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METHODS WITH DOMAIN SPECIFIC
KNOWLEDGE: OUTLINE OF A METHOD
FOR ENTERPRISE MODELLING

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ENRICHING OBJECT-ORIENTED METHODS WITH DOMAIN SPECIFIC KNOWLEDGE: OUTLINE OF A METHOD FOR ENTERPRISE MODELLING

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**Anschrift der Verfasser/
Address of the authors:**

Prof. Dr. Ulrich Frank
Institut für Wirtschaftsinformatik
Universität Koblenz-Landau
Rheinau 1
D-56075 Koblenz

iwi Institut für
Wirtschaftsinformatik

Fachbereich Informatik
Universität Koblenz-Landau

Abstract

This paper presents a method for enterprise modelling that enhances object-oriented modelling with concepts from Management Science and Business and Administration. It includes a framework that provides a set of conceptually integrated partial models, each of which is suited to represent a particular perspective on the enterprise - a strategic, an organizational, and an information system perspective. While the conceptual foundation is provided by a common object model and a corresponding meta object model, the partial models have specialized semantics and provide intuitive notations. An overall process model fosters a coherent coordination of the various activities to be performed during analysis and design. The activities themselves are described in detail referring to the partial models and to analysis and design techniques, some of which are integrated in the overall object model. The framework is accompanied by an integrated tool environment which controls a model's integrity, provides various analysis techniques, and allows to navigate through a model. It will be shown that an enterprise model not only offers abstractions which are useful during the development of a corporate information system, but also some of them are well suited to support managerial decision making on an everyday base. Hence, an enterprise model can be regarded as a repository storing and managing concepts and resources directly related to a company's information system, as well as general knowledge about a firm.

1. Introduction

Corporate Information Systems (CIS), being systems that support business processes as well as managerial decision making, have an essential influence on a company's overall performance. Planning, designing, introducing, and maintaining a CIS is a complex endeavour. More than demanding a deep understanding of a company's current situation, it has to be taken into account that introducing advanced information technology allows for or may require new ways to target and organize the business - an aspect that has been stressed emphatically by numerous authors who recommended "business redesign" or "business process redesign" ([HaCh93], [Dav93]). Like system design, analysing and redesigning a corporate strategy and a company's organisation respectively are complex tasks on their own. Management Science and organisational theory offer a wide range of dedicated approaches for analysing and shaping a firm's strategy as well as for organisational design. Often they are based on models which are introduced to illustrate essential concepts and interrelations - and to communicate them to others who should be involved. Organisational models cover a wide range from rather prosaic to more formal representations. This is similar to models for strategic planning. They usually stress a more abstract view with highly aggregated data (for an overview see [Has92], [Sco86]). Regarding the highly specialized background of those models it is not surprising that strategic and organisational models are usually based on different concepts. Furthermore, they have, in general, nothing in common with conceptual models used in software engineering.

While there is certainly need for specialization, such a separation of concerns implies the risk of redundant work and friction:

> "I see the artificial split between organizational and technical issues as dangerous and unnecessary, and the frequent cultural chasm between business people and information technology professionals as the one factor that can block the effective use of computers and communications." [Kee91]

In order to allow for a more synergistic approach, a number of authors ([Zac87], [Kat90], [SoZa92], [Pet93]) have suggested enriched modelling frameworks - often named "enterprise modelling" (a term which, however, is not used in a unique way). Such methods usually suggest a number of views on the enterprise and intend to capture the relationships between these views. Studying them however shows that they remain on a rather abstract level (for instance: [SoZa92], [Za87]). Not only that they lack detailed concepts from a managerial point of view. Furthermore they neglect models to be used for software development. On the other hand there are a few approaches to support organisational redesign ("business process reengineering") which are based on software development methods ([Jac94], [Hen94]). However, they do not refer to existing concepts from organisational theory or strategic planning. Instead, they more or less emphasize that a general object-oriented approach is well suited to build the models required for business process reengineering.

This paper presents a method for enterprise modelling that enhances object-oriented modelling with concepts from Management Science. It includes an overall process model that fosters a coherent coordination of various activities. Furthermore it provides a set of conceptually integrated, problem specific modelling concepts, each of which is suited to represent a particular perspective on the enterprise. The method not only supports the design of CIS which are in line with organisational and strategic guidelines. Additionally, we will show that an enterprise model provides a number of advantages for the run time of a CIS as well.

2. MEMO: Overview of the General Framework

MEMO ("Multi Perspective Enterprise Modelling") is a method that supports the development of enterprise models. Often the term *method* is not clearly distinguished from the term *methodology*. We regard a method in general as a systematic approach that helps with solving a class of problems. The term "systematic" is to express that usually a class of problems is divided into classes of subproblems - together with techniques, or methods - to solve them. Furthermore, a method includes a process description: a more or less rigid temporal/logical order of the various problem solving activities together with the required skills and resources. The term methodology in contrast denotes a study or a theory of methods in the sense that it includes a set of methods together with guidelines or principles to evaluate, select, apply, and develop them. From our point of view, an enterprise model is a set of interrelated abstractions of a whole enterprise or of a relevant business unit. It should serve different purposes, one of which is the development of a CIS.

2.1 Rationale

The development of MEMO started in 1991 as an interdisciplinary research project ([Fra94a]). While some of the team members were convinced that object-oriented modelling would allow for intuitive models of any aspect of an enterprise, we soon had to learn that this was not the case. For those, who were not familiar with software development, object-oriented models - like object models or message flow diagrams - did by no means provide a natural representation. This experience corresponds to the results of various empirical studies which indicate that most people without a professional background from software engineering find entity relationship models difficult to understand ([Hit95], [GoSt90]). To allow for modelling constructs, "which correspond directly and naturally to our own conceptualizations" ([MyLe84], p. 11), we introduced a set of additional models. Some of them are based on generic object models that reconstruct corresponding concepts from Management Science. The user of these models typically works on an instance level. For example: He will usually think about *the* strategy of a firm, not about corporate strategies in general. In order to make those instance diagrams more intuitive for the prospective users, we added special modelling constructs and notations.

MEMO suggests three main *perspectives* on the enterprise: strategic, organisational, and information system. The perspectives themselves are further detailed by different *foci. Process* provides a process-oriented view on a perspective. Within the organisational perspective, this would be represented by models of business processes. *Structure* stresses the static elements of a perspective. In the case of the information system perspective, this would be an object model. Differentiating process and structure is based on the assumption that starting with a process-oriented view often helps to identify the requirements to be met by a corresponding structure. *Resource* reflects the fact that analysing and designing the different perspectives depend on the specific resources that are available or required. Analysis and design imply an idea of the intended results. *Goals* is to serve this purpose. Since each partial model can become rather complex, it can be decomposed into smaller models. Fig. 1 gives an overview of the partial models suggested by MEMO.
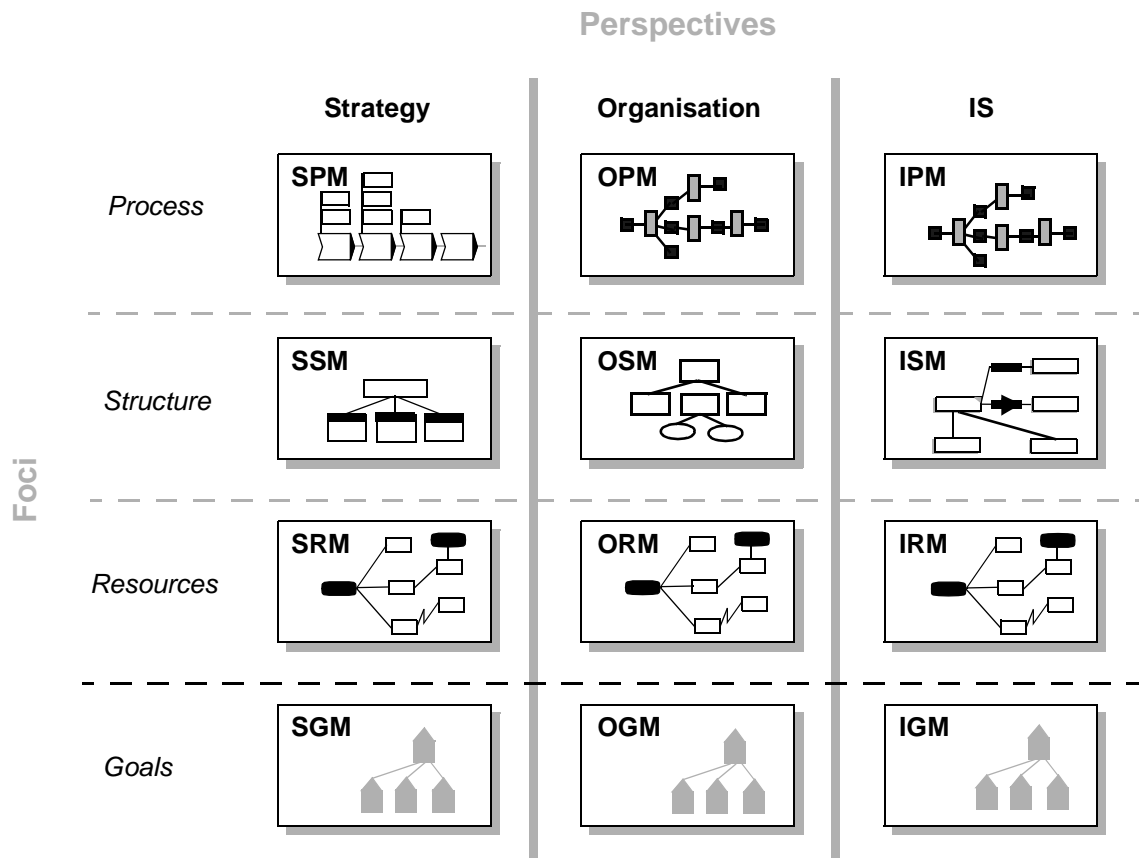
Perspectives

	Strategy	Organisation	IS
Process	SPM	OPM	IPM
Structure	SSM	OSM	ISM
Resources	SRM	ORM	IRM
Goals	SGM	OGM	IGM

Foci

Fig. 1:   Partial Models within MEMO

2.2   The Partial Models

Strategy Process Model (SPM)

The modelling constructs used to provide a process-oriented view on a corporate strategy are adapted from Porter's *value chain* approach ([Por85]). This decision was mainly based on the fact that Porter's approach is relatively well known. Therefore it can be expected that there is a certain amount of managers who find corresponding models to be intuitive. On the top level Porter describes an enterprise as a system of "activities" which form a "value chain". "The value chain disaggregates a firm into its strategically relevant activities in order to understand the behavior of costs and the existing and potential sources of differentiation. A firm gains competitive advantage by performing these strategically important activities more cheaply or better than its competitors." ([Por85], p. 33) There are two categories of activities: *Primary* activities are directly involved in the process of making the products that are offered to a firm's customers - for instance: inbound logistics, operations, outbound logistics, sales and service. *Support* activities (for instance: human resource management, technology development, etc.) serve to support primary activities. Activities can be decomposed into a set of subordinated activities. An activity can be specified by a set of attributes (for instance: estimated cost, performance ratio, core competence, role ...). Role can be instantiated with one of three predefined qualifiers (*direct*, *indirect*, *quality assurance*) which are to characterize the way a customer perceives the value added by a particular activity. Relationships between activities are a pivotal concept for analysing a value chain. An activity may be supported by or depend on other activities.
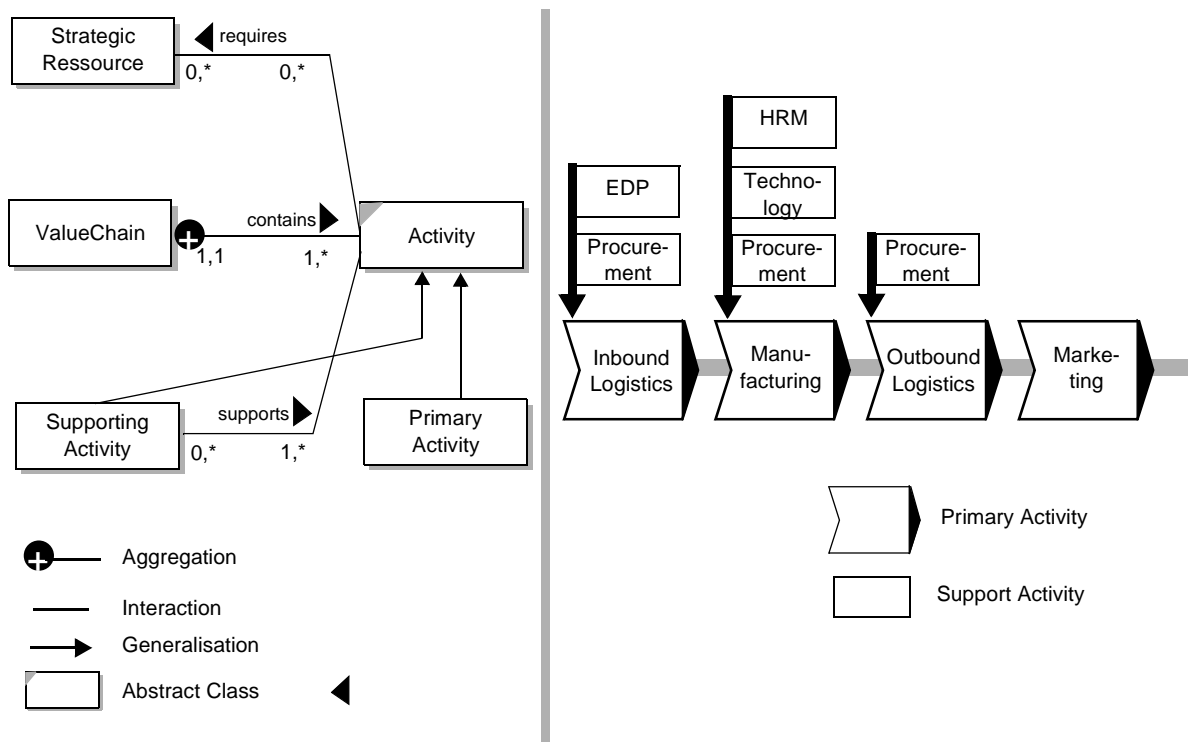
Fig. 2:   Notation for value chains and part of corresponding object model

The main modelling concepts to be used here are activity and value chain, as well as temporal and causal relationships between activities. MEMO includes an object model of the value chain concepts as well as a diagram notation to render value chains on the instance level (fig 2). These diagrams not only provide intuitive graphical elements (as suggested by [Moo96]), but also include specific constraints (for instance: a supporting activity must not be supported by a primary activity). Notice that the concepts can be modified on the object model level (for instance: adding/removing attributes from the class "Activity").

Strategy Structure Model (SSM)

The static elements of a corporate strategy include, among other things, strategic business units, competitors, and markets. Again these concepts are provided as a generic object model which may be modified. As in the use of the SPM the preferred interaction will happen on an instance level. MEMO includes an (intended to be) intuitive graphical representation of those instance diagrams - together with a set of constraints (for instance: it is not possible to establish a strategic alliance with a market). These constraints are specified in the generic object model.

Strategy Resource Model (SRM)

The resource models within all three perspectives are based on a common object model. It mainly consists of classes to represent a resource category (such as "human", "technology", ...), and a resource type (like "management", "software developers", ...). The corresponding diagram provides means to express various relationships between resources (like "requires", "can be replaced by", etc.). On the strategic level there are three pre-instantiated resource categories: human, financial, and technological.

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Strategy Goal Model (SGM)

Again there is a generic object model to represent goal systems for all three perspectives. The corresponding instance diagrams allow to render three different types of relationships between goals: "complementary", "conflicting", "contradictory". A few generic goals are pre-instantiated. On the top level: "share holder value", "stake holder value"; on the subordinated level - following the "generic strategies" suggested by Porter ([Por85]): "cost leadership", "differentiation", "focus".

Organisation Process Model (OPM)

This model focuses on business processes. MEMO includes a special process modelling language (MPML) that allows to render a business process as a directed graph of activities. An activity may be a business process itself. Each activity is triggered by a certain state of a virtual information container that contains information from various sources (forms, letters, files, objects ...). An activity produces one or more new states of the information container. MPML includes constructs to render parallel activities as well as various synchronization mechanisms. It is accompanied by a notation that provides domain level representations (see fig. 3). Models of business processes may be used both on a conceptual as well as on an instance level. Usually you would prefer a conceptual model in order to describe all processes of a particular kind using one abstraction. However, in case you want to study the performance of processes of this kind, it can be helpful to prototypically instantiate a process.
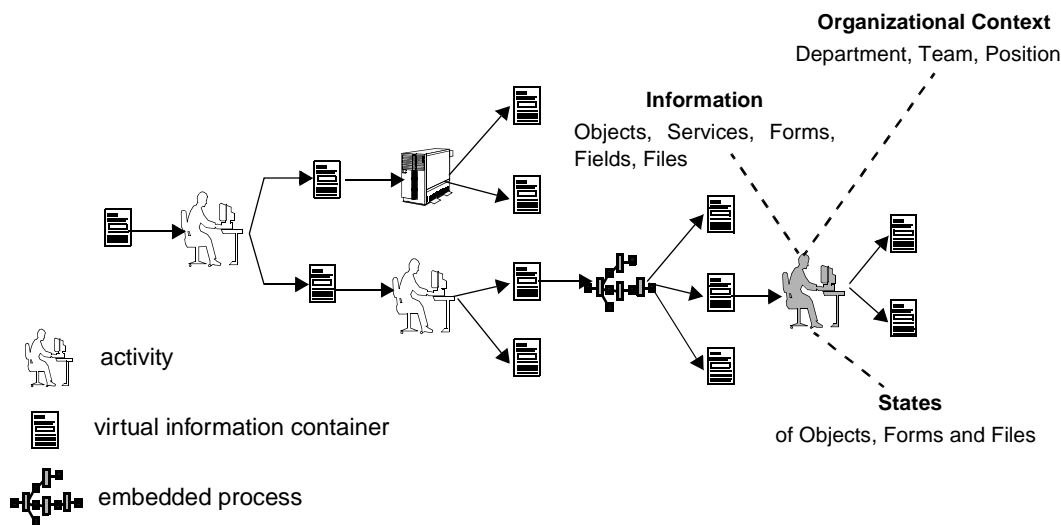

Fig. 3: An impression of business process modelling with MPML

Organisation Structure Model (OSM)

The essential concepts needed to describe an organisational structure are represented within an object model. It contains, among others, the class "OrganisationalUnit" and two specializations, "Organisation", and "Position". Organisational structures are represented as instance dia-

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grams. The notation suggested by MEMO is inspired by organisational charts. It allows, however, to add additional links between organisational units (for instance: "cooperates with", "depends on", "competes with", etc.). Furthermore it includes a number of constraints (for instance: Instances of "Organisation" cannot be included in any other instance of "OrganisationalUnit", instances of "Position" on the other hand cannot include any other instance of "OrganisationalUnit").

Fig. 4: Part of OSM object model
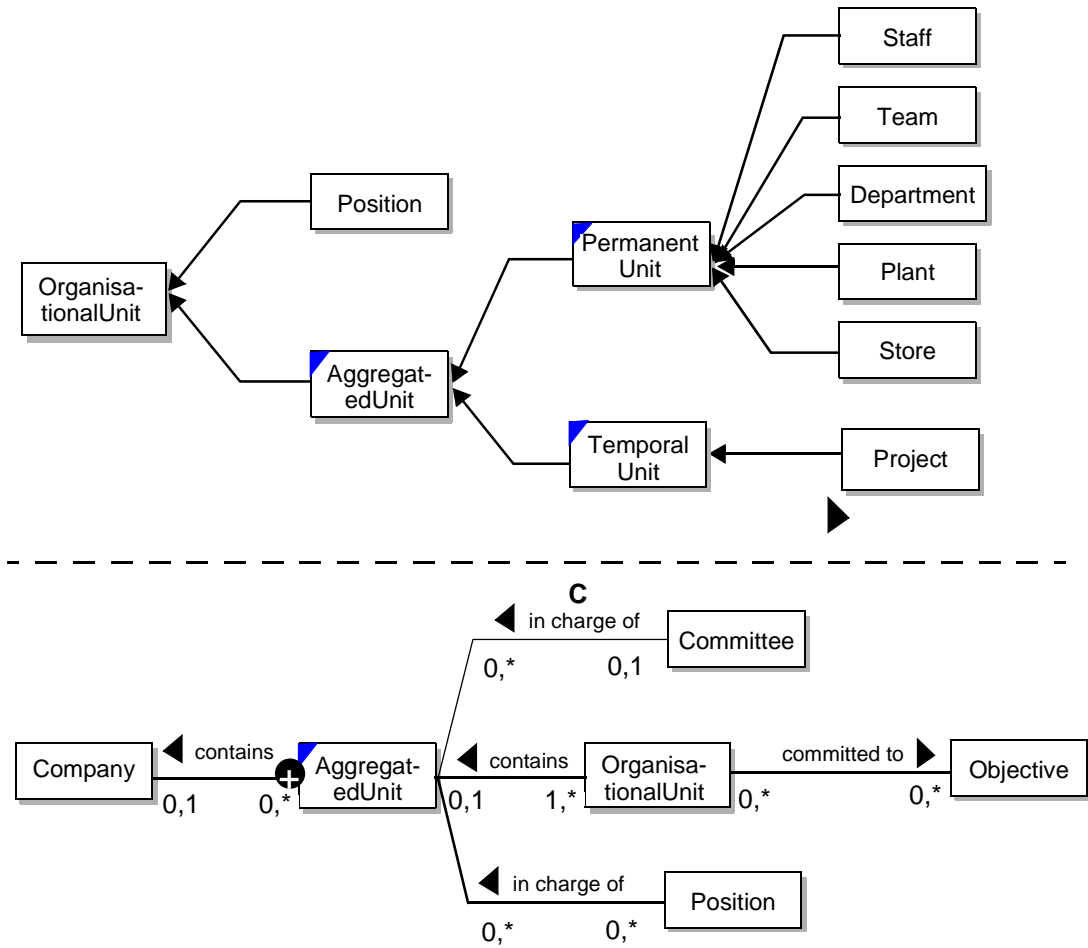
Organisation Resource Model (ORM)

On the organisational level there are four pre-instantiated resource categories: "people", "office equipment", "documents", "objects" - the latter allowing for references to the object model within the IS perspective.

Organisation Goal Model (ORM)

There are a few pre-instantiated goals: "quality", "time to serve a customer's request", "productivity".

Information System Process Model (IPM)

The focus here is on workflows. A workflow describes the flow of digitized information through a business process together with the automated operations on this information. Within the abstractions offered by MEMO this information is represented as objects within the ISM, and operations of those objects respectively. A workflow is an abstraction of a business process. Workflows can be modeled using a specialized version of MPML that - for instance - does not allow to associate non digitized information with a process model.
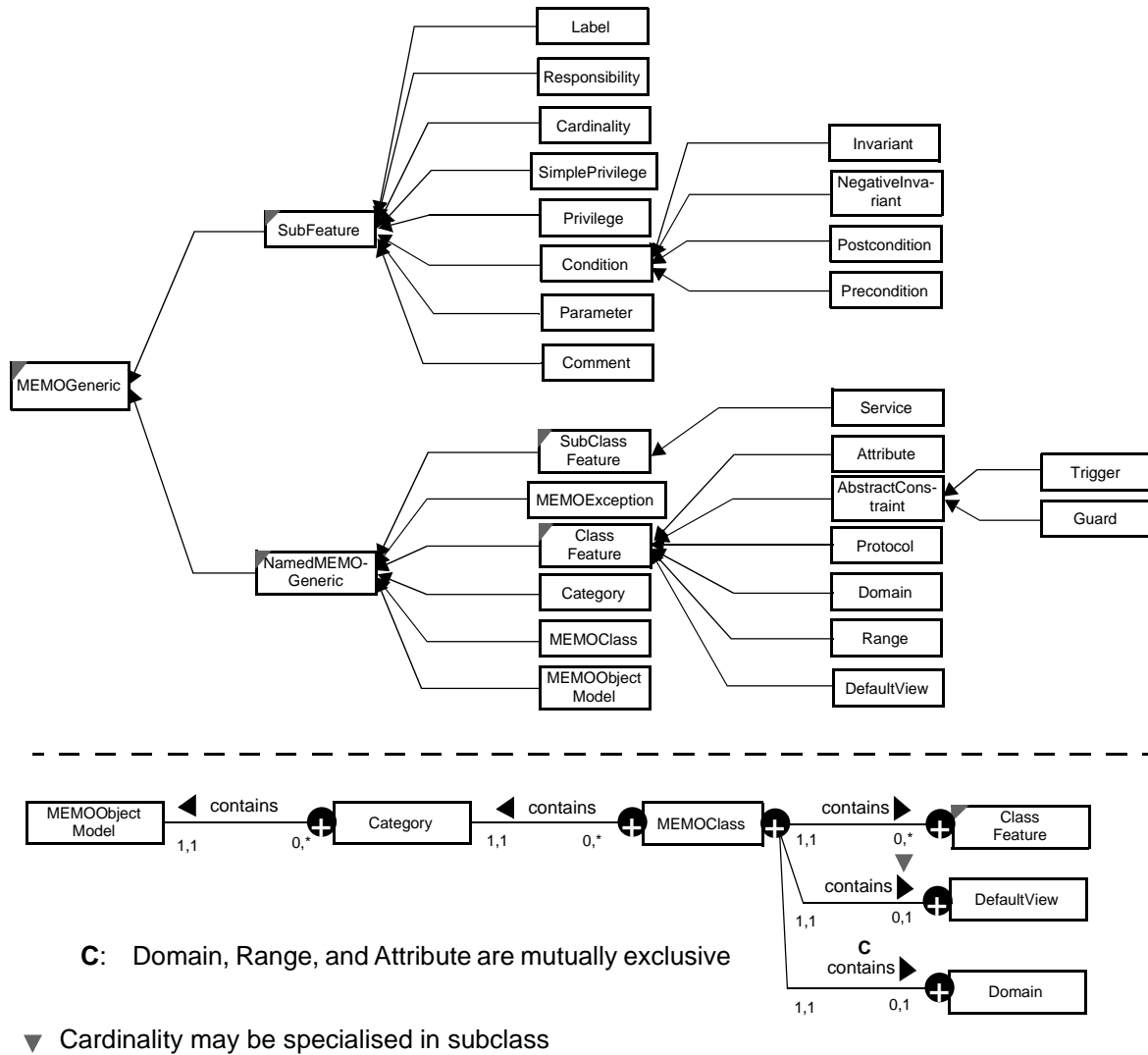
Fig. 5:   Partial meta model of the MEMO Object Modelling Language

Information System Structure Model (ISM)

The static aspects of the IS perspective are represented in an object model, using the MEMO object modelling language (M-OML). It provides common modelling concepts, similar to - alt-

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hough not as extensive as [Rat97]. One outstanding feature of M-OML is a concept to express delegation as an association between a role object and a role holder object ([FrHa97]). As soon as the OMG will release a standard for object-oriented modelling languages ([OMG96b], see [Fra97b]), we will decide whether or not to adopt it for MEMO. In addition to an object model an architecture model can be used to render another level of abstraction.

Information System Resource Model

On the IS level there are two pre-instantiated resource categories: "platforms" (CPU, OS), "networks". Notice that human resources (such as programmers, analysts, project managers, etc.) would be recorded in the organisational perspective.

Information System Goal Model

Predefined goals include "maintainability", "integrity", "maturity", "user-oriented", "modularity", "open system".

3. Integrating the Models

While the various models introduced so far may help with analyzing certain aspects of a business firm, the essential benefit, enterprise modelling is promising, results from integrating those models. Only then it is possible to express relationships between models, and to protect against friction between various interrelated activities. Furthermore integration helps with maintaining the models' overall integrity. The chances to integrate concepts within a partial model depend on the semantics of those concepts. This is also the case for integrating concepts from different models, which implies that those models share common concepts. Fig. 6 outlines the relationships between relevant partial models. If it was possible to define the semantics of the partial models on a sufficiently high level, we could think of logically deducting the IS models from the organisational models which in turn could be deducted from the strategic models. However, there are no theories within Management Science that would allow to define generic concepts of this kind. Instead we have to take into account that concepts within an enterprise model, as well as associations between them, exist on different semantic levels. Not all of the concepts used within the various partial models can be formalized in a satisfactory way. For instance: "competitive advantage" within the strategic level.
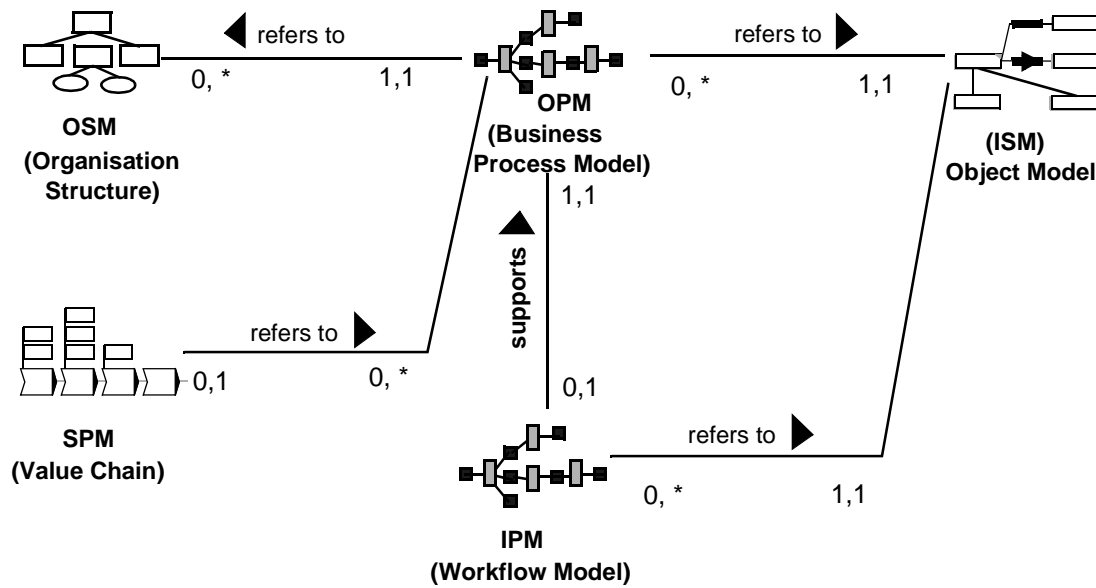
Fig. 6:   Relationships between selected partial models

Within the underlying object model there are various associations between concepts. They are either interactions ("uses"-associations) or - more specific - aggregations. The cardinalities of those associations serve to express integrity constraints. There are - for instance - interaction associations between the activities of a business process model (OPM) and objects within the ISM, or between those activities and organisational units defined in the OSM (see fig. 6). An activity within a value chain (SPM) is an aggregation of business processes (OPM), which in turn may refer to corresponding workflow models (IPM). Note that the generic models in ME-MO do not include any specific semantics on how to compute features of an activity within a value chain (like "competitive strength") from characteristics of associated business processes. It is, however, possible to add appropriate transformations in a semi-formal way - basically in order to allow for their implementation in the tool environment (see 4.2).

Beside these semantic associations it is possible to add "user specified links". They serve to establish "weak" relationships between instances. For example: A goal such as "customer satisfaction" within OGM may be linked to a constraint within a business process model, where this constraint specifies that exactly one employee must be in charge of an entire process instance. User specified links primarily allow to navigate through a model, which are meaningful only to the user.

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C

Service — uses → ContextClass — uses → Process

1,* 1,1   0,* 1,*

BasicProcess   Composed Process — contains ▶

C Instances of Service that are associated with an instance of ContextClass have to be part of a MEMOClass.
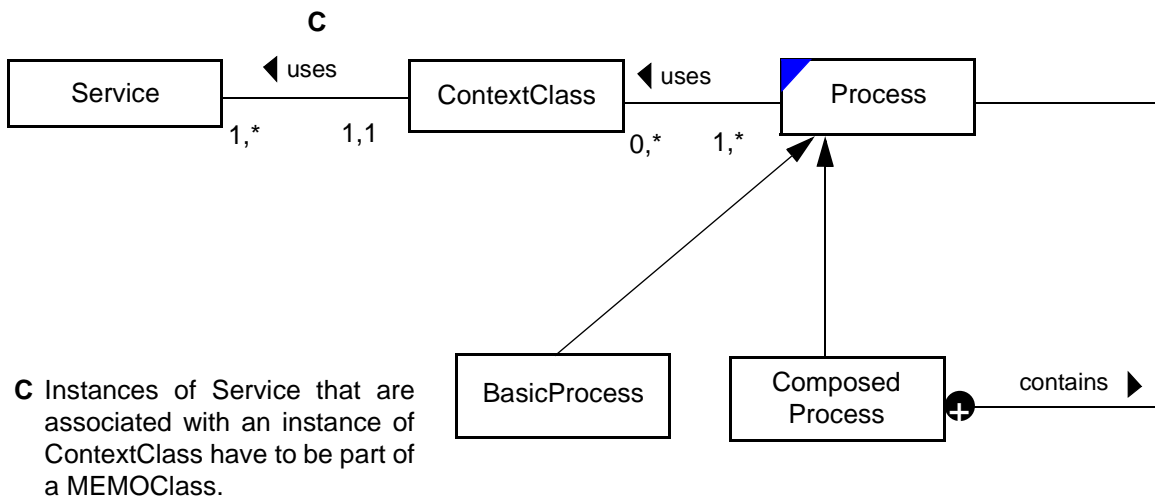
Fig. 7: Part of the meta object model that describes the integration of process models (either OPM or IPM) and a corresponding object model via services

4. Applying MEMO

A modelling method that features 12 partial models may appear rather confusing. Indeed it is not intended to be an approach that can be applied in a straightforward way: Enterprise modelling is a very complex matter. In order to exploit its potential benefits, and to avoid its pitfalls, it is necessary for the developers to gain a deep understanding of the essential concepts. To foster such an understanding, and to allow for a systematic approach, MEMO offers a description of how to plan and organize the modelling process. It is complemented by a description of roles in order to support an appropriate staffing of project teams. Last but not least, MEMO refers to organisational theory to provide insights which are beyond the scope of a mere engineering approach.

4.1 Process Support

The process of applying MEMO is mainly supported by two concepts. Firstly, there are a few interrelated process models (not to be confused with the process models within an enterprise model) which describe the temporal/logical order of the relevant tasks to be performed. Secondly, there are techniques, heuristics, and metrics that help with analyzing and (re-) designing partial models.

The Overall Process

Developing an enterprise model is in general much more complex than developing a conceptual model for a particular application. For this reason it is recommended to carefully conduct a feasibility study. The overall process model shown in fig. 8 presents the main activities in a temporal/logical order. Notice, however, that the activities are connected via feedback loops.
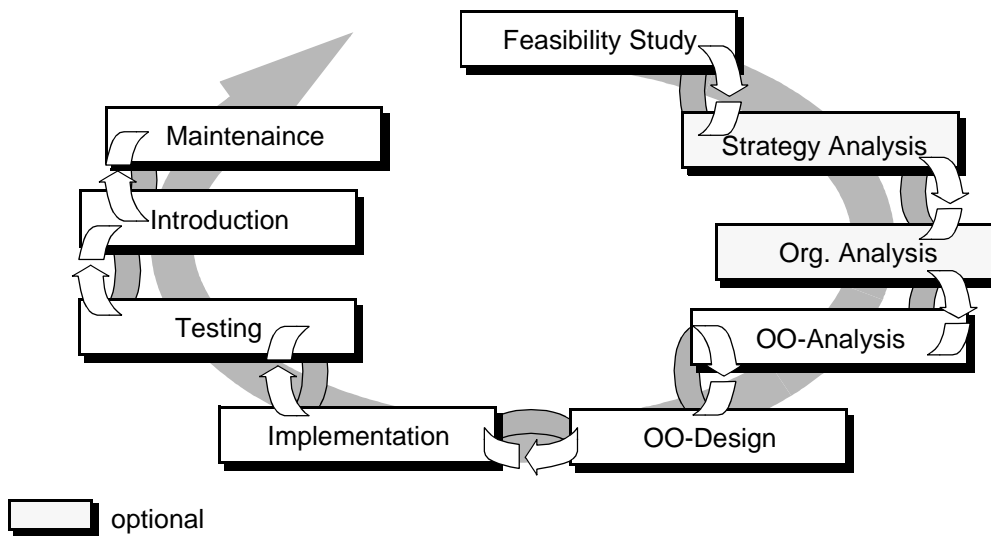
Fig. 8:   Overall MEMO process

While the development of a CIS recommends to refer to strategic and organisational guideli-nes, it will not always be necessary to analyse the corporate strategy or a company's organisa-tion: Maybe it was done only recently within another project, or it has been decided that both the current strategy and the organisation are in good shape. For each activity there is a more or less elaborated special process model. An activity itself is characterized by a number of fea-tures. *Subject and goal* are natural language descriptions, complemented by references to goal models of involved perspectives. *Required documents* refer to MEMO models as well as to ad-ditional documents (for instance: various business reports). Furthermore there is a reference to *heuristics/techniques* which are applicable within this activity (see below). *Roles* refers to a common role model in order to describe the roles to be filled within this activity. Finally *pro-duced documents* points to MEMO models to be produced or modified within the activity. ME-MO includes an object model of the overall process, its activities, and the required roles.
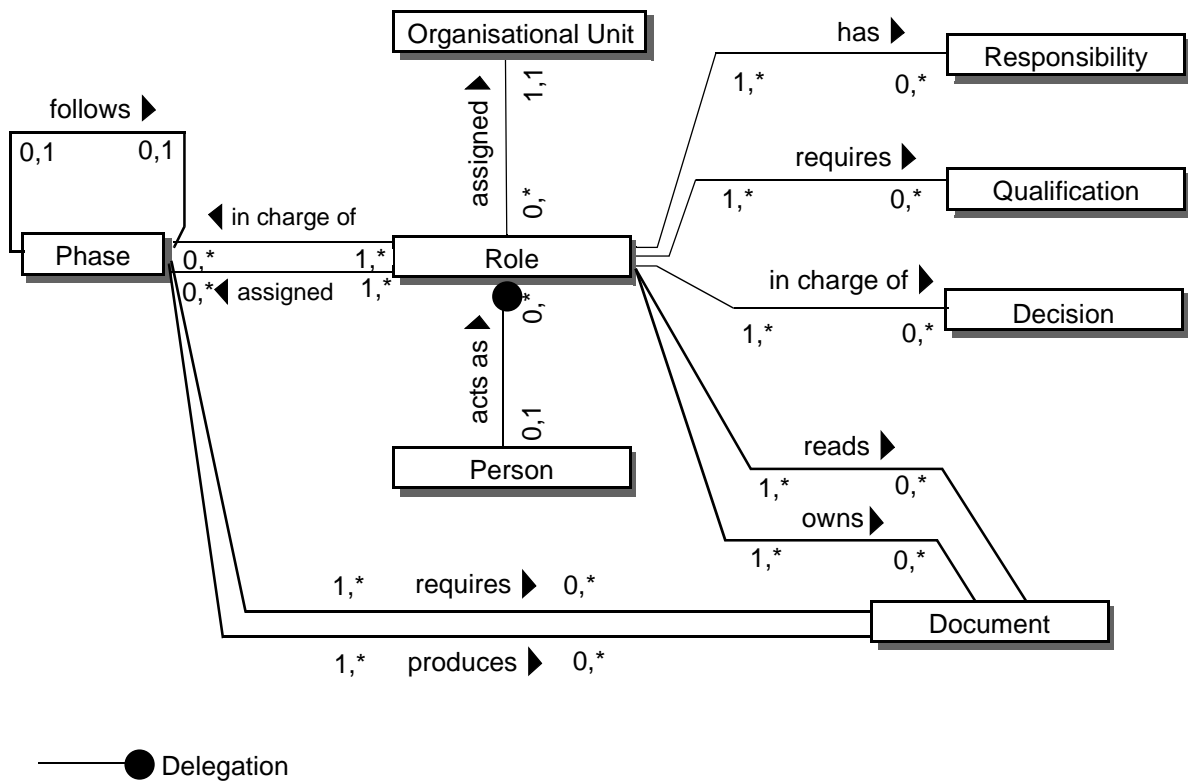
Fig. 9:   Partial object model of concepts required for project management

Techniques, Heuristics, and Metrics

MEMO provides various aids to help with decisions that have to be made during modelling. On the communication level there are guidelines how to organize workshops, and how to conduct interviews. Design and analysis are supported on different levels of abstraction. On an abstract level there are textbook style comments on the different subject areas of the overall model. For instance for the organisational perspective: reflections on the relationship between flat hierarchies and the quality and pace of decision making; for the IS perspective: comments on the quality of abstractions, or on the relationship between semantics and reusability. General design principles provide guidelines for design. For instance for the IS perspective: "Only if a real world aspect is going to have an identity of its own within the abstraction of interest, model it as an object. Otherwise consider to model it as an attribute." For the organisational perspective: "There should be a clear correspondence between decision making powers and responsibility", or: "Avoid bottlenecks and media clashes within business processes". While some of those principles can be formalized and therefore checked automatically (like the last one, provided a business process model contains the information needed to detect bottlenecks or media clashes), others require additional human interpretation. Furthermore there are extensible checklists that provide the analyst with questions/hints to analyse relevant aspects. For instance within the strategic perspective: "How can the activity performed differently or even eliminated?", "How can a group of linked value activities be reordered or regrouped?" ([Por85], p. 110).

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Organisational Analysis

Required Input	Documents produced during strategic analysis (**SGM, SPM, SSM)**, organisation manual, existing problem statements, specialised journals, data from managerial accounting, results from previous organisational studies
Subject/Objectives	Analysis of selected business processes, redesign of processes, develop requirements for organisation structure, revision of corresponding accounting systems, profiles of relevant positions
Participants	representatives of the involved business domains, project-manager, system analyst, user, system-architekt, possibly external consultants
Methods/Concepts	Workshops, interviews, presentations, conceptual frameworks, process modelling, templates, checklists
Output/Results	models of business processes, dictionary of required information, communication diagrams, organisational charts, profiles of required positions, outline of impact on management

Fig. 10: Example for structured description of a process phase

There are several analysis techniques that support the analyst with proceeding through a subject of interest in a step by step manner. Some of those techniques are reconstructed as object models, which makes them suitable to be used with a tool. Fig. 11 gives an example of how to apply an analysis technique. It also shows a relationship between concepts within the strategic and within the organisational perspective. *Metrics* correspond both to the goal models within each perspective as well as to design principles. While they may give hints on certain relevant aspects, they usually require additional interpretation. Management Science offers a plethora of metrics which can be applied to various partial models within MEMO. Within the strategic perspective: ratio of direct (value directly perceived by customer) to indirect activities, cohesion between activities, etc. Within the organisational perspective: number of levels in the organisational hierarchy, average number of directly subordinated positions per management position, number of employees per organisational unit, etc. Within the IS perspective: average number of attributes/operations per class, cohesion between classes, average depth and width of generalization hierarchies, etc.
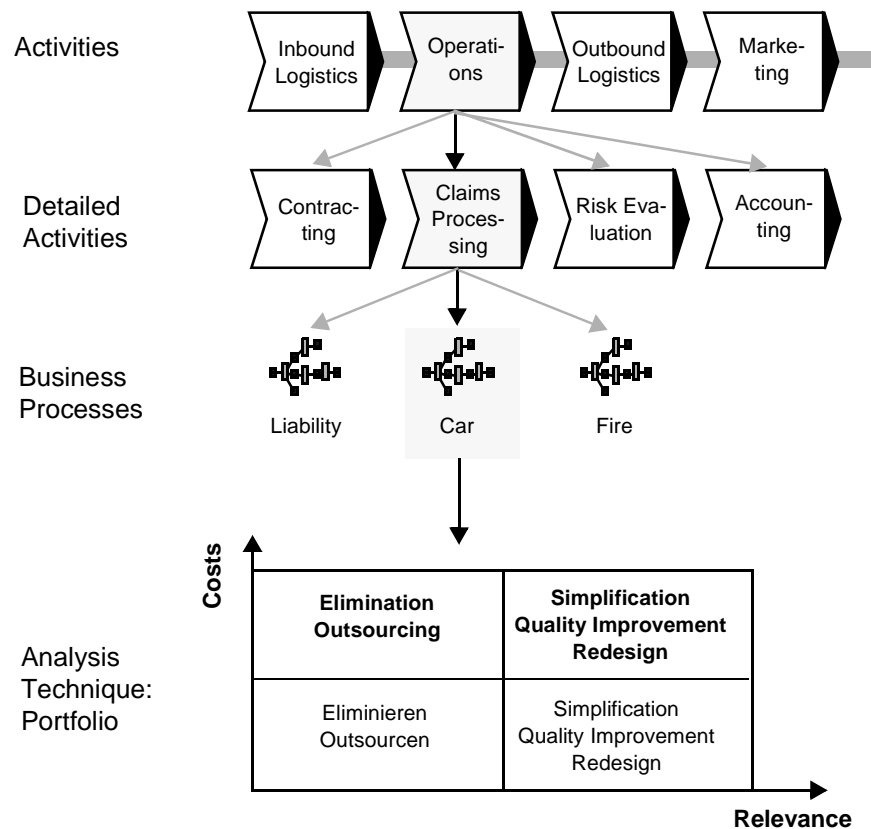
Activities

Inbound Logistics | Operati-ons | Outbound Logistics | Marke-ting

Detailed Activities

Contrac-ting | Claims Proces-sing | Risk Eva-luation | Accoun-ting

Business Processes

Liability | Car | Fire

Analysis Technique: Portfolio

Costs

| Elimination Outsourcing | Simplification Quality Improvement Redesign |
| Eliminieren Outsourcen | Simplification Quality Improvement Redesign |

Relevance

Fig. 11: Example for applying an analysis technique on concepts within an enterprise model

4.2 Social Aspects of Organisations

A method for enterprise modelling which is based on semi-formal models of reality may be easily misunderstood: as an approach that neglects the fact that organisations are vivid social systems where human perception, expectations, fears, and power are of essential importance; an approach that propagates a tayloristic view of organisations, reducing the process of orga-nising to a mere engineering task. This is not our intention. However, the development of cor-porate IS together with shaping a company's strategy and organisation is a complex task. That recommends the use of appropriate abstractions, hence the use of models. Formal descriptions are necessary, when it comes to prepare for the implementation of an IS. Furthermore, formal models are a prerequisite for optimization and simulation (whenever they make sense). Com-plexity implies the risk of failure. For this reason, a systematic approach that emphasizes rigor and the measurement of results is required. Nevertheless, we do not believe that an engineering perspective is sufficient to master the delicate challenge of organisational change. This is the case for the subject as well as for the way we approach it: There is need to take into account the peculiarities of organisations as social systems. Additionally, it is helpful to complement the scientific method that is inherent to an engineering perspective with a hermeneutic ap-proach. In contrast to the (intended to be) objective and formal descriptions that are characte-ristic for a positivist perspective, hermeneutic approaches rely mainly on the researchers per-sonal involvement in the social situations they analyse (for a comparison of both positions see

[Wri71]). Analysis is based on establishing associations and analogies to previous experience - thereby replacing description/explanation with understanding as the primary source of knowledge, in other words: hermeneutic approaches want to "develop deep appreciations of the situations being addressed." ([Mor86], p. 11)

There is a plethora of publications which are more or less hermeneutic in nature. In general they fulfil two important functions. Firstly, they have a critical function by warning of rash "explanations". They stress that organisations are complex *phenomena* with many different faces. For instance, Weick ([Wei79]), draws our attention to the fact that companies are usually not as organised as it may seem. Instead, he argues that coordinated action is often based on ambiguity. Morgan emphasizes that our perception of organisations is usually rather narrow, which recommends to keep a sceptical attitude towards them:

> "Stated in more conventional terms, there is a difference between the full and rich reality of an organization, and the knowledge that we are able to gain about that organization. We can know organizations only through our experience of them. We can use metaphors and theories to grasp and express this knowledge and experience, and to share our understandings, but we can never be sure that we are absolutely right. I believe we must always recognize this basic uncertainty." ([Mor86], p. 341)

The second function aims directly at a deeper understanding of the subject, by offering unusual interpretations and by using analogies, metaphors, and images. The following citations about the prerequisites of successful management may illustrate this function: "The argument advanced here is that management's effect is primarily with respect to expressive or symbolic actions ..." (Pfeffer 1981, p. 5). Weick ([Wei79], p. 42) offers a similar interpretation: "... the manager may be evangelist rather than accountant." Another example is given by the work on organisational culture ([AlFi84], [Wil84]), a phenomenon that hardly allows for a precise definition: "... an undefined, immanent characteristic of any society ... with varying and little understood incidence on the function of organizations." ([AlFi84], p. 194) While some of the assumptions suggested by popular authors like Peters and Waterman ([PeWa82]) are questionable, there is no doubt that organisational culture is relevant, both for understanding and changing organisations. Case studies are an important instrument of hermeneutic approaches. Not only that they allow the researchers to participate in a concrete situation, their publication also helps to communicate relevant insights in an illustrative way.

Organisation development ([FrBe73]) is an attempt to turn hermeneutic approaches into a method to support organisational change. It is based on the assumption that effective change requires to involve everybody who is affected by the change; that organisations cannot be changed merely by applying new designs. Instead, organisational development is a method that regards organisational change as a social process of common learning. Specialised consultants act mainly as process catalysts - by empowering people and applying techniques such as survey guided feedback. Note, however, that they typically do not take into account the requirements which are imposed by the design of information systems.

In the current stage MEMO does not incorporate any hermeneutic approaches. We only refer to them in order to emphasize the importance of those approaches as a regulative for a one-sided engineering approach. However, future versions of MEMO Center (see below) may include a library of case studies to illustrate certain aspects of the overall analysis and design process.

4.3 Supporting Tools

Enterprise modelling recommends the use of appropriate tools. The various interrelated models require support for browsing and searching. Furthermore it is hardly possible to manually maintain an enterprise model without jeopardizing its integrity. Finally it is impossible to do without tools when simulation (for instance: of business processes) or code generation is an issue. MEMO is accompanied by a development environment, called MEMO Center ([Fra94b]).
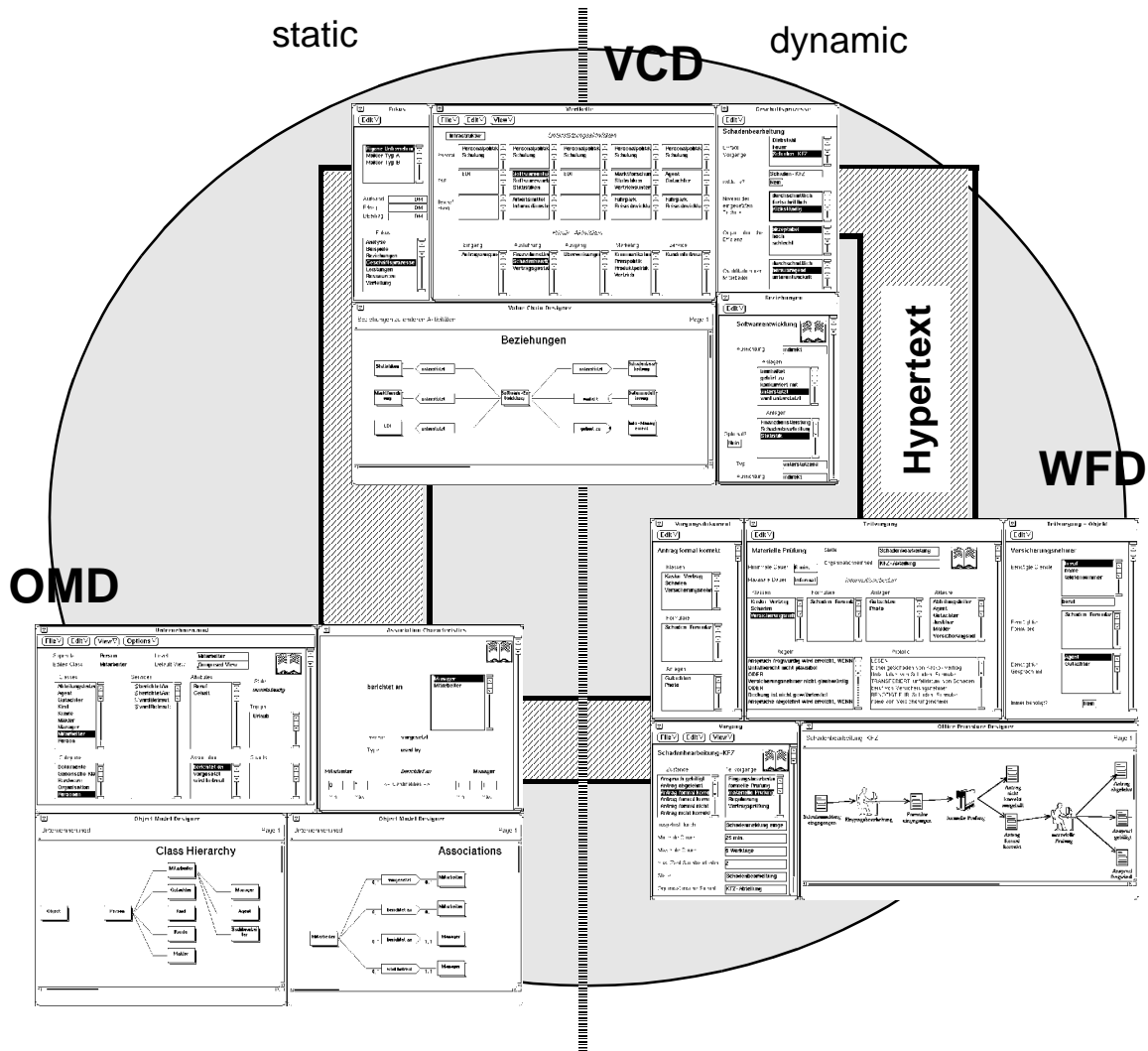
Fig. 12: Overview of MEMO Center

It controls a model's integrity and provides means to navigate through the views of an enterprise model on various levels of detail. Furthermore it allows for generating Smalltalk code from object models. Currently MEMO Center includes three components: an Object Model Designer (OMD), a Business Process Designer (BPD), and a Workflow Designer (WFD). The Value Chain Designer (VCD) is being redesigned. All components combine editors for graphi-

cal notations with textual editors and browsers. MEMO Center is implemented in Visual-works® and runs on any platform a Visualworks® virtual machine is available for. The components are integrated through a common object model. In order to prepare for its implementation, the object model itself is defined in a object-oriented metamodel.

4.4   Run Time Aspects of Enterprise Models

An enterprise model as a conceptual foundation for the development of a CIS offers substantial benefits: It helps to take into account all relevant aspects and fosters the organisational and strategic fit of a CIS. Furthermore it promises to provide an intuitive medium to support communication between the different participants involved in the overall process - such as senior managers, system analysts, system architects, prospective users, etc. - thereby allowing all participants to get a satisfactory understanding of all relevant aspects. Nevertheless, despite these benefits, there is no doubt that designing a comprehensive enterprise model as it is outlined above will usually be too expensive, if it was for CIS development only. There is, however, good reason to take advantage of enterprise models also during the run time of a CIS. In this case an enterprise model can be considered as an integrated part of a CIS that describes the conceptual foundation - similar to a data or object model, but with a much wider scope. Considering the many and diverse relationships between the various aspects of an enterprise is certainly not only an issue during the build time of a CIS. Instead it is an essential characteristic of managerial decision making. Systems to support managerial decision making have been a research topic for long: "Management Information Systems" ([Par89]), "Decision Support Systems" ([Tur93]), or "Executive Information Systems" ([Tur93]) are usually regarded as special systems on top of an existing CIS. They are accompanied by recent approaches which focus on data management, and data retrieval/analysis respectively. Again both approaches, the (sometimes rather vague) concept of a "data warehouse" ([BaEd97]) and the idea of "data mining" ([Fay96]) are thought to be used with existing information systems. Hence, they have a clear bottom up orientation - with all the problems that result from reconstructing semantics out of ill defined data.

An enterprise model, as it is suggested with MEMO, is a much better foundation for supporting managerial decision making, since it allows for describing relevant relationships in a top down approach on a high level of semantics. As soon as the various partial models become an integrated part of a CIS, they can be instantiated as far as possible from data within other parts of the CIS (see 3). Those instance level models will not only allow for intuitive interactions with relevant decision domains (such as value chains or business processes) on an everyday basis. They will reveal their underlying conceptual models as well. Furthermore a CIS that is based on an enterprise model, can be regarded as a general repository, not only for concepts and resources directly related to a company's information system, but in general for knowledge about a firm - like corporate goals and strategy, relevant metrics, organisational responsibilities, professional guidelines, corporate culture. While most of this knowledge cannot be completely formalized, its embedding - even as a natural language text - within the overall network of relevant concepts and instances fosters its effective utilization. In order to keep this knowledge up to date it has to be permanently maintained by authorized users. This would be similar to the ideas expressed with visions such as "organisational memory" or "organisational knowledge" ([Ack94]) - however, based on a more solid conceptual foundation.

Notice that once a comprehensive enterprise model has been implemented as integrated part of a CIS, it will support future system development projects with only a fraction of the costs

caused by its original development. Being based on an object-oriented approach, it allows to develop a coherent conceptual model that includes all kinds of information that is stored within a CIS - traditional data as well as electronic documents ([Fra97a]).

5. Related Work

There has been a substantial amount of work on enterprise modelling (for an overview see [Pet92]). Scheer suggests a framework for enterprise modelling (called ARIS) that is based on four different views: an organisational view, a data view, a process view, and a control view ([Sch94]). All the views, except the process view, are represented as ER models, and complementary data flow models. In order to model business processes, Scheer introduces a specific modelling language, which allows to define so called "process chain models". Different from MEMO Scheer does not include a strategic view. Furthermore it is not evident how the partial models are integrated - within the tools that accompany the method, the models are not tightly integrated. From our point of view the most interesting aspect of Scheer's approach is the evolutionary development of reference models for certain branches of industry which are integrated in the overall enterprise model. Those reference models are basically process chain models and corresponding ER models, for instance for wholesale companies. While Scheer's activities started as a research project, the ARIS tools are now commercially available.

CIM-OSA ("Open System Architecture") is a joint research effort, sponsored by the European Union that aims at developing a framework for modelling manufacturing enterprises ([Gor92], [ESP89]). The framework consists of four views ("organisation", "resource", "information", "function"), each of which is differentiated in three levels of abstraction: "generic", "partial", "particular". Different from MEMO the models within the framework are not described in detail. The final goal of the initiative is to specify various interfaces for CIM systems, which then are to be standardized. However, this goal has not been accomplished so far.

Recently comprehensive models of business firms have gained attention from an additional perspective. With efforts to standardize application level classes to be used within CIS, often referred to as "business objects", it becomes an important issue not only to specify the semantics of those classes on a conceptual level, but also to present them in an intuitive way: "The business object model becomes the driving force of the information system, not the technology. The business object model is derived directly from the shape of the enterprise." ([OMG96a], p. 5) These efforts, however, are still in a rather early stage. In order to allow for more intuitive models, and to take advantage of domain level artifacts, one of the proposals for the standard on object-oriented modelling languages intended by the OMG ([OMG96b]) suggests application specific modelling languages "as formal extensions to the Core Meta-Model" ([IBM97], p. 11).

6. Conclusions

Different from general purpose modelling methods (such as [Boo94], [Jac92], [Rum91]) MEMO as a method to support enterprise modelling is focusing primarily on CIS. This allows for introducing special views/models that include domain specific semantics. These models do not only free the analyst from the burden of reconstructing relevant concepts on his own. Furthermore they are represented in an intuitive way - even for people with a professional background other than software engineering. An enterprise model can be a valuable medium to foster com-

munication - not only during the development of a system, but also during its run time. Despite those promises it cannot be neglected that a framework for enterprise modelling is a huge research effort - especially when you intend to complement it with comprehensive and mature tools. However, while the development of tools is a helpful approach to evaluate - and communicate - underlying concepts, it is not our primary goal. The concepts we have developed so far proved to provide a rather intuitive medium, both for teaching, and for coordinating research efforts. A framework for enterprise modelling can be regarded as a stimulating laboratory for analysing different, interrelated research topics. For future versions of MEMO we plan to integrate generic reference models for managerial accounting. On the tool level we will analyse possibilities to generate workflow descriptions in the "Workflow Process Definition Language" that is to be standardized by the "Workflow Management Coalition" ([WFM96]). Furthermore we are thinking about integrating an adequate formal language together with an extensible lexicon (like [OrSc96]) that would allow to express semantics that is beyond the scope of the current models.

References

[Ack94]   Ackerman, M.S.: Answergarden and the Organisation of Expertise. Working Paper, MIT, Cambridge, Mass. 1994

[AlFi84]   Allaire, Y.; Firsirotu, M.E.: Theories of Organizational Culture. In: Organization Studies. Vol. 5, 1984, pp. 193-226

[BaEd97]   Barquin, R.C.; Edelstein, H.A. (eds.): Planning and Designing the Data Warehouse. Prentice Hall 1997

[Boo94]   Booch, G.: Object-oriented Analysis and Design with applications. 2nd ed., Benjamin Cummings, Redwood/CA., 1994

[Dav93]   Davenport, T.H.: Process Innovation. Reengineering Work through Information Technology. Boston/Mass. 1993

[ESP89]   ESPRIT Consortium AMICE: Open System Architecture for CIM. Berlin, Heidelberg et al.: Springer 1989

[Fay96]   Fayyad, U.M. et al. (eds.): Advances in Knowledge Discovery and Data Mining. Menlo Park, Ca.: MIT Press 1996

[Fra97a]   Frank, U.: Enhancing Object-Oriented Modeling with Concepts to Integrate Electronic Documents. In: Proceedings of the 30th HICSS, vol. VI, ed. by R. H. Sprague, Los Alamitos, Ca.: IEEE Computer Society Press 1997, pp. 127-136

[Fra97b]   Frank, U.: Towards a Standardisation of Object-Oriented Modelling Languages? Arbeitspapiere des Instituts für Wirtschaftsinformatik. Nr. 3, Universität Koblenz-Landau 1997

[Fra94a]   Frank, U.: Multiperspektivische Unternehmensmodellierung Theoretischer Hintergrund und Entwurf einer objektorientierten Entwicklungsumgebung München: Oldenbourg 1994

[Fra94b]   Frank, U., MEMO: A Tool Supported Methodology for Analyzing and (Re-) Designing Business Information Systems. In: Ege, R.; Singh, M.; Meyer, B. (eds.): Technology of Object-Oriented Languages and Systems. Englewood

Cliffs: Prentice Hall, 1994, pp. 367-380

[FrBe73]   French, W.L.; Bell, C.H.: Organization Development. Englewood Cliffs: Prentice Hall, 1973

[FrHa97]   Frank, U.; Halter, S.: Enhancing Object-Oriented Modeling with Delegation. Arbeitspapiere des Instituts für Wirtschaftsinformatik. Koblenz 1997

[GoSt90]   Goldstein, R.C.; Storey, V.C.: Some Findings on the Intuitiveness of Entity Relationship Constructs Aus: Lochovsky, F.H. (Hrsg.): Entity Relationship Approach to Database Design and Query Amsterdam: Elsevier 1990

[Gor92]   Goranson, H.T.: The CIMOSA Approach as an Enterprise Integration Strategy Aus: Petrie, Charles J. (ed.): Proceedings of the First International Conference on Enterprise Integration Modeling Cambridge, Mass.: MIT Press 1992, pp. 167-178

[HaCh93]   Hammer, M.; Champy, J.: Reengineering the Corporation. New York 1993

[Has92]   Hassey, D.E.: Glossary of Management Techniques. In: International Review of Strategic Management. Vol. 3, 1992, pp. 47-75

[Hen94]   Henderson-Sellers, E.: Book two of Object-Oriented Knowledge: The Working Object. Prentice-Hall 1994

[Hit95]   Hitchman, S.: Practitioner Perceptions on the Use of some Semantic Concepts in the Entity Relationship Model In: European Journal of Information Systems. Vol. 4, 1995, pp. 31-40

[IBM97]   IBM; Objectime: OMG OA&D RFP Response Version 1.0. 1997

[Jac94]   Jacobson, I. et al.: The Object Advantage. Business Process Reengineering with Object Technology. Wokingham 1994

[Jac92]   Jacobson, I. et al.: Object-Oriented Software Engineering. A Use Case Driven Approach. Reading/Mass.: Addison Wesley 1992

[Kat90]   Katz, R.L.: Business/enterprise modelling. In: IBM Systems Journal, Vol. 29, No. 4, 1990, pp. 509-525

[Kee91]   Keen, P.W.: Shaping the Future. Business Design through Information Technology. Boston/Mass.: Harvard Business School Press 1991

[Moo96]   Moody, D.: Graphical Entity Relationship Models: Towards a More User Understandable Representation of Data. In: Thalheim, B. (ed.): Conceptual Modeling - ER'96 Proceedings of the 15th International Conference on Conceptual Modeling Berlin, Heidelberg etc.: Springer 1996, pp. 227-244

[Mor86]   Morgan, G.: Images of Organization. London: Sage 1986

[MyLe85]   Mylopoulus, J.; Levesque, H.J.: An Overview of Knowledge Representation. In: Brodie,M.L.;Mylopoulos,J.;Schmidt,J. (eds.): On Conceptual Modelling. Perspectives from Artificial Intelligence, Databases and Programming. Berlin/Heidelberg: Springer 1985, pp. 3-17

[OMG96a]   OMG: Common Facilities RFP-4: Common Business Objects and Business Object Facility. OMG, TC 13CF/96-01-04, 1996

[OMG96b]   OMG: Object Analysis & Design RFP-1. OMG, TC 96-06-06, 1996

[OrSc96]   Ortner, E.; Schienmann, B.: Normative Language Approach - A Framework for Understanding. In: Thalheim, B. (ed.): Conceptual Modeling - ER'96 Proceedings of the 15th International Conference on Conceptual Modeling Berlin, Heidelberg etc.: Springer 1996, pp. 261-276

[Par89]   Parker, C.: Management Information Systems. Strategy and Action. New York et al.: McGraw-Hill 1989

[PeSc93]   Peters, L.; Schultz, R.: The Application of Petri-Nets in Object-Oriented Enterprise Simulations. In: Nunamaker, J.F.; Sprague, R.H. (ed.): Information Systems: Collaboration Technology, Organizational Systems, and Technolgoy. Proceedings of the 26th HICSS. Los Alamitos 1993, pp. 390-398

[Pet92]   Petrie, C.J. (ed.): Proceedings of the First International Conference on Enterprise Integration Modeling Cambridge, Mass.: MIT Press 1992

[PeWa82]   Peters, T.J.; Waterman, R.H.: In Search of Excellence. New York 1982

[Pfe81]   Pfeffer, J.: Management as Symbolic Action. In: Cummings, L.L.; Staw, B.M.: Research in Organizational Behavior. Vol. 3, Greewich 1981, pp. 1-52

[Por85]   Porter, M.E.: Competitive Advantage. New York 1985

[Rat97]   Rational: UML Semantics Version 1.0. 1997

[Rum91]   Rumbaugh, J. et al.: Object-oriented Modelling and Design. Englewood Cliffs, N.J. 1991

[Sch94]   Scheer, A.-W.: Business Process Engineering, 2. ed., Berlin, New York, et al.: Springer 1994

[Sot86]   Scott Morton, M.S.: Strategy formulation methodologies. Cambridge, Mass. 1986

[SoZa92]   Sowa, J.F.; Zachman, J.A.: Extending and formalizing the framework for information systems architecture. In: IBM Systems Journal, Vol. 31, No. 3, 1992, pp. 590-616

[Tur93]   Turban, E.: Decision Support and Expert Systems. Management Support Systems. 3rd ed., New York: Macmillan 1993

[Wei79]   Weick, K.E.: The Social Psychology of Organizing. Reading, Ma.: Addison-Wesley 1979

[Wil84]   Wilins, A.: The Creation of Company Cultures: The Role of Stories in Human Resource Systems. In: Human Resource Management, Vol. 23, 1984, pp. 41-60

[WFM96]   Workflow Management Coalition: Interface 1: Process Definition Interchange. (WfMC TC-1016) 1996

[Wri71]   Wright, G.H.: Explanation and Understanding. Ithaca, NY: Cornell University Press 1971

[Za87]   Zachman, J.A.: A framework for information systems architecture. In: IBM Systems Journal, Vol. 26, No. 3, 1987, pp. 277-293