Essential Challenges in Business Systems Modeling

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Abstract. This paper argues for the need to respect so-called 'Principle of Modeling' and its consequences in the information system development methodologies. Principle of Modeling expresses the presumption that the objective basis for the implementation of the information system in the organization must be constituted by real facts existing outside of and independently of the organization. In other words, information system as an information infrastructure of some business system is always a model of the Real World. The Philosophical Framework for Business System Modeling is used as a platform for the discussion about basic aspects of the Real World and their relationships which should be covered by the information system in terms of the Principle of Modeling. Then some important consequences following from the framework in mutually connected fields of Business Processes Modeling, Conceptual Modeling, and Information System Development are discussed.

Keywords: Information systems development · Principle of modeling · Business process model · Conceptual model · Object orientation · Process orientation

1 Introduction

One of the essential principles of the information systems development methodologies is the Principle of Modeling. Principle of Modeling expresses the presumption that the objective basis for the implementation of the information system in the organization must be constituted by real facts existing outside of and independently of the organization. In other words, information system as an information infrastructure of some business system is always a model of the Real World.

The roots of the Principle of Modeling are closely connected with the technique of Normalization of Data Structures firstly introduced by E.F. Codd in [3] and then elaborated in further detail together with R.F. Boyce in [2]. Although the original Codd's intention was mainly technical and located in the field of database system design, this technique started uncovering the essential Principle of Modeling as a generally valid principle in the field of information systems development. The principle has been later used by Peter Chen who followed-up the Codd's ideas by introducing the 'entity-relationship model' that 'adopts the natural view that the real world consists of entities and relationships and incorporates some of the important semantic information

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about the *real world*' [9]. This way Chen switched from the traditional thinking just about the organization of data to thinking about the real world and its reflection in data later known as the 'conceptual modeling'. During the following decades this way of thinking has been established as the essential general principle which manifests itself not just in the field of data but in all substantial dimensions of information system development.

Principle of Modeling significantly increased the possibilities of ISD methodologies to assure the quality of the information system in the analysis phase of its development. If the contents of the information system is fully determined by the Real World then the quality of the information system should be measurable with the attributes of the Real World. So the ability to achieve the proper quality of the information system is directly related to the ability to uncover the proper attributes of the Real World. The correctness of the information system follows from the truthfulness and completeness of the Real World models used in the process of its development. Based on these ideas the ISD methodologies can be equipped with detailed quality rules following from the attributes of the Real World. These rules can cover both main meanings of the model quality: correctness and completeness. Information system should support its user with correct (i.e. truly) as well as complete information about the relevant part of the Real World.

Despite its four decades long existence, the full respect to the Principle of Modeling and its essential consequences in the field of quality of the contents of the information system is still not usual in contemporary information system development methodologies. Instead of the orientation on objective categories of truthfulness and completeness of the picture of the Real World in the information system most methodologies prefer relative and subsidiary categories for measuring the quality of the system contents like 'user requirements', 'user satisfaction' or even 'user pleasure'.

In this paper we argue for the need to respect the Principle of modeling and its consequences in the information system development methodologies. We introduce the Philosophical Framework for Business System Modeling as a platform for the discussion about basic aspects of the Real World and their relationships which should be covered by the information system in terms of the Principle of Modeling. Using the framework we describe four basic dimensions of the model of the Real World and their natural attributes together with related methods and techniques from the field of information systems analysis. Special attention we pay to the relationships of particular dimensions as important field for the consistency of models.

Finally, we discuss the most important emergent consequences of the nature of basic dimension of the Real World informatics model in the mutually connected fields of Business Processes Modeling, Conceptual Modeling, and Information System Development.

2 Philosophical Framework for Business System Modeling

The main purpose for creating the framework was the need to comprehensively understand all important aspects of the Real World which should be reflected in the information system. This need is based on the idea that information system as an information infrastructure of the business (Real World) system is intended to support the business system with the right, truthful and up-to-date information about its state, as well as its history and possible relevant future events.

For such comprehensive understanding the Real World we need to have the general idea about basic dimensions of the Real World. This idea should be as much as possible general because we aim to use as much as possible knowledge from different research fields focused on the Real World including philosophical disciplines, especially logic. Because of its needful generality we call our framework for business system modeling 'philosophical'.

The framework is based on the following premise: *The picture of the given business domain (Real World) is determined by two basic phenomena:* ***being*** *and* ***behavior*** *and two basic views:* ***system view*** *and* ***particular (temporal) view***.

Being represents the Real World as it is (can be, must be, etc.). Real World being covers the basic facts about the existence and possible changes of the Real World objects and their relationships, and can be formally described by means of the modal logic. On the other hand, ***behavior*** represents the happening in the Real World as a consequence of the acting of the Real World actors in terms of achieving goals, executing plans, etc. (intentional behavior). Such behavior can be formally expressed by means of the process-oriented description. ***System view*** sees the Real World as a system of particular elements. As the primary purpose is to describe the attributes of the system, such model has to cover the whole system. The system point of view requires the abstraction of individual attributes of system parts which excludes especially modeling of their temporal aspects because they are always partial (see the following paragraph). The system model thus can be also characterized as a static view. ***Particular (temporal) view*** focuses on Real World events and their consequential changes. To be precise enough such model cannot cover the whole system but just its part. Temporal Real World aspects can be formally modeled by means of the algorithmic description which principally excludes any parallelism. Therefore, each particular model has to be made from the point of view of a single element of the system – temporal view disallows the description of the system characteristics.

By the combination of these two phenomena with these two views we can obtain four essential types of models (see Fig. 1):

(1) The model of the *Real World Modality*, as a static view of being, describes the system of *Real World objects* and their possible mutual relationships.
(2) The model of the *Real World Causality*, as a temporal view of being, describes possible *states in the life of the particular Real World object* and possible transitions among them.
(3) The model of *Collaboration*, as a static view of behavior, describes the *system of business processes* and their mutual relationships. Regarding the necessary intentional character of behavior the relationships among processes always mean their collaboration in order to achieve the defined goals.
(4) The model of *Acting*, as a temporal view of behavior, describes the chains of actions in the particular business process intended to achieve the given process goal under possible circumstances.

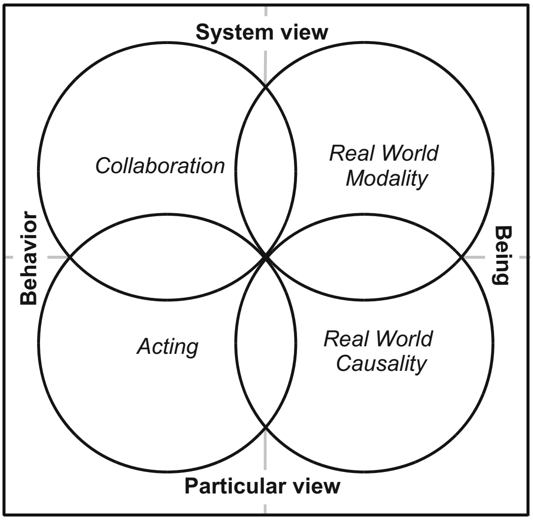

Fig. 1. Philosophical framework for business system modeling (Source: author)

Figure 1 shows not only four basic types of models but also the importance of their mutual intersections which represent the fact that the different types of models are not completely mutually exclusive. Some facts about the Real World are expressed just once in the corresponding type of model. Some other facts are expressed more times, in different models from different points of view. It is simply because basic phenomena and views used in the framework are really not exclusive. Being without behavior does not make sense because each change in the Real World is always a consequence of some action which, seen from the business system perspective, is driven by some purpose. Similarly, particulars do not make a sense without a system which they belong to. Each element of the given particular model is determined by the corresponding system model which defines its necessary context. This awareness of the basic relationships among different informatics models arising from the fact that all models describe the same complex Real World is a base for so-called consistency rules which characterize the high quality methodologies as it is also discussed in the following paragraphs.

Figure 2 describes the kinds of analytical models typically used in the information systems development methodologies which correspond to the particular model types defined in the framework.

For the purpose of this paper the *Real World Modality* means the static Real World rules in terms of the basic (i.e. 'alethic') modal logic. This view of the Real World is in informatics represented by the traditional data-oriented conception of the **conceptual model** represented by [9] for instance. This model describes which Real World objects can (must) be related to which Real World objects at which circumstances.

For the purpose of this paper the *Real World Causality* means the temporal Real World rules in terms of tense logic. This view of the Real World can be in informatics represented by the model of the **object life cycle**. This model describes the causality of

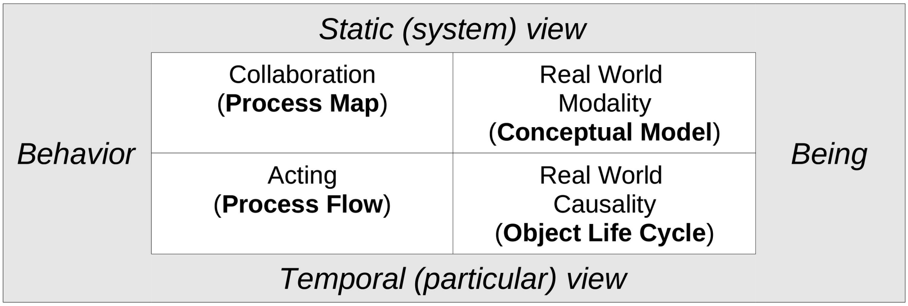

Fig. 2. Kinds of business system models in informatics (Source: author)

the evolution of the Real World object in terms of defined states and their possible sequentiality under specified circumstances.

By the model of *collaboration* we mean the mutual context of business processes: their mutual relationships. Regarding the natural intentionality of behavior in the business system the relationships of the business processes have to be interpreted as their collaboration on achieving the goals. This view of the behavior in the Real World can be in informatics represented by the **Process Map**. The most commonly used notation for the process map comes from the methodology by Erikson and Penker [5].

By the model of *acting* we mean the algorithmic description of one business process which covers all important variants of the behavior of actors in terms of the particular process goal. This view of the behavior in the Real World can be in informatics represented by the **Process Flow Diagram**. Besides the 'de iure' standard Business Process Model & Notation (BPMN) [1] there are more concurrent commonly accepted notations for the process flow diagram like eEPC from ARIS methodology [15], IDEF3 [10] from IDEF, or some of UML extensions, the Eriksson/Penker's one for instance [5].

3 Emergent Consequences

The complex view of the Real World models represented by the framework allows seeing the basic consequences following from the described facts in particular connected fields. In the following paragraphs we discuss those of them which seem to be critically important for the information systems development regarding especially the current state of the art in the fields of IS development methodologies, languages and tools.

In the field of Business Processes Modeling

In the field of Business Processes Modeling the framework uncovers two main actual challenges for current methodologies:

- **The need to model not just the process flow but also the process system**: the global model of processes (usually called Process Map).

- **The need to model business process with respect to the fact that it is primarily an expression of the intention**

The **need to model** not just the process flow but also **the process system** means that it is necessary not only to model the process as a process (i.e. how to run it) but also as a part of the system of processes which is a collection of collaborating processes mutually connected with services. We call this model the Global Process model. As a system view, this model shows the system parts (business processes) and their mutual relationships (cooperation) and that way it allows the needed functional differentiation of processes; clearly distinguishing between the key and support ones according to the business nature of processes expressed in [7]. Unfortunately, this need is still not sufficiently reflected by the current BPM methodologies as it is visible at the state of the art of business process modeling languages. For example BPMN [1], even if it is established as a worldwide standard in the field of business processes modeling, it is still mainly oriented just on the description of internal algorithmic structure of a business process and disregards the global view on the system of mutually cooperating processes. The only way of modeling the cooperation of different processes in BPMN is using ‘swimming pools and lanes’ in the Collaboration Diagram. Unfortunately, the global aspects of the system of business processes cannot be sufficiently described this way nor its completeness ensured. The BPMN primarily views processes as sequences of actions in the time line. However, the global model requires seeing processes primarily as objects (relatively independent of the time), distinguishing different kinds of them (especially the key versus support ones), describing their global attributes (like the goal, reason, type of customer, etc.), and recognizing their essential relationships to other processes which all is obviously impossible to describe as a process flow.

The above criticized insufficiency of BPMN can be eliminated using the additional model which completes BPMN with needed object-oriented point of view. The most standard way is to use the Eriksson-Penker process diagram [5] as a complement to the BPMN diagram. Eriksson-Penker Notation [5] was created as an extension of Unified Modelling Language (UML) [16] which corresponds with the ‘object nature’ of the global view on processes discussed above. This notation distinguishes between the ‘Business Process View’ which illustrates the interaction between different processes and the ‘Business Behavioral View’ which describes the individual behavior of the actors of one particular process. This way it respects the important difference between the global object-oriented view of a process system and the detailed process-oriented view of a single process. The detailed explanation of the methodical need for global model of processes as well as related criticism of the BPMN can be also found in [14].

Business process details should be modeled with respect to the fact that it is primarily an **expression of the intention**. Intentionality, or more traditionally purposefulness, is also very important topic for the ideas Business Process Management Automation in general, particularly robotics and similar fields. In the legendary article [11], which is usually regarded as the root of cybernetics, the authors expressed the idea which essentially influenced the later development of cybernetics: *‘all purposeful behavior may be considered to require negative feed-back’. The concept of negative feed-back is explained there as follows: ‘...the behavior of an object is controlled by the margin of error at which the object stands at a given time with* *reference to a relatively specific goal. The feed-back is then negative, that is, the signals from the goal are used to restrict outputs which would otherwise go beyond the goal'.*

According to the basic work in the field of process-driven management [7], business process always follows some goal. The goal is a fundamental attribute of a business process as it is regularly used in matured methodologies like in [5] for instance. That means that *business process is always an intentional process*, more exactly the process of purposeful behavior of an interested object following some goal. For instance the behavior of the process manager is undoubtedly an intentional behavior which follows the goal of the process.

Taking into the account the definition of purposeful behavior discussed above, it can be said that every business process, as it is an intentional kind of process, have to have some negative feed-back which ensures restriction of its outputs in order to keep them in the margins of its goal. In the case of the business process the feed-back is represented by the input to the process from its environment which is causally connected with some process output. The value of the input should influence the following behavior of the process in terms of keeping it within the margins of its goal. This means that 'intermediate' inputs to the process (i.e. none-starting inputs to the process coming between its starting and end points) are critically important parts of the business process distinguishing it from other, non-intentional (i.e. non-business), processes. When working with processes we have to take into the account even the time dimension; every input to the process from its environment has to be synchronized with the process run. Thus, in each part of the process where some input which influences the following process run is expected the process state has to be placed. The process state means such points in the process structure where nothing can be done before the input to the process occurs, i.e. the point of waiting for the input. Process state thus represents the essential need to synchronize the process run with expected events. This need follows from the fact that the event is always an objective external influence and thus it must be respected. From the physical point of view such respect means synchronization – waiting for the event.

Not all methodologies and process modeling languages respect the concept of a process state. It is pretty well respected in IDEF [10], partially in ARIS [15] and not at all in BPMN [1]. As a 'de iure' standard BPMN do not recognize the concept of a process state there is no other way than to express the process state with the general symbol for synchronization – the 'AND gate'. Some further discussion about process states and other important consequences of the intentionality in business process models, especially regarding the standard BPMN, can be found in [12, 14] and is illustrated with Fig. 3.

In the field of Conceptual Modeling

The general emerging challenge in the field of Conceptual Modeling which follows from the framework is **the need to model also the system dynamics which means in the case of the conceptual model the essential causal rules**. Causality of the evolution of an object can be modeled via so-called object (entity) life cycle. For that purpose the UML is a well prepared language as it allows modeling of life cycles with the State Chart. Moreover, using UML the life cycle of an object class can be modeled

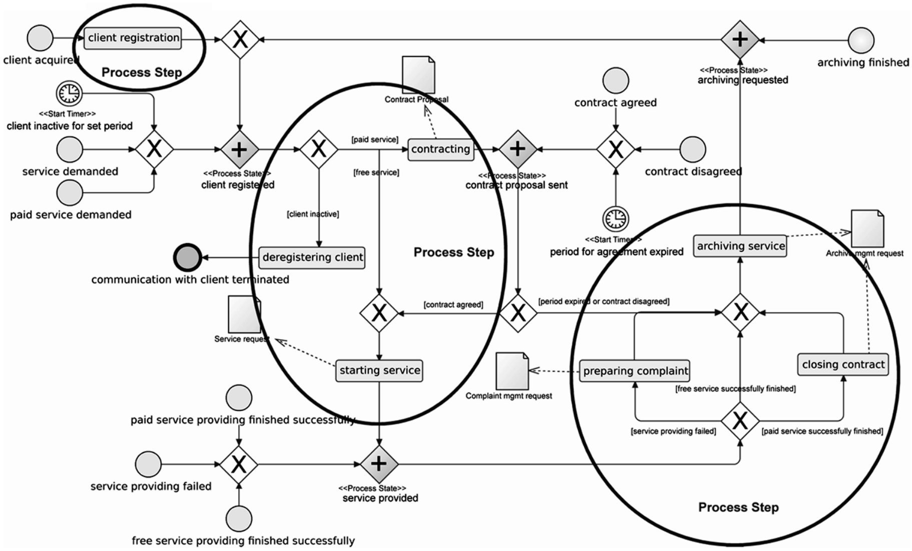

Fig. 3. Example of the use of process states in the BPMN language. (Source: [14])

in the context of other connected classes which is generally described with the Class Diagram. The language specification defines the essential relationships of both diagrams [16]. So in this case the problem does not lie in the language but in the conceptual modeling methodologies which are mostly still anchored in the traditional data-based conception of the conceptual modeling. In this conception the conceptual model is clearly static view of objects and their essential and thus stable relationships. All temporal aspects connected with modeled objects are then typically regarded as a matter of business processes and out of the scope of the conceptual model. Nevertheless, as the Philosophical Framework for Business System Modeling shows, there is a substantial difference between the dynamics of objects (representing the dynamics of being) and the dynamics represented by business processes as intentional chains of actions. Therefore, we believe that life cycles of the conceptual objects can be regarded as an integral part of the conceptual model allowing modeling of not just the static modality of the Real World but also a causal - temporal aspects of the Real World modality in terms of the temporal logic [4].

This way we argue for increasing the scope of conceptual modeling by making the life cycle diagram (State Chart from the UML) a regular diagram for conceptual modeling of object details which should be regarded as a new generation of the theory of conceptual modeling. Requirements for such extension also follows from the 'problem of identity' in connection with the temporal aspects of the Real World and the certain insufficiency of the UML for modeling them identified even in [6, 8].

Some further argumentation for the need to overcome this traditional limitation of the conceptual modeling by object life cycles can be found in [13].

In the field of Information Systems Development

The argumentation from previous paragraphs about the need to model not just static aspects of the Real World but also its dynamics with careful distinguishing between the causal and intentional kind dynamics is critically important also from the information system point of view.

The attempts to 'clear database solutions' are still frequent in the information systems development methodologies. Many researchers and developers still believe that the well designed database built on the precise data analysis (of the Real World) is a sufficient condition for building the whole information system because the functionality of the system is always subordinated to the possibilities of the database. This opinion is supported with the popularity and usefulness of the database tools supporting the standardized system functionality connected with the database in terms of the basic database operations of storing and retrieving data and supported with the integrity definitions which can cover most of the standard functionality of the information system. Another fact supporting such opinion is the approach of the development methodologies to the phenomenon of business processes. The business meaning of processes in terms of business-driven management (represented by [7] for instance) is usually regarded as something out of the scope of the information system development. System developers usually regard business process as just a description of the way of using the information system which can be expressed as a simple use-case.

The problem is that such approach ignores the intentional character of the behavior of business actors. Not only data requirement but also behavior of business actors have to be supported by the information system. It means that the contents of the information system cannot be based on the static Real World rules only. It has to be able to support primarily the intentions of its users. Intentions of the users of the information system are naturally changing and therefore they should not be hard wired in the information system with the standard, typified functionality. Instead of it the information system has to be permanently able to accommodate its behavior to the immediate needs of business processes.

Figure 4 illustrates the idea of the information system of a process-driven organization. It consists of the database and the predefined functionality which covers all standard business activities which are intended to be supported with the information system. System functions use the data from the system inputs and the database to transform them to the system outputs and transformed data in the database. System database contains the actual information about the state and the relevant history of the Real World. This part of the information system can be regarded as static as it represents the predefined, relatively stable and unchanging functionality. The dynamics of the information system required by the business processes (see the upper part of the figure) is ensured by the standard component 'Workflow Management System' (WMS) which allows combining the standard functionality of the system according to the needs of processes. As business processes are naturally dynamic, still changing, the WMS also uses the system database for storing the data about processes, their states and other attributes. The most important part of the WMS thus must be the tool for creating and changing the descriptions of processes which ensures the real dynamics of the whole information system. This way the business processes are supported by the control data and business rules which support their run as well as by the functional data

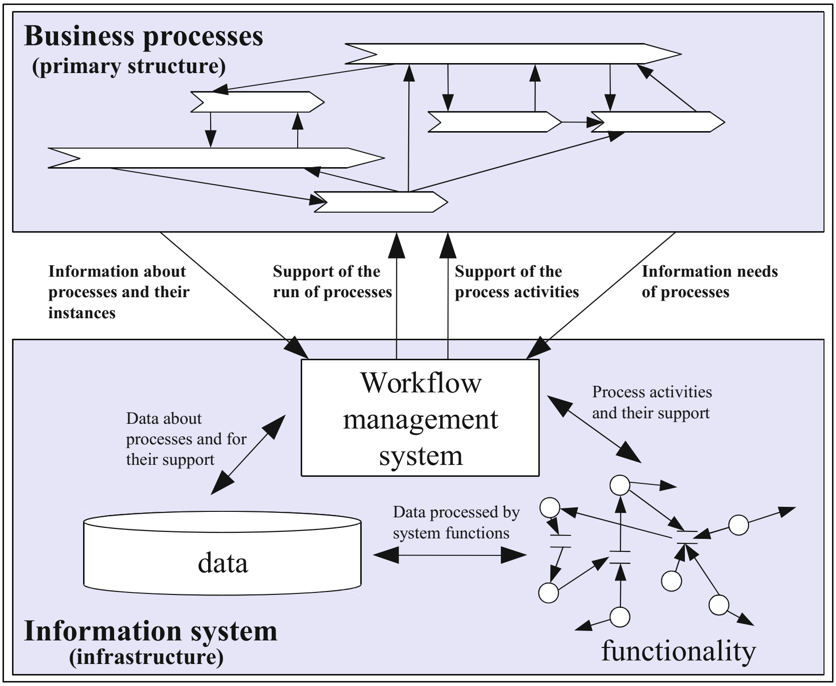

Fig. 4. Information system of a process-driven organization (Source: [14])

and business rules which support their activities. Business processes then deliver the information about themselves (changes in process definitions, state information and performance information) and about their information needs (requirements for functions).

4 Conclusions

The purpose of this paper is to emphasize the most important challenges in the field of business system modeling with use of the Philosophical Framework for Business System Modeling as a tool for the comprehensive understanding all important aspects of the Real World which should be reflected in the information system and consequently in information systems development methodologies. The used approach is build on the belief in the critical importance of the Principle of Modeling which makes the modeling of the Real World the most critical part of the information system development process. Using the Real World as an objective determinant allows us to compare its natural aspects to the state of the art in the field of information systems development and this way uncover the most important challenges usually in the form of current methodical insufficiencies. Therefore, this paper is often critical to the mentioned methods, languages and approaches.

The paper discusses particular detail consequences of the nature of the Real World from the point of view of different research areas: business process modeling, conceptual modeling and information system development.

Besides those detailed consequences the framework also shows that the common opinion that the main difference between the conceptual model and the process model is a difference between the static (conceptual model) and the dynamic (process model) view on a business system is a common mistake. Process model always expresses the intentional dynamics (behavior) while object-oriented models can also describe dynamics but with different meaning: not a behavior but a causality. So the real difference between the process- and the object (conceptual)-oriented models is the difference between the intentionality and modality. The difference between static and dynamic description of the Real World is the difference between the system and the particular views. This finding can be regarded as a common general challenge for the current state of the art in the field of information systems development.

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References

1. Business Process Model and Notation (BPMN). OMG Document Number: formal/2011-01-03 (2011). Standard document URL: http://www.omg.org/spec/BPMN/2.0
2. Codd, E.F.: Recent investigations into relational data base systems. IBM Research Report RJ1385, 23 April 1974. Republished in Proc. 1974 Congress, Stockholm, Sweden, 1974. North-Holland, N.Y. (1974)
3. Codd, E.F.: A relational model of data for large shared data banks. Commun. ACM **13**(6), 377–387 (1970)
4. Emerson, E.A.: Temporal and modal logic In: Handbook of Theoretical Computer Science, vol. B, pp. 995–1072. MIT Press, Cambridge (1990)
5. Eriksson, H.E., Penker, M.: Business Modeling with UML: Business Patterns at Work. Wiley, USA (2000)
6. Guizzardi, G.: Ontological Foundations for Structural Conceptual Models. Telematica Instituut Fundamental Research Series No. 15 (2005). ISBN 90-75176-81-3, ISSN 1388-1795
7. Hammer, M., Champy, J.: Reengineering the Corporation: A Manifesto for Business Revolution. Nicholas Brealey Publishing, London (1993)
8. Heller, B., Herre, H.: Ontological categories in GOL. Axiomathes **14**, 71–90 (2004). Kluwer Academic
9. Chen, P.P.-S.: The entity-relationship model-toward a unified view of data. ACM Trans. Database Syst. **1**(1), 9–32 (1976)
10. Mayer, R.J., Menzel, C.P., Painter, M.K., deWitte, P.S., Blinn, T., Perakath, B.: IDEF3 Process Description Capture Method Report, Knowledge Based Systems, Inc. (1997)
11. Rosenblueth, A., Wiener, N., Bigelow, J.: Behaviour, purpose and teleology. Philos. Sci. **10**, 18–24 (1943)

12. Repa, V.: Business process modelling notation from the methodical perspective. In: Cezon, M., Wolfsthal, Y. (eds.) ServiceWave 2010. LNCS, vol. 6569, pp. 160–171. Springer, Heidelberg (2011). doi:10.1007/978-3-642-22760-8_18
13. Repa, V.: Modelling life cycles of generic object classes. In: Linger, H., Fisher, J., Barnden, A., Barry, C., Lang, M., Schneider, C. (eds.) Building Sustainable Information Systems, pp. 443–454. Springer, Boston (2013). doi:10.1007/978-1-4614-7540-8_34
14. Řepa, V.: Technical consequences of the nature of business processes. In: Gołuchowski, J., Pańkowska, M., Linger, H., Barry, C., Lang, M., Schneider, C. (eds.) Complexity in Information Systems Development. LNISO, vol. 22, pp. 185–199. Springer, Cham (2017). doi:10.1007/978-3-319-52593-8_12
15. Scheer, A.W: Architecture of Integrated Information Systems: Principles of Enterprise Modeling. Springer, Berlin (1992)
16. UML Superstructure Specification, v2.4.1, OMG Document Number: formal/2012-05-07, April 2012