The notion of business process revisited

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Abstract. The notion of business process is becoming increasingly important in all business and information/communication technology related disciplines, and therefore gets a lot of attention. Consequently, there is a variety of definitions as well as a variety in preciseness of definition. The research reported in this paper aims at clarifying the different understandings and unifying them in a common conceptual framework. Three fundamental questions concerning business processes are investigated: about the difference between business process and information process, about the distinction between the 'deep' structure and the 'surface' structure of a business process, and about the difference between system and process. These questions are discussed within the framework of the Ψ-theory and the DEMO methodology.

1 Introduction

Since the early 90's the term 'business process' has become widely accepted within the areas of business process and information systems engineering, particularly through the publications of Hammer, Champy and Davenport [11, 12, 6]. Numerous publications have followed upon these pioneering ones. At the same time a number of other disciplines have incorporated the notion of business process, like e.g. workflow and quality management. This has lead to a likewise diverse set of definitions, ranging from rather informal ones, like in [19], to quite formal definitions, like in [1].

It is the purpose of this paper to clarify this diversity and to try to unify the different understandings. In particular, the next research questions are addressed:

1. Is the notion of business process a really new notion or can it be defined, e.g. by means of specialization and/or aggregation, on the basis of existing notions? If so, how? If not so, how should it be understood and how should it be related to existing notions in information systems engineering?
2. The way in which business processes present themselves to us, may change while some 'essence' in it remains stable. Apparently there is a 'deep' structure behind the 'surface' structures that people observe and change. What is this deep structure and how can it be extracted from a surface structure?
3. What is precisely meant by 'process' in contrast to 'system'? To exemplify this question: it is quite common to speak of 'business *process*' and of 'information *system*'. Do people mean really different notions by these different terms or is 'process' in business process more like 'system' in information system?

We will seek answers to these questions within the conceptual framework of the Ψ-theory (Ψ is pronounced as PSI which is an acronym for Performance in Social Interaction). This theory has emerged from over ten years of practical experience and corresponding scientific research concerning the DEMO methodology (Design & Engineering Methodology for Organizations) [7, 8, 22, 22]. The Ψ-theory has its theoretical roots in three existing branches of philosophy: semiotics, language philosophy, and systemic ontology. Semiotics is the general study of signs, based on the seminal work of Peirce [18]. It has been elaborated by e.g. Morris [16] and Nauta [17]. In the last decade, a sub field has emerged, called organizational semiotics, which addresses in particular the use of signs by people in organizations [24]. Language philosophy starts with Austin [2] but has been brought to the public particularly through the Speech Act Theory of Searle [21] and the Communicative Action Theory of Habermas [9]. Systemic ontology is the more precise and more formal alternative for general systems theory [3]. It has been developed by Bunge [4, 5]. The outline of the paper is as follows. In section 2 a summary of the underlying Ψ-theory is provided, and in section 3 the DEMO methodology is briefly introduced. In section 4 an example case from health care is modeled and discussed. Section 5 contains the conclusions. Particular attention is given to the generalizability of the findings. Answers to the research questions as formulated above are developed, and conclusions of the whole study are drawn.

2 The Ψ-theory

There exist two different system notions, each with its own value, its own purpose, and its own type of model: the function-oriented or teleological and the construction-oriented or ontological system notion. The *teleological system* notion is about the (external) function and behavior of a system. The corresponding type of model is the *black-box model*. Ideally, such a model is a (mathematical) relation between a set of input variables and a set of output variables, called the transfer function. Knowing the transfer function means knowing how the system responds to variations in the values of the input variables by changing the values of the output variables. Otherwise said, through manipulating the input variables, one is able to control the behavior.

The *ontological system* notion is about the (internal) construction and operation of a system. The relationship with function and behavior is that these are brought forward, and consequently explained, by the construction and the operation of a system. The ontological definition of a system, based on the one that is provided in [5], is as follows. Something is a system if and only if it has the next properties:

- *Composition*: a set of elements of some category (physical, biological, social etc.).
- *Environment*: a set of elements of the same category. The composition and the environment are disjoint.
- *Production*: the elements in the composition produce things (products or services) that are delivered to the elements in the environment.
- *Structure*: a set of interaction relationships among the elements in the composition and between these and the elements in the environment.

An important characteristic is the category to which the elements of a system belong. Therefore, we prefer to call a system according to the definition above a *homogeneous* system. As will be shown later, homogeneous systems can be integrated to constitute heterogeneous systems. The corresponding type of model is the *white-box model*, which is a direct conceptualization of this ontological system definition.

The teleological system notion is adequate for the purpose of using or controlling a system. It is therefore the dominant system concept in e.g. the social sciences, including the organizational sciences. If the transfer function is too complicated to understand, the technique of *functional decomposition* can be applied through which the black-box model of a system is replaced by a structure of sub models of which the transfer functions are more readily understandable. One has to bear in mind however that the knowledge acquired about the system is still functional or behavioral knowledge, in other words, it does not reveal anything about its construction. It is a widely spread misunderstanding to think that if the technique of functional decomposition is applied down to some elementary level, one has revealed the construction of the system. This is not true and can never be true. Moreover, one can make virtually any functional decomposition of a black-box model one likes. Instead, for the purpose of building and changing a system, one needs to adopt the ontological system notion. It is therefore the dominant system notion in all engineering sciences.

The ontological definition of an *organization* is that it is a system in the category of social systems. 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 are produced in collaboration. The Ψ-theory provides an explanation of the construction and the operation of organizations, regardless their particular kind or branch (like industry or government, or manufacturing or service). It is based on several axioms, of which the relevant ones for this paper 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 kind of production act. The result of successfully performing a P-act is a *production fact* or P-fact. P-facts 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).

The result of successfully performing a C-act is a *coordination fact* or C-fact (e.g. the being requested of the production 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 created up to that moment. When active, actors take the current state of the P-world and the C-world into account (indicated by the dotted arrows in Figure 1). C-facts serve as agenda for actors, which they constantly try to deal with. Otherwise said, actors interact by means of creating and dealing with C-facts.

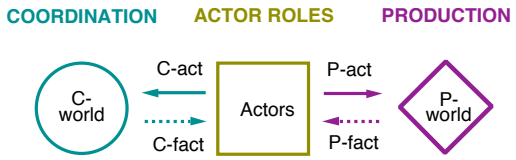

Figure 1 The white-box model of an organization

The transaction axiom

P-acts and C-acts appear to occur in generic recurrent patterns, called *transactions* [8]. The genericity of this pattern has turned out to be so omnipresent and persistent that we consider it to be a socionomic law. 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. 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 these two conversations there is the E-phase in which the executor performs the P-act.

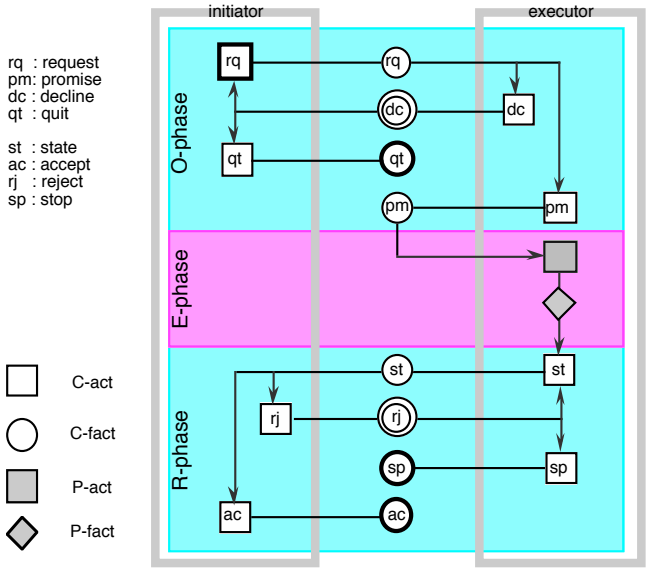

Figure 2 The standard pattern of a transaction

Figure 2 exhibits the standard pattern of a transaction. A white box represents a C-act (type) and a white disk represents a C-fact (type). A gray box represents a P-act (type) and a gray diamond a P-fact (type). The initial C-act is drawn with a bold line, as is every terminal C-fact. The gray colored frames, denoted by "initiator" and "executor" represent the *responsibility areas* of the two partaking actor roles.

The standard pattern 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. 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"). Third, next to the standard transaction pattern, four cancellations patterns are identified. Together with the standard pattern they constitute the complete transaction pattern. Every *transaction process* is some path through this complete pattern, and every *business process* in every organization is a connected collection of such transaction processes. This holds also for processes across organizations, like in supply chains and networks. Therefore, the transaction pattern must be taken as a *socionomic law*: people always and everywhere conduct business (of whatever kind) along this pattern.

The abstraction axiom

Three human abilities play a significant role in performing C-acts [7]. They are called forma, informa and performa respectively. The *forma* ability concerns being able to produce and perceive sentences (Note. By sentence is meant the atomic unit of information). The forma ability coincides with the semiotic layers syntactics and empirics [24]. 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. 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 this is at the core of doing business (on the production side), it is called the *essential* production.

Looked upon from the production side, the abstraction levels may be understood as 'glasses' for viewing an organization (see Figure 3). Looking through the *essential* glasses, one observes the essential business actors, who perform P-acts that result in original (non-derivable) facts, and who directly contribute to the organization's function. These essential acts and facts are collectively called *B-things* (from Business). Looking through the *informational* glasses, one observes intellectual actors, who execute informational acts like collecting, providing, recalling and

computing knowledge about business facts. Informational acts and facts are collectively called *I-things* (from Information and Intellect).

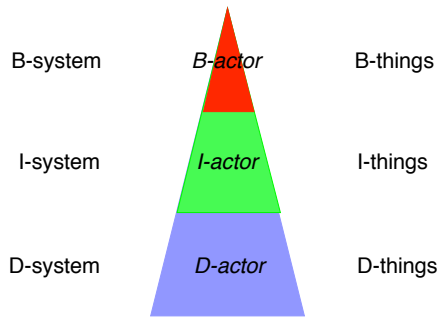

Figure 3 The three aspect systems of an organization

Looking through the *documental* glasses, one observes documental actors, who execute documental acts like gathering, distributing, storing, and copying documents containing the knowledge mentioned above. Documental acts and facts are collectively called *D-things* (from Document and Data). Recall that an actor is a person fulfilling an actor role. So, for example, a person may simultaneously fulfill a B-actor role, an I-actor role and a D-actor role: if you receive a customer order, you may perform some documental acts (like copying and archiving), you may need to perform some informational acts (like inquiring about the customer) and you will actually deal with the request for delivery.

The abstraction levels as distinguished in the Ψ-theory are an example of a *layered nesting* of (sub) systems. Generally spoken, a system in some layer *supports* (the operation of) a system in the next higher layer. Conversely, a system in a layer *uses* systems in the next lower layer. So, B-systems use I-systems and I-systems use D-systems. Conversely, D-systems support I-systems and I-systems support B-systems. If a system X supports a system Y, it means that the function of system X is expressed in terms of the construction and operation of system Y. For example, the actor in the B-system of a library who registers new members, needs to know the age of a candidate member. This information can by definition only asked for in the I-system. In order to get the information, the subject who fulfills the B-actor role has to take his 'shape' of I-actor and initiate an (informational) transaction resulting in the provision of the needed knowledge by the executor of this transaction (the I-actor who is the proprietor of this piece of knowledge). Usually, this I-actor will not know the requested knowledge by heart and thus has to initiate, in his 'shape' of D-actor, a (documental) transaction of which the executor is a D-actor who keeps record of the requested knowledge. A copy of the record (a document) is sent to the initiator who, in his shape of I-actor, is able to interpret the document and lastly, in his shape of B-actor, is able to take the appropriate action based on the acquired knowledge. What the layered nesting constitutes is an intrinsically solid integration of three homogeneous systems into one *heterogeneous* system, which is the (complete) organization. The integration is solid because it builds on the inseparability of the three human abilities.

3 The DEMO methodology

DEMO is a methodology for (re)designing and (re)engineering organizations that takes full advantage of the Ψ-theory. The model of an organization in DEMO consists of four aspect models. Together they constitute the complete white-box model of one of the aspect systems of an organization: the B-system, the I-system or the D-system. Figure 4 exhibits the aspect models and their interrelationships. The Construction Model (CM) specifies the composition, the environment and the structure of a system: the identified transaction types and the associated actor roles. The Process Model (PM) specifies the lawful sequences of events in the Coordination World and the Production World: the (atomic) process steps and their causal and conditional relationships. The State Model (SM) specifies the lawful states of the Coordination World and the Production World: the object classes, the fact types and the ontological coexistence rules. Lastly, 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 models are expressed in diagrams, tables and pseudo algorithms. In this paper, only the Actor Transaction Diagram, the Transaction Result Table, and the Process Step Diagram are presented, and only the B-system is modeled. The subsequent modeling of the I-system and the D-system goes rather straightforward. The general procedure to arrive at a correct and complete set of models of the B-system of an organization consists of three analysis and three synthesis steps:

1 The *Perfoma-Informa-Forma* Analysis. In this step all available pieces of knowledge (from documents, interviews etc.) are divided in three sets, according to the distinction between the three human abilities. Normally the relative sizes of these sets (amount of text) is about 1:2:4.
2 The *Coordination-Actors-Production* Analysis. The Performa things are divided into C-acts/facts, P-acts/facts and actor roles. This step goes rather straightforward since the three kinds are well distinguished.
3 The *Product Structure* Analysis. Every transaction type of which an actor in the environment is the initiator may be conceived as delivering and 'end product' to the environment. Generally, the (internal) executor of this transaction type is initiator of one or more other transaction types, and so on. The results of these cascaded transactions are 'components' of the 'end product'.
4 The *Transaction Pattern* Synthesis. The transaction pattern is put 'over' the results so far, as a template in order to cluster the things found into transaction types. Next, for every transaction type, the resulting P-event type is correctly and precisely formulated. The Transaction Result Table can now be produced.
5 The *Construction* Synthesis. For every transaction type, the initiating actor role(s) and the executing actor role are identified. This is the first step in producing the Actor Transaction Diagram.
6 The *Organization* Synthesis. A definite choice has to be made as to what part of the construction will be taken as the organization to be studied and which part becomes the environment. The Actor Transaction Diagram can now be finalized.

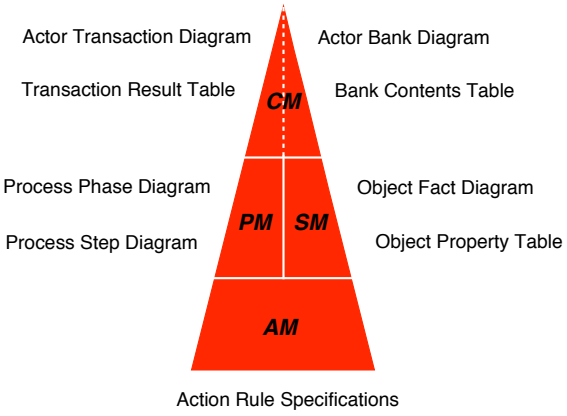

Figure 4 The four aspect models

The model of the B-system of an organization, also called the *essential* model of the organization, is concise but very comprehensible, particularly for managers; the construction model (CM) of most middle-sized or corporate divisions can be represented on an A1-size sheet of paper. The model of a B-system is also complete and coherent. Because of these properties and because of the abstraction from all implementation issues, it is a candidate reference model, applying to all organizations in a particular branch or industry.

4 The Health Care Reference Model

The health care model as discussed in this section is one of the outcomes of the research that has been reported in [10]. To identify generic transactions in care processes, we investigated four different care processes or patient groups: patients with (or suspected of) breast cancer, patients with a tumor in the head-neck area, patients with (or suspected of) Schizophrenia and patients with rheumatism. We consider the identified commonalities in these processes sufficiently representative for calling the presented common model a health care reference model.

The research was carried out in four phases. In the first phase we identified all the care-clusters involved in the care for each patient group and drew up an inventory of the activities performed in these care-clusters. In the second phase we identified from the inventory the core activities performed in each care-cluster and described them in a structured and generic way. In the third phase we compared the core activities of one care-cluster with the core activities of other care-clusters to identify generic transactions types. The generic transactions found were used to construct a generic Actor Transaction Diagram, Transaction Result Table and Process Step Diagram. The fourth phase was concerned with the evaluation of our results. Several care providers reviewed the results and tested them against real-life examples of clinical situations.

Transaction Result Table		
T#	**Transaction Type Name**	**Resulting Production-fact**
T01	(Re)establish patient problem	Patient problem PP is (re)established
T02	Execute clinical examination	Clinical examination CE regarding patient problem PP is executed
T03	Secure patient availability	The patient is available for performing a CE or a PA.
T04	Provide expert opinion on PP	Expert opinion EO regarding (re)establishing PP is provided
T05	Establish policy options	The policy options for PP are established
T06	Provide expert opinion on PO	Expert opinion EO regarding establishing policy option P is provided
T07	Execute policy	Policy P for patient problem PP is executed
T08	Execute policy activity	Policy activity PA in policy P is executed
T09	Secure material availability	Patient material PM is available for performing PA

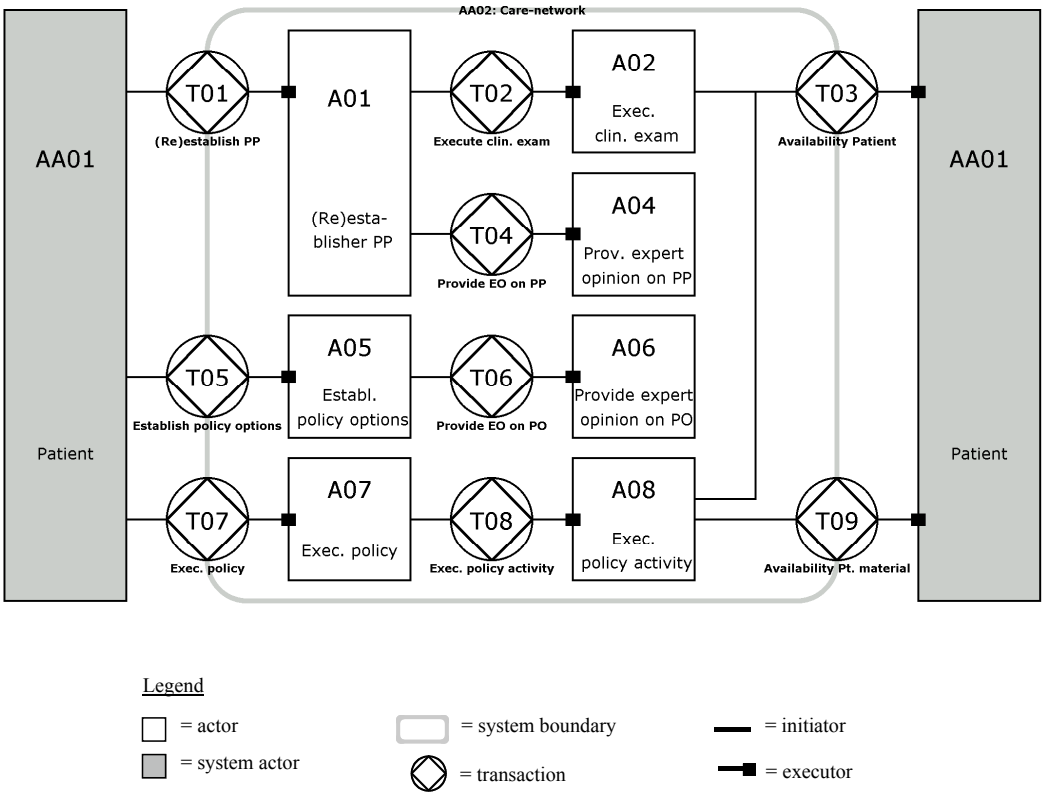

Figure 5 Generic Actor Transaction Diagram (ATD) for Care Processes

The generic Actor Transaction Diagram (ATD) for Care Processes as presented in Figure 5 shows the identified transaction types and the involved actor roles. In the ATD a transaction is represented by a circle (the generic symbol for coordination) in which a diamond is drawn (the generic symbol for production). Actors are displayed as rectangles. The small box on the edge of an actor symbol at the conjunction with

the transaction link indicates that the actor is the executor of the transaction. The scope of the model (system boundary) is represented by a gray-lined rectangle. The table on top of the figure is the Transaction result Table. It specifies the facts that are created as the result of successfully carrying through a transaction of the corresponding type. Words in capitals (like P, PP and PA) denote variables that have to be instantiated. They serve to uniquely identify the core entities. Examples are patient problem (PP) and policy activity (PA).

The actor roles A01, A02, A04, A05, A06, A07, and A08 constitute the composition of the modeled system. They are elementary, i.e. they are executor of exactly one transaction type. The environment consists only of actor role AA01. Actor roles in the environment are generally modeled as non-elementary, so-called aggregate actors (AA), since there is mostly insufficient knowledge about their (internal) operation. Aggregate actors are always colored gray.

Figure 5 contains three transactions that are initiated by the patient, namely transactions T01 *(Re)establish patient problem*, T05 *Establish policy options*, and T07 *Execute policy*. They are called input transactions, whereas T03 *Secure patient availability* and T09 *Secure material availability* are called output transactions. Transactions T02 *Execute clinical examination*, T04 *Provide expert opinion on patient problem*, T06 *Provide expert opinion on policy option*, and T08 *Execute policy activity* are so-called internal transactions. All transactions are identified as the outcome of applying the analysis and synthesis steps as presented in section 3. In understanding an ATD one has to bear in mind that a transaction symbol stands for a complete transaction process (cf. section 2). So, the knowledge contained in an ATD is that in the actual organization of which it is a model transactions of the identified types do occur. One also knows that every occurrence is some path through the complete transaction pattern. For each successful transaction, one knows that at least the so-called success pattern has been followed (rq-pm-st-ac). For each unsuccessful transaction, one knows that this is not the case.

The way in which the distinct transactions are related to each other is represented in the Process Step Diagram (Figure 6). On the basis of this model, we will briefly clarify the transactions and their interrelationships. For an extensive account, the reader is referred to [10]. An instance of a care process starts with a request for a T01 (establish patient problem) by AA01 (a patient). The resulting coordination fact, namely the being requested of a particular T01 is an agendum (something to do) for A01. One of the acts to be performed by A01 is the promise of this T01 (coordination step T01/pr). However, there exists a wait condition (wc) for this step, indicated by the dotted arrow from T02/pr to T01/pr. It means that actor A01 has to wait until the fact T02/pr is created before she is able to perform T01/pr (promising to the patient that she will establish his problem). The state T02/pr can be reached if A01 performs the T02/rq, i.e. the request for a clinical examination, which is directed to A02. This causal relation (cr) between T01 and T02 is optional. Accordingly, the wait condition on T01/pr is also optional (if no clinical examination is needed, A01 does not have to wait for promising T01). If the act T02/rq is performed, the coordination fact T02/rq is created (a clinical examination is requested). This fact is an agendum for A02. There is a (non-optional) causal relation from T02/rq to T03/rq, meaning that the first thing to do for A02 is to request to AA01 (the patient) for the execution of a T03 (becoming physically available for a clinical examination).

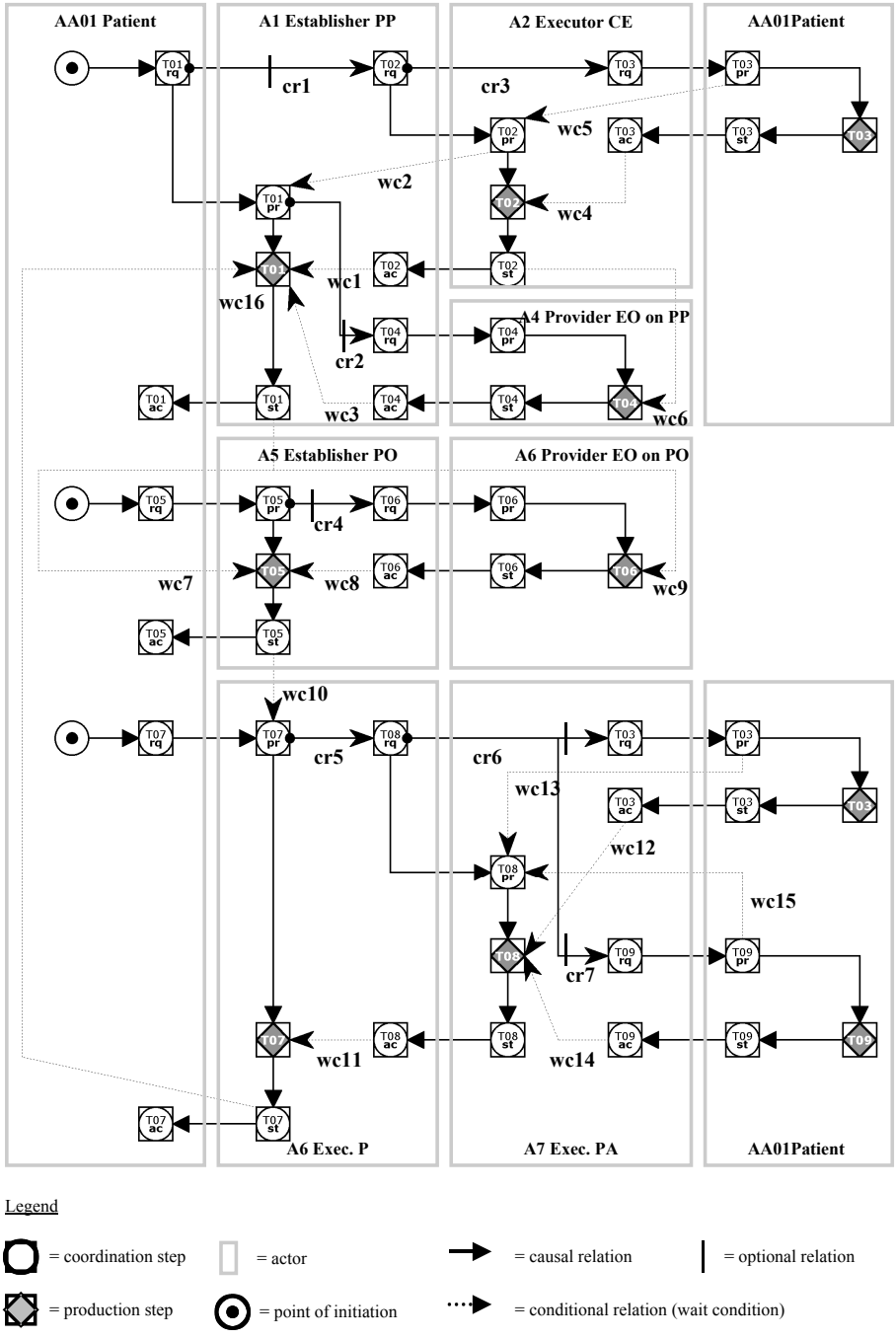

Figure 6 Generic Process Step Diagram (PSD) for Care Processes

The promise by the patient to be available (T03/pr) is considered to be a sufficient condition for proceeding by A02 with performing the T02/pr (promising to A01 that she will do the clinical examination). Note that A01 and A02 are distinct actor roles but that normally they will be fulfilled by the same person, namely the physician to whom the patient has addressed himself; for understanding the 'essence' of the care process however, this is irrelevant.

As soon as the fact T02/pr is created, the wait condition on T01/pr is satisfied, meaning that A01 can proceed with performing the production act of T01, the actual determination of the patient problem. It appears from Figure 6 that there are three wait conditions on this production act. One of them is the being accepted of T02, i.e. the completion of the clinical examination (Note. Like the wait condition from T02/pr to T01/pr, this condition is optional, i.e. depending on the actually being performed of a T02/rq). Another one is the being accepted (T04/ac) of the provision of an expert opinion regarding the patient problem at hand. This transaction has been started by A01 from the state T01/pr. Since the request for an expert opinion is optional, also the wait condition is optional. A third wait condition on the production act in T01 is the being stated of a T07 (execution of a particular chosen policy). It will be explained when transaction type T07 is discussed.

After a T01 has been completed successfully, the patient may start a T05 (establishment of policy options). Although in practice the act T05/rq will mostly be performed tacitly, as a more or less natural proceeding of the consultation, it is important to recognize it as an explicit act of the patient, as shown in the model. Sometimes, the opinion of an expert (mostly a colleague of the physician) about a suggested policy has to be sought for. Therefore the initiation of a T06 is optional. For both the execution (performance of the production act) of the T05 and the (optional) T06 the wait condition of the corresponding T01 holds. This is a rather logical condition; one cannot discuss policy options if the patient problem is not established.

The initiation of a T07 (policy execution) is the third act that must be recognized as an act that is performed explicitly by the patient, although in practice the actual 'surface' form will often be that the physician asks the patient for agreement with the discussed preferred policy. The carrying through of a T07, including the embedded T08, T03 and T09, is quite similar to the carrying through of a T01, explained above. Therefore we will not elaborate on it.

It is often the case in health care that the result of the treatment of a patient problem (the execution of a T07) is not quite satisfactory. What is usually done in such a case is to start again a T01, now in the sense of re-establishing the patient problem. That is why Figure 6 contains the wait condition wc16, from T07/st to the production act of T01. So, in the first execution of a T01 for a particular patient problem, the condition does not hold. In all subsequent iterations, it does.

The exhibited Process Step Diagram also shows that a business process according to the DEMO methodology follows a tree-like product structure. For example, the 'product' establishment of a patient problem (T01) consists of two 'components' (which both happen to be optional): a clinical examination (T02) and an expert opinion (T04). Furthermore, the 'component' has the (mandatory) 'sub component' patient availability (T03). In DEMO, a *business process* is defined as a collection of causally related transactions. So, the Process Step Diagram in Figure 6 contains three business processes, each of them initiated by the patient.

5 Discussion and conclusions

We will successively address now the three research questions as formulated in section 1. Before proceeding to do this, we like to discuss once more the important distinction between the teleological (function-oriented) and the ontological (construction-oriented) notion of system, as well as between the corresponding model types: the black-box model and the white-box model. This distinction appears to be recognized rarely, both in theory and in practice. It can also scarcely be recognized in the various modeling techniques that are currently in use. The point is that the two perspectives are complementary and that both are needed for a full understanding of a system. To be more precise, only a black-box model is helpful for understanding the function and the behavior of a system, and only a white-box model is helpful for understanding the construction and the operation of a system. Moreover, these two kinds of models cannot replace each other. If one has to deal with the usage or the control of a system, only a black-box model is appropriate. When one has to deal with building or changing a system, only a white-box model is appropriate. A good and pure example of a black-box model is the value chain model [19]. Good and pure examples of white-box models are the Petri Net [1] and the EPC [13]. There exists a quite large amount of model types that we would like to call black-grey models, indicating that they are not purely black but derivatives of the black-box model; anyhow, they are not white-box models. Examples of this class of model are the DFD in all its variants (cf. e.g. [28]), and IDEF0 [20]. Although widely applied in systems engineering, they are just not suited for it, as we have made clear.

From the Ψ-theory as explained in section 2, it follows that a business process or business system (the B-system of an organization) is fundamentally different from an information system (the I-system of an organization). The difference is strongly related to the social character of the interactions between actors. Only the B-system is able to produce original new facts, like decisions and judgements. It is important that they can be held responsible for these decisions and judgements. The I-system is only capable of computing or deriving facts from existing ones. There is no point in holding someone responsible for the rightness of mathematical or logical operations. Therefore, the production acts in the I-system can easily be replaced by acts of artifacts (computer applications, intelligent agents etc.), whereas the production acts in the B-system can only be produced by human beings. Consequently, business processes cannot be addressed appropriately if modeling techniques are used that consider decisions and judgments to be similar to computation or derivation and to data or document handling. Examples of such techniques, taken from the information systems area, are DFD, IDEF, UML, Petri Net and EPC. These techniques just lack the appropriate notions. So, the answer to question 1 is that the notion of business process is a really new notion and that it can only be dealt with correctly if it is taken as really different from information processes. Consequently, new theories and new methodologies are needed. Examples are the Ψ-theory and the DEMO methodology as presented in this paper. Other examples can be found in [14], [25], [26] and [27].

The Ψ-theory also provides the clue to answering question 2, about the distinction between a ‘deep’ structure and a ‘surface’ structure of business processes. As the ‘deep’ structure of a business process we propose to take the (white-box model of the)

B-system of an organization. As the 'surface' structure of a business process we propose to take the implementations of the B-system, the I-system and the D-system. We like to emphasize that the relationship between 'deep' and 'surface' is not simply a matter of generalization-specialization, as e.g. suggested in [15]. Instead it is both about the layered nesting of the three aspect systems and about the way these are implemented. An additional element in the 'deep' structure of a business process is the generic transaction pattern. As discussed in [7], a business process is a fiber of molecules (the transaction processes) that are composed of atoms (the C-acts/facts and the corresponding P-acts/facts). The generic transaction pattern is nothing less than a socionomic given. People all over the world, whether consciously or unconsciously, and in all organizations follow this pattern when doing business.

As we have also shown, a clear distinction can be made between system and process. It is also worthwhile to do it. To illustrate this, the Actor Transaction Diagram models the *business system* of an organization (the B-system), whereas the Process Step Diagram models its *business processes*. Note that both are white-box models, while in practice these terms 'system' and 'process' are also used to denote black-box models; this contributes of course to the current confusion. It is common practice however not to be so exact in distinguishing between these meanings. As a consequence, the term 'business process' must sometimes be understood as a teleological notion and sometimes as an ontological one. Moreover, sometimes it has to be taken as business system instead of business process. This answers question 3.

The analysis of the four different care processes has provided substantial practical evidence for the rightness of our conclusions. Regarding question 1, rather continuous discussions have taken place about the authority and responsibility of the actor roles in the B-system. It has led to the clarification of the various actor roles in these care processes. For example, the actor roles A01 and A02 (cf. Figure 5) are usually fulfilled by the same person (the physician). In discussing the model one has become aware of the distinct roles and the possible other ways of organizing the care process. Another important discussion was about the role of initiator of the patient in the transactions T01, T05 and T07. Normally, T01 and T05 are carried through during one consultation. Before we started our analysis and modeling activities, the two roles of the patient were not distinguished, and it was generally not clear who asked for establishing the policy options, it was even mostly not considered to be a separate transaction. Moreover, in many cases the physician thought he or she was the initiator of T05. As a general conclusion, it was appreciated that that these matters have been clarified and it was agreed that no one else than the patient could be the initiator of T05. So, as the overall result, the people in the care processes were pleased by the clarification of the way the patient's roles were modeled and they also considered it right in the context of the modern legal position of the patient in his/her relationship to care providers.

Regarding question 2, the conciseness of the essential model, together with a very clear abstraction from implementation issues, was very much appreciated. In one case (the breast cancer care process) we also have gone through a re-engineering project of the various business processes. The distinction between the three aspect systems has proven to be very helpful. None of the proposed changes appeared to be at the B-level, and most were at the D-level (new forms, new flows of forms, other archiving procedures etc.). The insight that these changes would not have a deep impact and

thus could not be very risky, while still improving the efficiency considerably, have been beneficial. At the same time, the deep structure has been very helpful in checking the effects of the I-level and D-level changes. Next, after the analyses of the four care processes, the idea of there being one common reference model popped up spontaneously. In first instance there were four different DEMO-models, however containing a large common core. The differences were analyzed and common solutions were proposed to each of the health care institutions. This has not only lead to the conception of the reference model, as presented in this paper, but also to an improved appreciation of this model as the valid model in all four institutions.

With these answers to the questions in section 1 we have shed a different light on the notion of business process. In the discussions we hope to have contributed to the clarification of the different understandings as well as to their possible unification. An implicit outcome of the Ψ-theory is that only social individuals are able to bear responsibility. Consequently, the usage of this term in the context of intelligent agents can only be metaphorical, as long as human beings are considered to be the only social individuals (as is currently the case). Lastly, the example of the health care processes that we have presented shows that the DEMO methodology is capable to deal with one of the most complicated existing kinds of business processes in an appropriate, concise but still very comprehensible way.

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