosely coupled and interact by passing services and messages. In this respect, business objects show the same characteristics as objects in object-oriented approaches do. In addition, the coordination of objects is specified on the basis of business transactions. This transaction-oriented concept is used complementary to the object-oriented concept. The two concepts are linked by the concept of tasks. A business object consists of a set of tasks, each transaction is performed by exactly two tasks of different objects.

The object-oriented and transaction-oriented concept of business processes constitutes a solid platform for flexible organizations. It allows to substitute or to re-implement a business object without affecting other parts of the organization and it allows to re-arrange the cooperation of business objects without changing them. Nevertheless this concept is not sufficient when an organization consists of several legally independent organizations, which cooperate for a limited time to create a particular supply or demand.

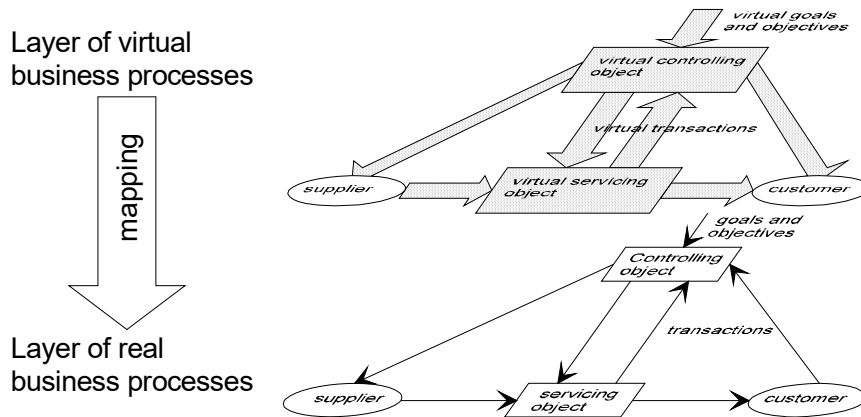


Figure 4: Concept of virtual business processes

To contribute to the solution of this problem, we introduce the concept of *virtual business processes* (fig. 4). Similar to the concepts of virtual machines in the area of programming and the concept of virtual resources in the field of operating systems, a virtual business process is implemented upon a system of real business processes. Virtual machines and virtual resources are implemented by a program or software layer on real machines and real resources. Unlike this way of implementation, the mapping of virtual business processes on real business processes is specified by a set of common business rules. Each real business process participating in a virtual business process agrees to obey these business rules. The business rules are replicated and stored in the controlling objects of the real business processes.

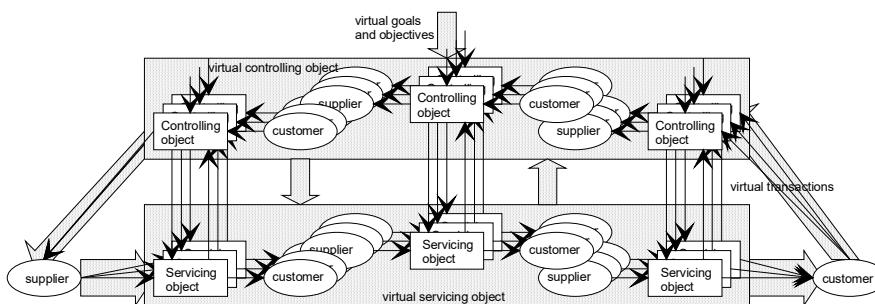


Figure 5: Virtual business process and real business processes

Finding out the business rules to map a virtual business process onto a set of real business processes is the big challenge when establishing a virtual organization. At present, in literature and practice there is no general approach to solve this problem. To contribute to a solution of this problem, we point out different characteristics of the mapping.

To decompose the problem of mapping a virtual business process onto a set of real business processes, the components of the outside view of a business process have to be considered: business objects, goals and objectives, and transactions. Consequently, the outside view of a virtual business process consists of virtual goals and objectives, virtual business objects, and virtual transactions. These components have to be mapped onto the corresponding components of real business processes (fig. 5):

- *Virtual goals and objectives* are achieved by *coordination* of real goals and objectives. This requires the real goals to be complementary. Otherwise, if conflicting, comparative advantages must arise for any participant. The real objectives have to be compatible.
- *Virtual business objects* are established by *cooperation* of real business objects. This can be achieved in two ways: (1) tight coupling using shared memory (common information base of real business objects) and (2) loose coupling using transactions (message passing between real business objects).

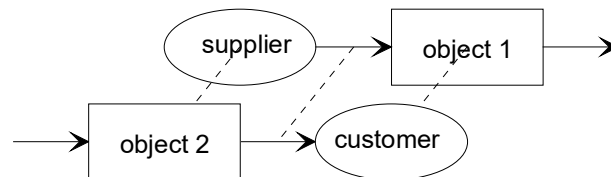


Figure 6: Loosely coupling of business objects

Referring to fig. 5, the technique of loosely coupling of business objects is shown in fig. 6.

- *Virtual transactions* are made by *bundling* up real transactions. The real transactions are invisible to any external customer or supplier. The transparency of transactions is restricted to the negotiation principle, e.g. initiating, contracting, and enforcing transactions. We assume, that control and feedback transactions as introduced with the feedback control principle should not be virtualized.

In the following, we discuss requirements on information systems which arise from the mapping of the components of virtual business processes onto the components of real business processes.

## **5 The Role of Information Systems within Flexible Organizations**

As pointed out in chapter 2 the sub-system within an organization which deals with information processing, storing, and transmission is called the information system. This definition uses a formal criterion to differentiate this sub-system from the residual system. The main function of an information system is to manage the organization. This function is also described by the term nervous system. An information system cannot be segregated precisely by specifying the persons or machines involved in the tasks of the information system. Each component of an organization needs an informational part at least to communicate with other components, otherwise it is not able to be part of an organization. The segregation of the informational sub-system cannot be made at the actor layer, it will be done at the task layer. Each real component at the actor layer usually participates in several tasks and is part of the information system because it has to communicate. Among other things, the assignment of tasks to actors is part of the automation problem. The following argumentation distinguishes between task layer and actor layer and realizes that the term information system segregates this sub-system only the task layer.

The information system penetrates all components of an organization. But there are different ways how an information system manages an organization. While organizations in the past preferred centralized hierarchical coordination procedures with long decision lines, modern flexible organizations use the paradigm of the distributed systems. They consist of business processes as autonomous organizational units which use nonhierarchical coordination procedures among one another and hierarchical or nonhierarchical coordination inside the processes. The result is a balanced system of hierarchical or nonhierarchical coordination to meet requirements such as gaining flexibility and managing complexity. Business processes within a distributed system are loosely coupled organizational units which interact via transactions. The protocol of transactions may be a matter of standardization, e.g. the EDIFACT standard for communication between companies.

Actors of the tasks of an information system are persons and application systems. Assignment of tasks to persons and application systems has to take into consideration a lot of parameters like qualification and availability of application systems and persons as well as maintainability of task specifications. An additional type of assignment problem has to be solved in virtual organizations. Here we have a mapping between the objects, transactions, and goals at the virtual level and the corresponding components on the level of real organizations. Flexible organizations use dynamic solutions in both assignment problems which becomes clear when we take a look at the interaction between the components from the viewpoint of communication.

From the viewpoint of communication protocols, the transition from real to virtual organizations and especially from real to virtual information systems shows

another effect. Packet switching networks use either virtual circuits or datagrams. A virtual circuit as used in wide-area networks establishes a logical connection between two communication partners at the begin of a session and retains this connection until the end of the session. There is a fixed assignment of real lines to the virtual one during the whole session. Datagrams use a flexible assignment between both layers. Each packet takes an individual route through the network, possibly using different real lines. Here it is necessary to use fast and flexible link controls. Datagrams offer much more flexibility than virtual circuits. A breakdown of parts of a network does not necessarily jeopardize the function of the network as a whole. The resources of a network can be fully exploited.

The transition from real to virtual information systems corresponds to the transition from virtual circuits to datagrams in many respects. Real information systems are built upon assumptions similar to those for virtual circuits. There are fixed links put down in organizational rules and application systems which are valid for an unlimited period of time. Virtual information systems use the concept of datagrams. They utilize flexible connections via dynamic mapping onto real information systems, benefiting from features equivalent to those of datagram methods. A virtual information system can be streamlined to the essential requirements just like a virtual organization is built around a specified spectrum of services and products which have to be produced by this organization. The resources of real information systems and real organizations can be fully exploited.

## 6 Distributed Business Application Systems

We define business application systems as automated actors within an information system. A business application system consists of specifications of automated information processing tasks and corresponding machine actors. The latter are computers and networks together with the necessary system software and application software.

From the viewpoint of distributed systems we distinguish three layers of specification (fig. 7):

1. A flexible organization is specified as a *distributed system of business processes*. Its information processing sub-system is the information system.
2. A *distributed business application system* which is the automated actor of an information system.
3. A *distributed computing system* which serves as actor for the distributed application system.

Using the SOM approach, these layers are specified independently. They have to be balanced with care to get the most out of a flexible organization. We examine some key issues:

- *Distribution of business application systems:* Business application systems should be distributed along with the business processes. If business processes and their relationships change, the corresponding application systems and their relationships should change with them without affecting other parts of the organization. The application systems should be designed seamless and without overlapping which would cause automation gaps and functional redundancy, respectively. More and more, the business process model shows to be the backbone of a widespread application systems architecture.

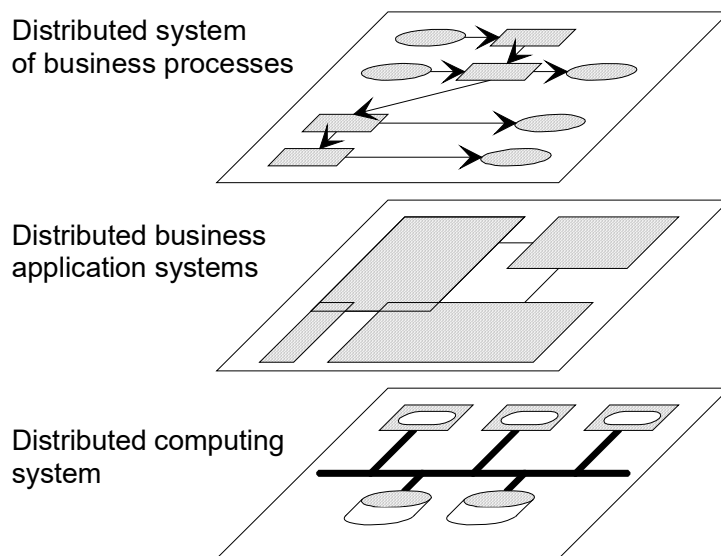


Figure 7: Layers of distributed systems

- *Integration of business application systems:* The predominant way of integrating application systems is data integration. Several application systems share a common database, the application functions operate on this database via external views. Although this form of integration preserves consistency and avoids redundancy of data, it is not sufficient for application systems of flexible organizations.

This is why the concept of data integration has to be completed by the concept of object integration (Ferstl 1992; Ferstl/Sinz 1994a, p. 207ff]. Following this concept, a distributed application system consists of several autonomous, loosely coupled sub-systems which themselves may be data integrated again. To achieve consistency of the whole application system, the sub-systems exchange messages according to detailed communication protocols. These

protocols are derived from the transaction-oriented coordination of business objects as specified in the business process models (Sinz 1995a).

- *Platforms for the development of business application systems:* The development of distributed application systems for flexible organizations requires high-level platforms to improve independency of physical platforms and to gain distribution transparency. Such platforms become increasingly available. Important examples are (object-oriented) database middleware (e.g. CORBA from the Object Management Group) and workflow management systems (see the activities of Workflow Management Coalition).

The client/server principle is the dominating architectural concept for distributed application systems. Usually an application system is decomposed into sub-systems for communication (presentation), application, and database management. These sub-systems are supported by corresponding platforms. Recently, the decomposition of the application sub-system has been further examined. For example, the SOM approach leads to a schema of task classes and a schema of conceptual classes (fig. 2) (Ferstl/Sinz 1990) which can be directly supported by workflow management middleware and database middleware.

- *Networking:* Communication networks are the enabling technique behind distributed application systems. At present, the borders of local-area networks and wide-area networks become blurred. An example is the generalization of the Internet by intranets which allows transparent networking within and across the boundary of an organization.

## 7 Conclusions

Organizations of today live in turbulent situations. They have to tackle a lot of problems in parallel. There are turbulent environmental conditions as well as varying goals and objectives. Organizations have to balance a spectrum of changing personnel and application systems. Flexibility is one of the key features to adapt to these new requirements.

This paper discussed requirements and design principles which may contribute to a solution of these problems. The application of the design principles *distribution* and *virtualization* will have impact on the design of organizations in general. The following theses summarize some of the crucial effects:

- Distribution of organizations, information systems, and application systems shows to be an important prerequisite for virtualization. Monolithic systems of today are not versatile enough to fit into the concept of virtualization.
- Virtualization of organizations requires new design methods. This paper introduced the concept of virtual business processes. This concept benefits from the concept of real business processes. It aims at an explicit specification

of the degrees of freedom within the mapping from the virtual layer to the real layer of business processes.

- The usage of the datagram concept in virtual organizations appears to be a universal concept for the communication of loosely coupled objects. Similar to the datagram concept in computer communication networks it leads to high flexibility and best utilization of real resources.
- The concept of virtual organizations has consequences on the design of real organizations. Small-sized real organizations will be the convenient components for future virtual organizations. These small-sized organizations are highly specialized and autonomous at the same time.
- The distribution of information systems leads to a network of small information processing components. This leads to a restructuring of application systems in turn. A comprehensive business process model of real and virtual business processes appears to prove as the backbone of the whole organization.

## 8 Remarks

1. The OEVIS project (1992 - 1996) was supported by the German Research Association (Deutsche Forschungsgemeinschaft) under no. Si-481/1
2. We use the term *goal* to denote the intended final state of an object, pursued by the execution of a task. The term *objective* refers to the corresponding quality aspects, aimed by the execution of the task.

## 9 Literature

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## **10 Autorenangaben**

Univ.-Prof. Dr. Otto K. Ferstl  
University of Bamberg  
Dept. of Information Systems  
D-96045 Bamberg  
Tel.: ++49 951 863 2679  
Fax: ++49 951 863 2680  
Internet: [otto.ferstl@sowi.uni-bamberg.de](mailto:otto.ferstl@sowi.uni-bamberg.de)

Univ.-Prof. Dr. Elmar J. Sinz  
University of Bamberg  
Dept. of Information Systems  
D-96045 Bamberg  
Tel.: ++49 951 863 2512  
Fax: ++49 951 863 2513  
Internet: [elmar.sinz@sowi.uni-bamberg.de](mailto:elmar.sinz@sowi.uni-bamberg.de)

## **11 Abbildungsdateien**

pic73-1.ds4 Micrografx Designer 4.0  
pic73-2.ds4 Micrografx Designer 4.0  
pic73-3.ds4 Micrografx Designer 4.0  
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