A meta ontology for organizations

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Abstract. The research reported upon in this paper aims at developing a meta ontology for organizations, i.e. a schema for devising the ontology of a particular organization or a reference ontology for a class of organizations. The prospect of such a meta ontology is provided by the Ψ-theory that underlies the DEMO methodology. General requirements regarding such a meta ontology are stated. The proposed meta ontology satisfies all of them. It has the added advantage that there are socionomic laws at its core; this reinforces the ontological quality. It has been applied in several health care cases in practice, out of which a reference model for health care organizations has arisen.

1 Introduction

It is becoming increasingly important for enterprises to collaborate in temporary or permanent networks, in order to survive in the growingly competitive global market. Collaboration requires at the operational level that the business processes of the participating enterprises are integrated. Inter-organizational information systems enable and support this integration. The design of these systems however comes after the integration of the business processes into cross-enterprise business processes. A prerequisite for integrating business processes is that their essential nature is well understood. This is what ontology is about. The notion of ontology is rather new in the field designing and engineering business systems and information systems. In its practical effects, ontology is a kind of standardization. That is why it has got the particular interest of the Semantic Web community [2, 25]. Ontology is about what reality is, what the things one observes really are. So, it must be about the apparent and inherent essence of something, it cannot be some possible view on it, next to other possible views. We define the ontology of an organization as the specification of the conceptual model of the essence of the organization, independent from its implementation. What we exactly mean by essence and by implementation independent will become clear shortly. Consequently, there is only one ontology for an organization. It shows the essential business activities, the participating actors, and the products and services that they are about or deal with.

We will present and discuss a meta ontology for organizations. The adjective 'meta' must be understood in the same way as it is understood in conceptual modeling. An ontology is comparable to a conceptual schema of a Universe of Discourse (UoD) [11]. A *meta ontology* is a schema for ontologies. This meta ontology should serve to develop ontologies in such a way that the next requirements are met. The rationale behind these requirements is that they cover important properties of an ontology while taking optimal advantage of work that has already been done. It is not an exhaustive list:

1. Full advantage is taken of the achievements in conceptual modeling, in particular of the achievements by the natural language based modeling approaches (cf. [14, 15]), since they map directly to logic [24].
2. An ontology should not include lexical issues such as the naming of things and the denotation of values.
3. A clear distinction is made, based on a sound theoretical foundation, between a world (states and events) on the one hand, and the causes of change in this world (actors and acts) on the other hand.
4. An ontology should only be concerned with the essential aspects of production and communication in an organization, not e.g. with how actors communicate. This is a matter of implementation.
5. The meta ontology should be specific for organizations. Ideally, it is founded on the socionomic laws that govern human collaboration, in much the same way as physical laws govern the behavior of physical objects.

As has been explained in e.g. [6, 7, 8, 17], the scientific roots of DEMO are the philosophy of Mario Bunge, in particular the volumes on ontology [4, 5], the language/action perspective [1, 11, 20, 21, 22], and semiotics [16, 19], but also general systems theory [3] and logic [24]. The knowledge from these sources has been combined in the Ψ-theory about organizations that underlies the methodology; Ψ (to be pronounced as PSI) stands for Performance in Social Interaction. It has proven, in many practical projects, including large civil engineering projects and health care projects [13], to be an exceptionally appropriate paradigm for (re) designing and (re) engineering organizations.

The outline of the paper is as follows. In section 2, a concise summary of the Ψ-theory is provided, just enough for understanding the remainder of the paper. The proposed meta ontology is introduced in Section 3, which also contains the formal definitions of the two ontological aspect models on which we focus in this paper. In section 4, the ontology of an example case, namely a library, is developed, by applying the proposed meta ontology. Discussions of the findings as well as the conclusions that can be drawn are provided in section 5.

2 Concise summary of the Ψ-theory

The ontological definition of an organization is that it is a system in the category of social systems [5]. This means that the elements are social individuals, i.e. human beings in their ability of entering into and complying with commitments about the things that have to be produced in collaboration. The Ψ-theory provides an explanation of the construction and the operation of organizations, regardless their particular kind or branch. It is based on four axioms, which are presented hereafter.

The construction axiom
An organization consists of *actors* (human beings fulfilling an actor role) who perform two kinds of acts. By performing *production acts*, the actors bring about the mission of the organization. A production act (P-act for short) may be material (e.g. a manufacturing or transportation act) or immaterial (e.g. deciding, judging, diagnosing). By performing *coordination acts* (C-acts for short), actors enter into and comply with commitments. In doing so, they initiate and coordinate the execution of production acts. An *actor role* is defined as a particular, atomic 'amount' of authority, viz. the authority needed to perform precisely one type of P-act. The result of successfully performing a P-act is a *production fact* or P-fact. P-fact types in a library, for example, include "membership M has started to exist" and "the late return fine for loan L is paid". The variables M and L denote an instance of membership and loan respectively. Examples of C-acts are requesting and promising a P-fact (e.g. requesting to become member of the library).

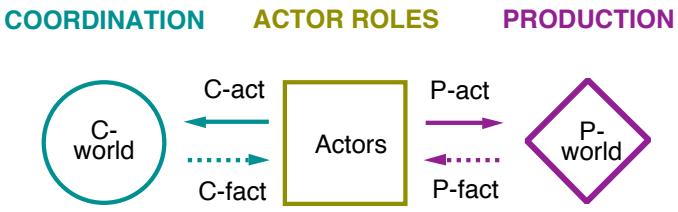

Figure 1. The white-box model of an organization

The result of successfully performing a C-act is a *coordination fact* or C-fact (e.g. the being requested of the P-fact "membership #387 has started to exist"). Just as we distinguish between P-acts and C-acts, we also distinguish between two worlds in which these kinds of acts have effect: the *production world* or P-world and the *coordination world* or C-world respectively (see Figure 1). At any moment, the C-world and the P-world are in a particular state, simply defined as a set of C-facts or P-facts respectively. While being

active, actors take the current state of the P-world and the C-world into account (indicated by the dotted arrows in Figure 1). The P-world and the C-world collectively constitute the UoD of an organization.

The operation axiom

C-facts serve as agenda[1] for actors. The operational principle of organizations is that actors feel committed towards each other to adequately and timely deal with their agenda. This principle is elegantly explained by the Habermas' theory of social action [11]; it is therefore a socionomic law. Actors interact by means of creating and dealing with C-facts. For every type of C-act there is a particular action rule. Such a rule specifies which C-fact(s) may be created and which information is needed in order to decide on creating a C-fact. In principle action rules serve as guidelines for an actor. This means that for some agendum at some instance of time, an actor may deviate from the rule because of current circumstances. Ultimately, it is the actor who is held responsible for taking appropriate action(s).

The transaction axiom

P-acts and C-acts appear to occur in generic recurrent patterns, called *transactions*. A transaction goes off in three phases: the order phase (O-phase), the execution phase (E-phase), and the result phase (R-phase). It is carried through by two actors, who alternately perform acts (cf. Figure 2). The actor who starts the transaction and eventually completes it, is called the *initiator*. The other one, who actually performs the production act, is called the *executor*. The O-phase is a conversation that starts with a request by the initiator and ends (if successfully) with a promise by the executor. The R-phase is a conversation that starts with a statement by the executor and ends (if successfully) with an acceptance by the initiator. In between is the E-phase in which the executor performs the P-act. The so-called standard pattern (Figure 2) must always be passed through for establishing a new P-fact. A few comments are in place however. First, performing a C-act does not necessarily mean that there is oral or written communication. Every (physical) act may count as a C-act (cf. [21]). Second, C-acts may be performed *tacitly*, i.e. without any signs being produced. In particular the promise and the acceptance are often performed tacitly (according to the rule "no news is good news"). The complete transaction pattern consists of the standard pattern plus four cancellations patterns. Every *transaction process* is some path through this complete pattern, and every *business process* in every organization is a structure of such transaction processes [9]. Therefore, the transaction pattern must be taken as a socionomic law: people always and everywhere conduct business (of whatever kind) in conformity with this pattern.

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[1] Agenda is the plural form of the Latin word 'agendum' which means 'thing to do'.

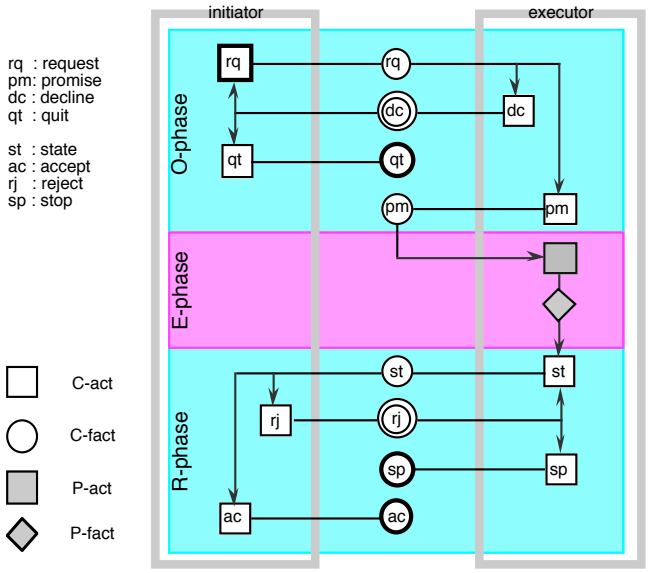


Figure 2. The standard transaction pattern

The abstraction axiom

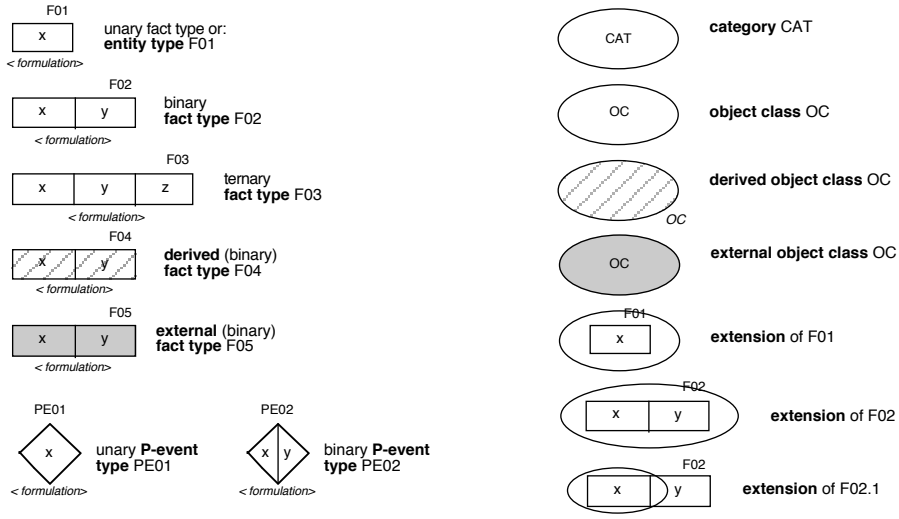
Three human abilities play a significant role in performing C-acts. They are called forma, informa and performa respectively. The *forma* ability concerns being able to produce and perceive sentences (the atomic unit of information). The forma ability coincides with the semiotic layers syntactics and empirics. The *informa* ability concerns being able to formulate thoughts into sentences and to interpret sentences. The term 'thought' is used in the most general sense. It may be a fact, a wish, an emotion etc. The informa ability coincides with the semiotic layers semantics and pragmatics. The *performa* ability concerns being able to engage into commitments, either as performer or as addressee of a coordination act. It coincides with the (organizational) semiotic layer socialics [19]. This ability may be considered as the *essential* human ability for doing business (of any kind). A similar distinction in three levels of abstraction can be made on the production side. The *forma* ability now concerns being able to deal with recorded sentences, called documents (Note. The term 'document' is used here to refer in a most general sense to the forma aspect of information). The *informa* ability on the production side concerns being able to reason, to compute, derive etc. Lastly, the *performa* ability concerns being able to establish original new things, like creating material products or making decisions. Because these acts are at the core of doing business (on the production side), they are called the *essential* production acts.

3 The meta ontology

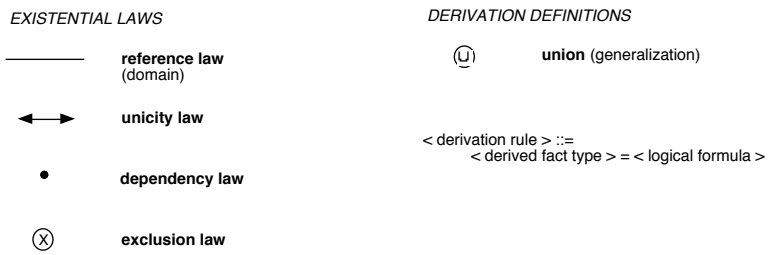
In this section, we propose a meta ontology and investigate the extent to which it satisfies the requirements, as stated in section 1. We define the *ontology* of an organization as the model of the organization at the essential level of abstraction, according to the Ψ-theory. Thus, only the essential production matters are considered, not the informational and documental ones that (only) serve to support the bringing about of these essential ones. Also, only the essential level of coordination is taken into account. Thus only the performative acts, the entering into and the complying with commitments, are considered; not the supporting acts of expressing and inducing knowledge and of uttering and perceiving information. The complete ontology of an organization consists of four aspect models. The Construction Model (CM) specifies the composition, the environment and the structure of an organization (according to [5]): the identified transaction types and the associated actor roles). The Action Model (AM) specifies the action rules that serve as guidelines for the actors in dealing with their agenda: there is an action rule for every type of agendum. The State Model (SM) specifies the lawful states of the C-world and the P-world: the object classes, the fact types and the ontological coexistence rules. The Process Model (PM) specifies the lawful sequences of events in the C-world and the P-world: the atomic process steps and their causal and conditional relationships.

In this paper, only the CM and the SM are presented and discussed. The CM is expressed in the Actor Transaction Diagram (ATD) and the Transaction Result Table (TRT); the SM is expressed in the Object Fact Diagram (OFD) and the Object Property Table (OPT). The ATD and the OFD are formally defined in a language of twhich the legend is provided in Figure 3. It is a variant of the ORM language [14]. Through this property, requirement 1 (as stated in section 1) is satisfied. Space limitations prohibited us to exhibit these formal definitions. From the Ψ-theory it follows that a clear distinction is made between the cause and the effect of a change in a UoD: a C-event is the result of successfully performing a C-act and a P-event is the result of the successful completion of a transaction. Moreover, this distinction is well founded in the Ψ-theory. Therefore, also requirement 3 is satisfied. Lastly, the fact that the CM and the SM are based on the Ψ-theory, which incorporates socionomic laws like the operational principle of organizations and the transaction pattern, ensures that the meta ontology satisfies requirement 5. The OPT is actually just a concise notation of all those fact types in the SM that are purely mathematical functions. These functions map to measurement scales. The scale type (Categorical, Ordinal, Interval, Ratio, Absolute) determines the lawful mathematical operations on the scale values.

Object Fact Diagram :



Object Fact Diagram (continuation) :



Object Property Table :

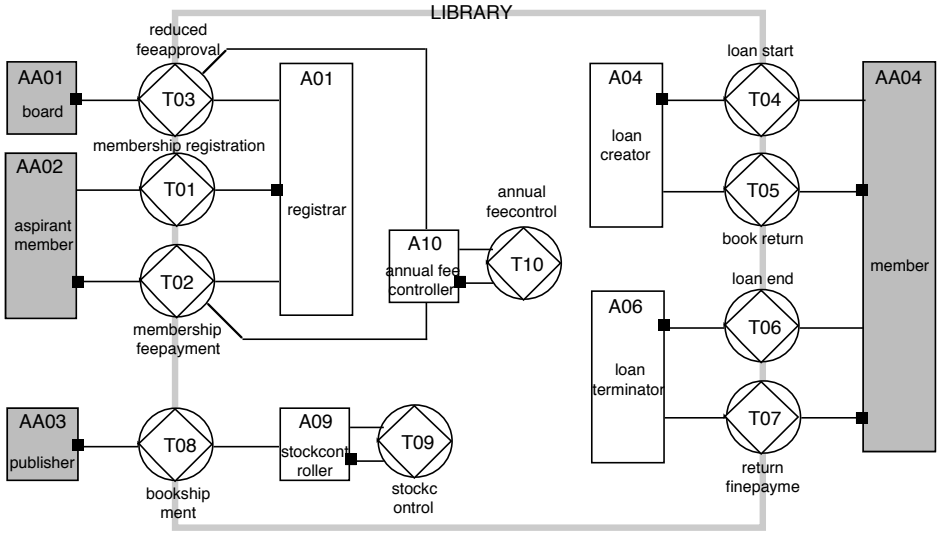
< object property table > ::= { < property type > < domain > < range > (“O” | “D”) }
< domain > ::= < object class >
<range> ::= < scale type > < scale kind >

Note. “O” stands for “Original”, “D” stands for “Derived”

Figure 3. Legend of the OFD and the OPT

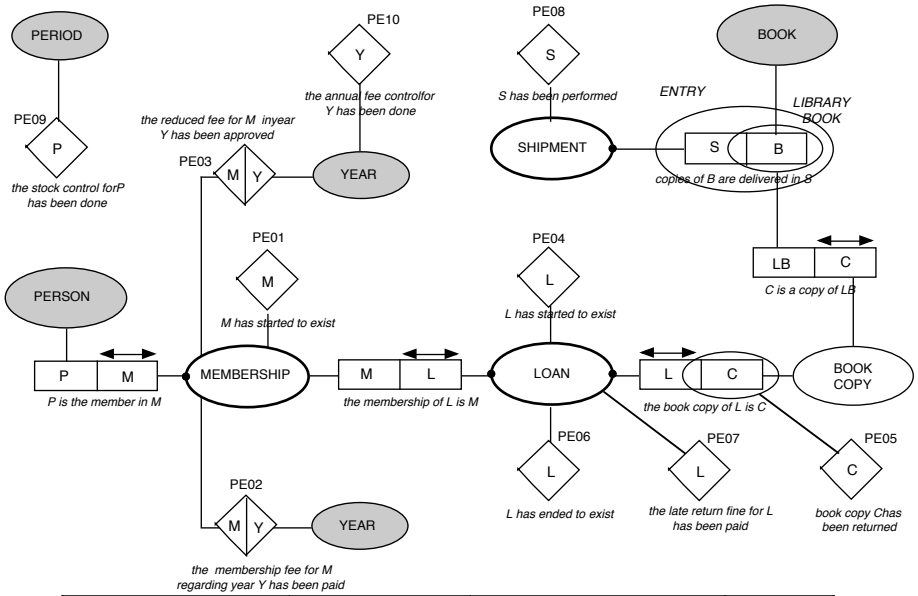
4 The Library Case

To illustrate how the ontology of an organization looks like and how it is developed, we use the library as the example organization, the same one as was taken in [10]. For a full narrative description, the reader is referred to that article. Figure 4 shows the ATD of the library case: the actor roles, transaction types, and the relationships between them. An actor role is represented by a box; the transaction symbol is a diamond (representing production) in a disk (representing coordination). A small black box on the edge of an actor box indicates that this actor role is the executor of the connected transaction type. The boundary of the considered part of the library is represented by the gray-lined open box. All actor roles inside the boundary are elementary: they are executor of exactly one transaction type. Actor roles outside the boundary are (in principle) non-elementary. Therefore they are called aggregate actor roles; they are colored gray. The TRT below the ATD lists all transaction types and specifies for each of them the resulting P-event type. Space limitations prohibit us to provide an explanation of the CM of the library. For such an explanation the reader is referred to [10]. No information systems or flows are exhibited in the ATD. Also these things are ontologically irrelevant. Instead, the Ψ-theory states that every C-fact and every P-fact is knowable at any point in time to the actor(s) who have the right to know them, according to their action rules. For similar reasons the computation of (derived) information is not included in an ontology.



transaction type		resulting P-event type	
T01	membership_registration	PE01	*membership M has started to exist*
T02	membership_fee_payment	PE02	*the fee for membership M in year Y has been paid*
T03	reduced_fee_approval	PE03	*the reduced fee for membership M in year Y has been approved*
T04	loan_start	PE04	*loan L has started to exist*
T05	book_return	PE05	*book copy C has been returned*
T06	loan_end	PE06	*loan L has ended to exist*
T07	return_fine_payment	PE07	*the late return fine for loan L has been paid*
T08	book_shipment	PE08	*shipment S has been performed*
T09	stock_control	PE09	*the stock_control for period P has been done*
T10	annual_fee_control	PE10	*the annual_fee_control for year Y has been done*

Figure 4 The ATD and the TRT of the Library



property type	object class	scale type + scale kind		int. / ext.
date_of_birth	PERSON	JULIAN_DATE	I	E
age (*)	PERSON	NUMBER	A	-
#days_overdue (*)	LOAN	NUMBER	A	-
incurred_fine (*)	LOAN	EURO	R	-
minimal_age	YEAR	NUMBER	A	E
standard_fee	YEAR	EURO	R	E
reduced_fee	YEAR	EURO	R	E
normal_loan_period	YEAR	NUMBER	A	E
max_#copies_in_loan	YEAR	NUMBER	A	E (=5)
daily_late_fine	YEAR	EURO	R	E
control_increment	YEAR	NUMBER	A	E
#books_of_line_item	LINE_ITEM	NUMBER	A	I
#books_in_loan (*)	MEMBERSHIP	NUMBER	A	-

age (P) = (current_date - date_of_birth (P)) {Note: age in days}
#days_overdue (L) = < (start date of L) + (normal_loan_period) - (current date) >
#books_in_loan (M) = < the sum of book copiess in loans of M that are not yet ended >
incurred_fine (L) = #days_overdue (L) * daily_late_fine (current_year)

Figure 5 The OFD and the OPT of the Library

Figure 5 shows the SM corresponding to the CM of Figure 4. The OFD and the corresponding OPT specify all object types and fact types that are ontologically relevant. These are the (only) object types and fact types that appear in the AM (the action rules). Otherwise said, the SM of (a part of) an organization is an *ontological* conceptual schema of its UoD: it describes the types of things and facts (relationships) that are essential, that are and must always be there, as well as the laws that appear to hold for the co-existence of these things and facts (Note. We leave out the state model of the C-world. This is generic for all organizations because of the socionomic laws that shape the interaction (cf. section 2)). As said earlier, Figure 3 contains the legend of the OFD and the OPT. The gray-colored boxes depict external object classes. They contain objects that play a role in the business processes, but their existence is determined by transactions other than those in Figure 4. The white-colored boxes depict internal object classes. The objects in these classes are created in the mentioned transactions. For the classes Membership, Loan, and Shipment, this is obvious. For BookCopy, these are the books delivered in shipments to the library.

The diamond shaped fact types are the production fact (event) types that also appear in the Transaction Result Table of Figure 4. These fact types link the conceptual schema of the P-world to the transactions that change its state. Consider e.g. the creation and termination of loans. There are two binary fact types: "the membership of L is M" and "the book copy of L is C". A unicity law holds for the role of the loan in both fact types: a loan always relates to at most one membership and one book copy. Also, a dependency law holds for Loan in both fact types. Hence a loan always coexists with exactly one membership and one book copy. Lastly, a new loan can be conceived of (and put in a database) but that doesn't mean that it actually exists yet. In order to come into being, an event of type PE04 is needed. This event has a time stamp (the point in time at which it occurs). By definition this is the point in time at which the transaction T04 concerning L has successfully been completed [8]. The loan ends its existence by an event of type PE06. During the lifetime of the loan, an event of type PE07 may occur (late return fine payment).

From Figure 5 it is also apparent that no lexical object types or fact types are included in the ontology. No name classes are associated with object types and no denotations of values are associated with scales. This illustrates the satisfying of requirement 2 (in section 1). Next, there are also no fact types regarding the way of communicating between actors, like the postal address of persons. Postal (or other kinds of) addresses are ontologically not relevant; they are only needed for realizing the communication between persons. This illustrates that the ontology satisfies also requirement 4.

5 Discussion and conclusions

The notion of ontology, as presented and elaborated in this paper, is largely a systematic, mathematical and science-oriented notion, contrary to the highly verbal or even esoteric notions that go around. We think that such a rigorously defined notion is necessary for the field of application we have in mind: the (re) designing and (re) engineering of organizations of any kind, all over and across the world. Although this notion heavily relies on the work of Mario Bunge [5], it transcends this basic and important work through the addition of socionomic laws (the operational principle of organizations and the transaction pattern) and of the three human abilities: forma, informa and performa. These additions make our work not easily comparable with the other work in ontology that is also based on Bunge's ontology [23]. This also holds for the criticisms regarding [23], like those in [18]. An important difference is that our work is mainly based on [5] while the work of Wand and Weber is mainly based on [4].

The concept of ontology as commonly understood nowadays [25] is like a conceptual schema of a UoD. Such a schema is itself an instance of a meta schema (which by definition is an instance of itself, cf. [14, 15]). Likewise, an ontology is an instance of a meta ontology. We have stated five requirements for ontologies and meta ontologies that we consider indispensable. They make the notion of ontology something that is clearly distinguished from the notion of conceptual model, as applied in information systems design. The aspect models of the DEMO methodology, which is fully based on the Ψ-theory, appear to constitute an appropriate meta ontology for organizations, as we have demonstrated in section 3. It turned out that this meta ontology and the the notion of ontology, as we defined it, satisfy all requirements.

The proposed meta ontology has been tested in numerous practical projects. A particular extensive and meticulous evaluation has been performed in three health care organizations [13]. These experiences have lead to the conception of a reference ontology for health care providing institutions. Likewise, the ontology we have developed in section 4 for the library case may turn out to be a reference ontology for libraries. It contains (most of) the peculiarities of a library and it is abstracted fully from all implementation issues.

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