

Use Cases and DEMO: Aligning Functional Features of ICT- infrastructure to Business Processes

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Abstract**Objectives**

The proper alignment of functional features of the ICT-infrastructure to business processes is a major challenge in health care organisations. This alignment takes into account that the organisational structure not only shapes the ICT-infrastructure, but that the inverse also holds. To solve the alignment problem, relevant features of the ICT-infrastructure should be derived from the organisational structure *and* the influence of this envisaged ICT to the work practices should be pointed out. The objective of our study was to develop a method to solve this alignment problem.

Methods

In a previous study we demonstrated the appropriateness of the business process modelling methodology DEMO (Dynamic Essential Modeling of Organizations). A proven and widely used modelling language for expressing functional features is UML (Unified Modelling Language). In the context of a specific case study at the University Medical Centre Utrecht in the Netherlands we investigated if the combined use of DEMO and UML could solve the alignment problem.

Results and conclusion

The study demonstrated that the DEMO models were suited as a starting point in deriving system functionality by using the use case concept of UML. Further, the case study demonstrated that in using this approach for the alignment problem, insight is gained into the mutual influence of ICT-infrastructure and organisation structure: a) specification of independent, re-usable components – as a set of related functionalities – is realised, and b) a helpful representation of the current and future work practice is provided for in relation to the envisaged ICT support.

Introduction

A major challenge facing ICT-staff in health care organisations nowadays is the proper linkage of ICT-infrastructure to organisational structure [1]. A straightforward model for this linkage process is one based on deriving the ICT-infrastructure from the organisational structure. In this model the organisational strategy is developed, along with an organisational structure supporting this strategy. A number of important determinants of the organisational structure are: the allocation of responsibilities, the procedures agreed upon and the way the most important processes are shaped. Given this organisational structure, design decisions are taken for the ICT-infrastructure. This model has proven to be somewhat naive in that it neglects the partial autonomy of the ICT-infrastructure. Such an infrastructure develops also as a result of technological developments and commercial changes, irrespective of the specific needs encountered by an individual health care organisation. As a result, health care organisations are more and more confronted with an ICT-infrastructure that is composed of ready-made solutions provided by different vendors. This means that shaping the ICT-infrastructure exactly to the organisational structure is no option; work practices will need to be adapted to the envisaged ICT support. So, the organisational structure not only shapes the ICT-infrastructure, the inverse also holds. In this situation the problem of relating the ICT-infrastructure to the organisational structure, becomes more an *alignment* problem [2], than just a derivation problem.

To be able to align ICT and organisation we must be able to derive the relevant features of the ICT-infrastructure from the organisational structure *and* to anticipate on the changes in work practices as introduced by this ICT-infrastructure. With respect to the features of the organisational structure this challenge has been taken up in the field of business process modelling [3, 4] or organisation modelling [5]. Earlier we demonstrated the appropriateness of the business process modelling methodology DEMO (Dynamic Essential Modeling of Organizations) to obtain an adequate process view by a clear and comprehensive view of the core processes, responsibilities, co-ordination of activities, and a clear description of causal and conditional relations [6]. However, DEMO does not offer adequate modelling constructs for describing the features of the ICT-infrastructure. A proven and widely used modelling language for expressing these features is UML (the Unified Modeling Language) [7]. In contrast to DEMO, UML has a somewhat unelaborated elicitation phase; there is no systematic approach for modelling the business processes in the environment, and relating these to the use cases that model the information system's functionality. In general, such a systematic approach is highly needed to design and develop ICT-infrastructures that integrate well with the organisational structure.

Little attention has been paid to the exact way in which models of organisations can be related to models of ICT-infrastructures in a systematic way. Business (process) modelling efforts are often done in the context of organisation re-design efforts [5, 8-11] and little relation is established with the construction of the ICT-infrastructure, although the usefulness of DEMO in the alignment process is argued for [12]. On the other hand, if we look at the unified process [13] – the software engineering methodology advocated by the UML designers – we see that it is stated many times that modelling constructs such as use cases and domain classes can be related to the business processes in the environment, but a systematic model of this environment is lacking.

One of the authors has investigated the alignment problem with respect to integration of the different sub-systems in the ICT-infrastructure, where the analysis was not constrained to one specific business process modelling or ICT modelling technique [14]. In this paper we address the problem of aligning the functional features of the ICT-infrastructure with the structure of a business process in the context of a specific case study: the process of the Pre Operative Screening Centre at the University Medical Centre Utrecht in the Netherlands. Our main research question in performing this case study, has been:

*Is a combined use of the business modelling technique **DEMO** and the information systems modelling language **UML** of help in solving the alignment problem?*

While previous investigations showed that DEMO supports the modelling of business processes [6] our case study focuses on the contribution of the *combined use* of DEMO and use cases to the solution of the alignment problem. In the next section we briefly introduce DEMO and UML. We also explain which parts of DEMO and UML are relevant for our research. Subsequently we present our case study. This case study focuses on the derivation part of the alignment problem; we explain the derivation of use cases to obtain a specification of the functionality of the information system. From the results of the case study we discuss our findings in relation to our main research question in the last section.

Introduction to DEMO and UML

Dynamic Essential Modeling of Organizations

The modelling methodology DEMO was developed at the technical university of Delft in the Netherlands. DEMO starts from the premise that business systems need to be conceived as social systems that consist of an interrelated network of people in specific roles (actors) acting according to their specific responsibilities and authorities. The co-ordination of actions between the different actors in the system is achieved by means of communication. DEMO defines communication as a form of governed behaviour that creates commitments between actors to act, which is in line with the Speech Act theory [15-18]. This so-called Language/Action Perspective (LAP) was introduced for the understanding of business systems by Flores and Ludlow in 1981 [19] and greatly expanded by Winograd and Flores [20].

In DEMO every business process is a chain of related business transactions. A transaction is a pattern of communicative and objective actions that are performed by two actors: the initiator and the executor. In figure 1 the transaction and its three phases – order phase, execution phase, and result phase – is displayed. The order phase and the result phase consist of communicative acts in the subject world between the initiator and executor, the execution phase is the objective action of the executor to execute the posed request.

Business transactions are realised at the so-called *essential* level of an organisation, which is conceptualised as a system of communicating actors, creating new, original, information. This is in contrast to the *informational* and *documental* level. At these two levels the organization is observed as elements deriving information from the original information at the essential level (informational), and as elements manipulating the medium that carries the information (documental). The focus of DEMO is on the essential level. Although important, the analysis and design of the informational and documental level of the essential model are performed after there has been a sound understanding of the business processes.

To provide a graphical representation of the transactional structure of organisations, the DEMO concept is effected by a modelling facility consisting of six models each describing a particular aspect of the essential model of an organisation. For the alignment with functional features of the ICT-infrastructure only two of these models are relevant: the interaction model and the business process model [6]. These two models will be explained in the next section by elaborating them for our case study. A relevant description of the theory and modelling facilities of DEMO is constituted by [3, 21-23].

Unified Modeling Language

The Unified Modeling Language (UML) is a graphical language that is based on the object oriented methods from Booch, Jacobson and Rumbaugh that were combined to establish an improved and more unified method [7].

Using the UML method the modelling of requirements may be started with defining use cases. A use case is defined as “a description of a set of sequences of actions, including variants, that a system performs to yield an observable result of value to an actor”. A use case describes the interaction of actors and the system where an actor represents a coherent set of roles that users play when interacting with the system. Starting from these use cases other modelling constructs may be derived, like interaction diagrams, activity diagrams, collaborations, object diagrams etc.

To answer our research question as posed in the introduction we do not need to apply the elaborate set of modelling constructs as offered by UML. Since the starting point for UML may be the use cases, we focus on the possibility to derive use cases from the transactional process structure as expressed in the DEMO model of the care process.

Case study

Aligning a DEMO model of a care process with functional features of the ICT-infrastructure to be acquired was elaborated in the context of the care process of the Pre Operative Screening (POS) centre. The main reason for considering this to be a good case study, was that the management of the POS centre was looking for an information system to support the core activities of the POS, and that it would not be an option to have such a system tailor-made. An off-the-shelf solution would have to be purchased that had to fit in the organisational structure of the POS. So, being able to align the purchased solution with the POS organisation was a main selection criterion.

At the POS centre patients are screened to judge whether they are capable of having the anaesthesia for a certain intervention. This screening takes place before the patient is admitted to the hospital. During a visit at the POS centre different activities are performed. To judge the health status of the patient, the anamnesis is taken, the patient is physically examined, and possibly some laboratory tests, X-rays, or consultations by other specialties are performed. Both a physician and a nurse educate the patient concerning all kind of aspects of the anaesthesia. If during screening no problems are encountered, the physician will deliver a so-called POS fiat for the patient. During the screening also some activities may be performed concerning pre-operative and post-operative preparations, like ordering blood conserves or medication.

Below, the derivation of the requirements will be demonstrated for this specific case study. First the modelling of the process – resulting in two DEMO models – will be discussed, subsequently the derivation of the functional requirements – resulting in use case diagrams – will be illustrated.

Process modelling

Interviews with the POS employees, and observational analysis preceded the structured presentation of the POS process in DEMO. Also, a couple of meetings were organised together with the POS employees resulting in the necessary feedback to obtain the definitive models.

By applying the DEMO approach to the POS process, 11 transactions were discerned. The responsible persons – the initiators and executors – of these transactions and the hierarchical organisation of the transactions are presented in the interaction model, as displayed in figure 2. The business process model is partly showed in figure 3. From this model we learn which causal and conditional relations are discerned, and which transactions are optional.

Interaction model

By analysing the process we first focussed on the essential activity representing the reason of existence of the POS centre: delivering a POS fiat for a patient (T2 ‘deliver POS fiat’). Since a patient is always referred to the POS centre by another physician, who is responsible for the treatment of the patient, T2 is not initiated by the patient but initiated by the referring physician.

This referring physician is not part of the POS centre, therefore this *external* actor is coloured grey. Transaction T2 further shows that delivering a POS fiat is executed by a physician being part of the POS centre.

To deliver a POS fiat the health status of the patient should be judged positively (T3 ‘judge health status’). Judging the health status of the patient includes an anamnesis (T4 ‘take anamnesis’), physical examination (T5 ‘perform physical examination’), and possibly an examination by another specialty (T6 ‘consult other specialty’) or the performance of additional examinations (T7 ‘perform supplementary exam.’). In case the health status of the patient does not allow to administer the required anaesthesia, treatment of the concerning health problem will delay the delivery of a POS fiat. Since the treatment of patients is part of other departments (or e.g. the general practitioner), this part is not modelled.

Besides judging the health status, a POS fiat may not be delivered without properly educating the patient about the possible side effects of the anaesthesia, pre-operative procedures etc. (T8 ‘educate patient’).

Interviews with the POS employees learned that during the POS process also certain activities may be performed concerning preparations in case of future admission of the patient to the hospital. This is expressed by a separate transaction (T9 ‘prepare admission’). To realise T9, three other essential activities may be performed: T7 ‘perform supplementary exam.’, T10 ‘order material’, and T11 ‘give order’.

To obtain a POS fiat, the patient may visit the POS centre without an appointment. If an appointment is made this results in a transaction (T1 ‘make appointment’).

Note that the actor names in this model refer to specific disciplines instead of abstract roles. This is not conforming the DEMO method. However, discussions with the POS employees learned that the use of abstract roles was confusing since the responsibility of the execution of each transaction was clearly accounted for by a specific discipline.

Business process model

As an illustration the causal, conditional and optional relations concerning the execution of transaction T2 (‘deliver POS fiat’) are displayed in figure 3. We see, from the dotted lines from T3/R (‘judge health status’) and T8 (‘educate patient’) to T2/E that the acceptance of the results of these transactions is conditionally for the execution of delivering a POS fiat. The dotted lines from T4 and T5 to T6 and T7 show that the consultation of another physician or the request of additional (diagnostic) tests is only initiated after the anamnesis and physical examination are performed. The dotted lines from T4, T5, T6, and T7 to T3/E express the activities necessary to judge the health status.

The small vertical line on the arrows to T6 and T7 indicate the optionality of these transactions. Finally, we see from the extra grey circle surrounding T6 and T7, that these transactions may be performed more than once during the judgement of the health status.

Deriving use case diagrams

Based on these two models, the next step was performed: applying the UML use cases concept to derive the functionality of the future information system.

With DEMO we see processes as related transactions representing communicative actions between initiating and executing actors. The specified set of transactions in the POS process concerns all new original information created at the POS centre. All informational and documental aspects can be derived from these essential transactions. Describing processes with DEMO and subsequently deriving functionality, means that we have to start from this transactional structure. To fulfil a specific transaction and realise the associated fact, all kinds of informational and documental actions are required. By supporting the processes with an automated information system it will be these actions – or a subset of these actions – that this system should support. We could say that by enumerating these informational and documental actions in the form of use cases, we are able to specify functionality related to the overall

business process. By doing so it will be clear in which way these use cases will have a task in supporting the automation of this process. Also, we will be certain that all essential parts of the process will be attended for.

The above indicates that we may say that from a theoretical point of view transactions are suited as a starting point in deriving use cases to specify system functionality. Together with the employees of the POS centre we evaluated if this also worked in practice. Before we started to specify the desired functionality, we first demarcated which transactions should be supported by the future information system. This resulted in five transactions not to be supported by the system: T1, T6, T7, T10, and T11. T1 is already supported since the current hospital information system includes a module for making appointments in an adequate way. The other transactions all represent order management. This functionality will be supported by the current hospital information system in the future.

In a number of sessions the employees of the POS centre determined which functionality – informational and documental actions – was necessary to realise and support the transactions with an automated information system. We involved the employees with a responsible role as represented in the interaction model and those having a role on the informational and documental level. To envision the required functionality, the transactions turned out to be very effective in guiding the users to analyse which functionality the future information system should offer. Guiding the employees in analysing which functionality was required, was realised by asking them to enumerate all actions that should be supported by the future information system to effectuate the process of one transaction. As an illustration the actions required to effectuate the process of taking the anamnesis of a patient (T4) are given below:

1. Answer the questions on the health questionnaire – having the same questions as the current paper form – for a new patient.
2. Answer the questions on the health questionnaire for a patient visiting the POS centre for a second time, where the values of a previous visit are represented as default values for the current visit. Of course, there will only be default values, if the patient visited the POS centre before. These default values are only accepted and saved after an active confirmation of these values.
3. Answer the questions on the health questionnaire, using different kinds of structured data entry (like coding lists, booleans, numbers, text).
4. Add some free text to a value as an addition to the structured data entry.
5. Select a question and its value to be included on a survey, resulting in a survey presenting the most important data of a patients' visit.
6. Consult an answered health questionnaire of a patient.
7. Consult the author, and the registration time and date of a given value.
8. Consult the history of corrected values (including the value, author, date and time of registration).
9. Consult other medical data – like laboratory results – as available in the current hospital information system.
10. Share values of those questions that are already electronically entered by the referring specialism and that are also relevant for taking anamnesis.
11. Correct a value to a question; since all changes should be tracked in a medical status, the previously given value is saved together with its author and date and time of registration.
12. Print all questions and values as presented on the health questionnaire.
13. Print only those questions and values that may be considered as deviating from normal values.

After analysing which functionality was required for each transaction, these users' needs were analysed and subsequently structured to the official notation of the use cases. For transaction T4 the above mentioned functionality was structured as five use cases. These are presented in

figure 4, where actions 1, 2, 3, 4, 5, and 10 are related to use case *enter health questionnaire*, actions 5, 6, 7, 8, and 10 to use case *present health questionnaire*, action 9 to use case *present medical record*, action 11 to use case *correct data health questionnaire*, and actions 12 and 13 to use case *print health questionnaire*. We see that some of the actions are related to more than one use case. For example, action number 5 requires the possibility of data entry and requires a certain presentation of the entered data.

Together with each use case a description is given specifying the required details as expressed in the above enumerated actions.

In figure 4 each use case is accompanied by a description, specifying the requirement in more detail as expressed in the above-enumerated actions.

The actor presented in figure 4 does not necessarily need to be the specific actor in the interaction model. The DEMO model presents the responsible actors while the actors connected to the UML use cases are those persons really executing the use cases. For example, while a physician is responsible for the anamnesis, it may be the secretary that actually enters the data in the system.

Further, it should be mentioned that use cases are not specific for one transaction. The use case present medical record is essential to realise and support a number of other transactions.

So far, we did not show how we used the DEMO business process model. This is because, in just listing the functionality for each transaction, the business process model is not essential. However, the relational dependencies between the transactions as represented by this model, are conditional to deduct important relational dependencies between use cases. For example, from the business process model we see that the physician can only decide to deliver a POS fiat if the health status of the patient is judged *and* the patient is properly educated. On use case level this means that the use case *enter POS fiat* (part of T2) can only be activated after the performance of use cases *enter conclusion of judgement of health status* (part of T3) and *sign checklist education nurse/physician* (part of T8).

Results and discussion

The relevant process features were captured in two DEMO models: the interaction model and the business process model. The POS employees considered the interaction model as a clearly structured model representing the essential activities and their responsible actors. The transactions enabled a structured walkthrough of the actions needed to realise each transaction. During this walkthrough, functional requirements were put forward that had to be met by the information system to be acquired. By subsequently structuring these formulated users' needs according to the UML approach, a set of use cases was obtained that clearly records the functionality of the information system. By starting from the DEMO interaction model in specifying use cases, we see that the functionality is explicitly related to the business processes in the environment, i.e. the POS centre.

The business process model representing causal, conditional and optional relations was experienced as a difficult model to communicate to the employees. Only a step by step walkthrough with the employees made it possible to communicate this model and derive dependencies between requirements. Since the relations as presented in this model are essential to formulate conditions on and relations between use cases, further research will concentrate on a simplified, more easy to understand version of this model.

The case study demonstrated that in using this approach for the alignment problem insight is gained into the mutual influence of ICT-infrastructure and organisation structure:

- *With the specification of transactions, the specification of independent, re-usable components – as a set of related functionalities – is realised.* This is enabled by modelling the process as a set of related transactions that represent clearly demarcated clusters of

activities. The transactions ‘deliver POS fiat’ and ‘prepare admission’ give an illustration of this. By just observing the process or interviewing the different employees, these activities are not recognised as attributing to *two* different goals of the POS centre. Activities concerning the preparation of admission are performed rather inconspicuous during other parts of the process. For example, the ordering of blood conserves is registered on the same form as the conclusion of the judgement of the health status. However, by explicitly naming the facts associated with each transaction, the DEMO approach envisioned that a *prepared admission* is a separate fact and is not encapsulated by the transaction delivering a POS fiat. By not interweaving the preparation of admission with other activities of the POS centre, one enables the development of an independent and therewith reusable component for possible other processes. The interaction model clearly envisions the existence of these separate components. So, one can say that the use of the DEMO model in shaping the ICT-infrastructure can accommodate a good *separation of concerns* [24], which is taken to be a feature of good designs in the field of software engineering.

- *A helpful representation of the current and future work practice is provided for in relation to the envisaged ICT support.* Implementation of an information system certainly causes changes in the entire work organisation. To express these changes, a clear and comprehensive representation of the existing and future work organisation in relation to the system to be implemented, should be provided for. Discussing these changes with the employees and finding solutions for possible undesired side effects will motivate employees in working with the newly introduced techniques. The transactions together with the use cases provide a helpful representation of the work organisation. By first itemising which activities are performed in the current situation to realise the transactions, and thereafter comparing these activities with the changes involved by introducing the functionality of the use cases, a systematic comparison of the current and future process is obtained. Since most of the necessary information is already collected during the process and requirements analyses, this comparison can be drafted without much extra effort. The feedback of this comparison to and the subsequent discussion with the employees will be easy, since they are already known with the transactions and future functionality of the system.

So, the case study supports the conclusion that the combined use of DEMO and UML is useful for aligning business processes and functional features of the ICT-infrastructure. However, we have also seen that the alignment is not ‘mechanical’. End-users play a vital part in the process of linking the DEMO models with the use cases. Although this might at first sight be considered as a weak point, we, on the contrary, consider it to be a strong point. The heavy involvement of the end-users in the linkage of process and information system gives them insight into the mutual dependencies between organisation and information technology. This will help them in understanding why changes (or the lack of changes) in their work processes sometimes hamper the optimal use of the technology, and at the other hand why design decisions with respect to the information system used, imply restrictions on work process design. This intricate relation between work processes and technology is well studied in literature [25] but often poorly understood by end-users. Nevertheless, its recognition is essential for the acceptance of new technology.

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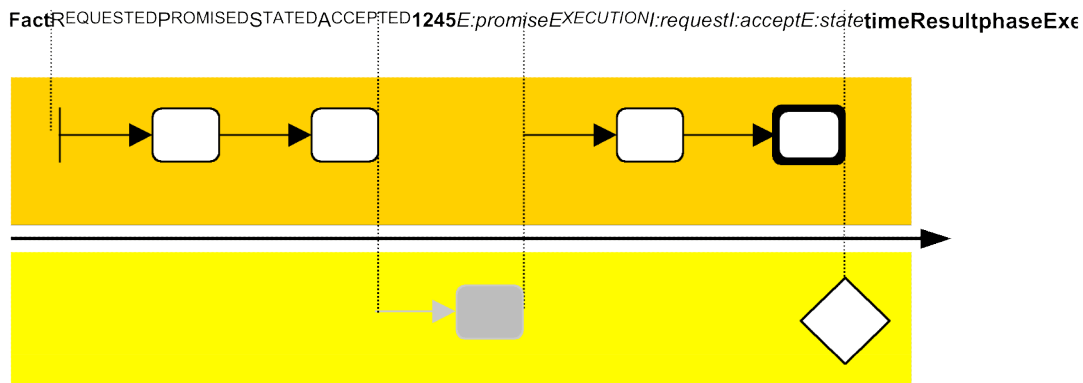


Figure 1: The basic pattern of an essential business transaction. The order phase represents the communicative action in which the initiator expresses his request to the executor. For example, a patient requests for a medicine at a pharmacist by presenting a recipe. The promise of the pharmacist to execute this action ends this phase. In the execution phase the objective execution of the request takes place, i.e. the medicine is prepared according to the prescription on the recipe. The transaction finishes with the result phase. The executor states that the request is executed; the pharmacist presents the medicine to the patient. Only after acceptance of the initiator, a new fact is created in the object world. For this example this means that the fact 'delivering medicine' is created after the patient accepts the presented medicine. Like the other communicative actions this is not a necessarily explicit action. Just taking the medicine, and leaving the pharmacy is understood as an acceptance. Of coarse, discussions may take place in each of these phases and lead to a premature ending of the transaction, or lead to a newly formulated request.

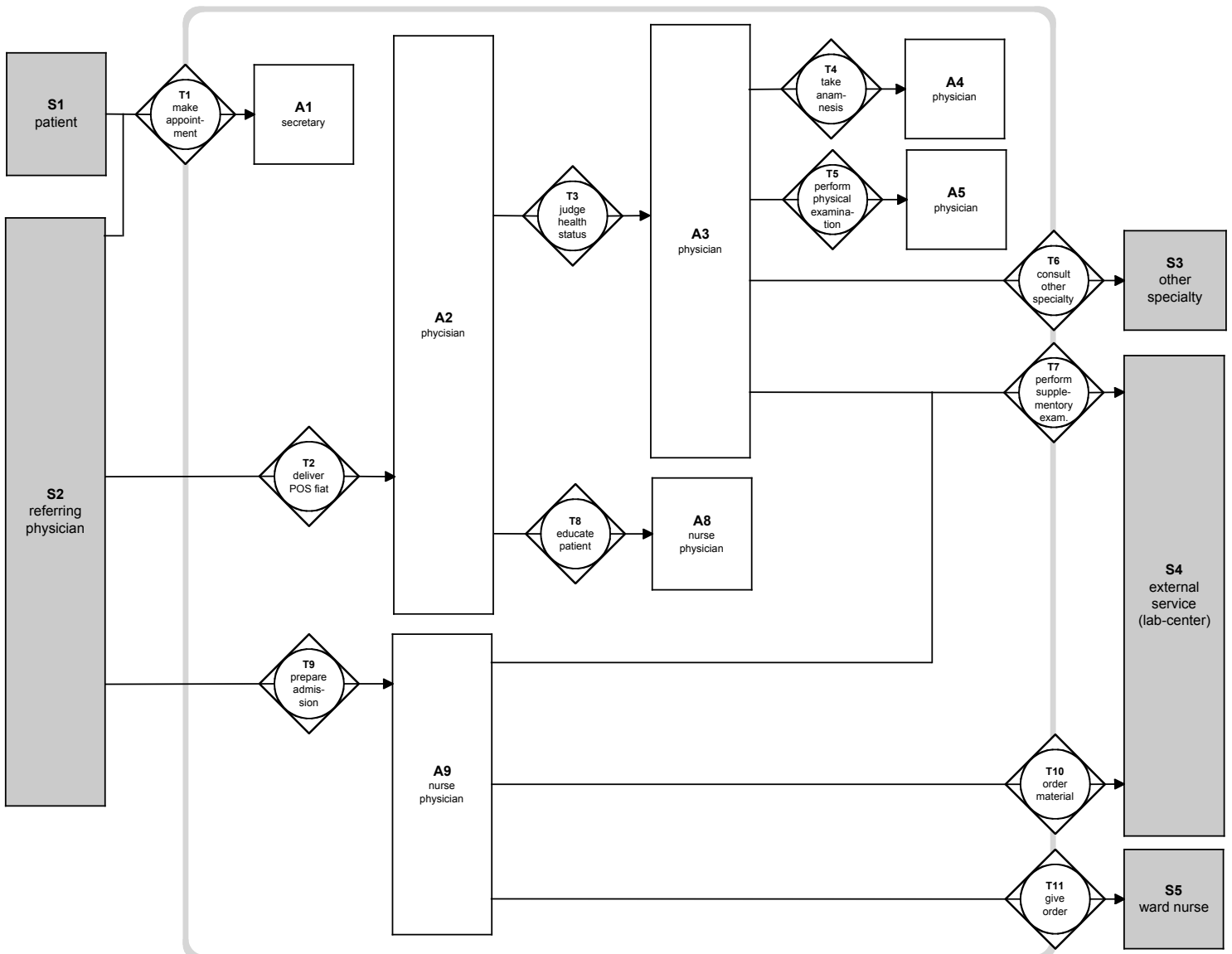


Figure 2: Interaction model of the POS process. Transactions are displayed by a circle-in-the-diamond symbol. This symbol represents the transaction as displayed in figure 1. Actors are displayed as squares. The arrow connecting the transaction symbol to the actor points at the executor of the transaction, while the plain line connects the initiator to the transaction symbol. To visualise the scope of the analysis, the model is delineated by a grey rounded square, the system boundary.

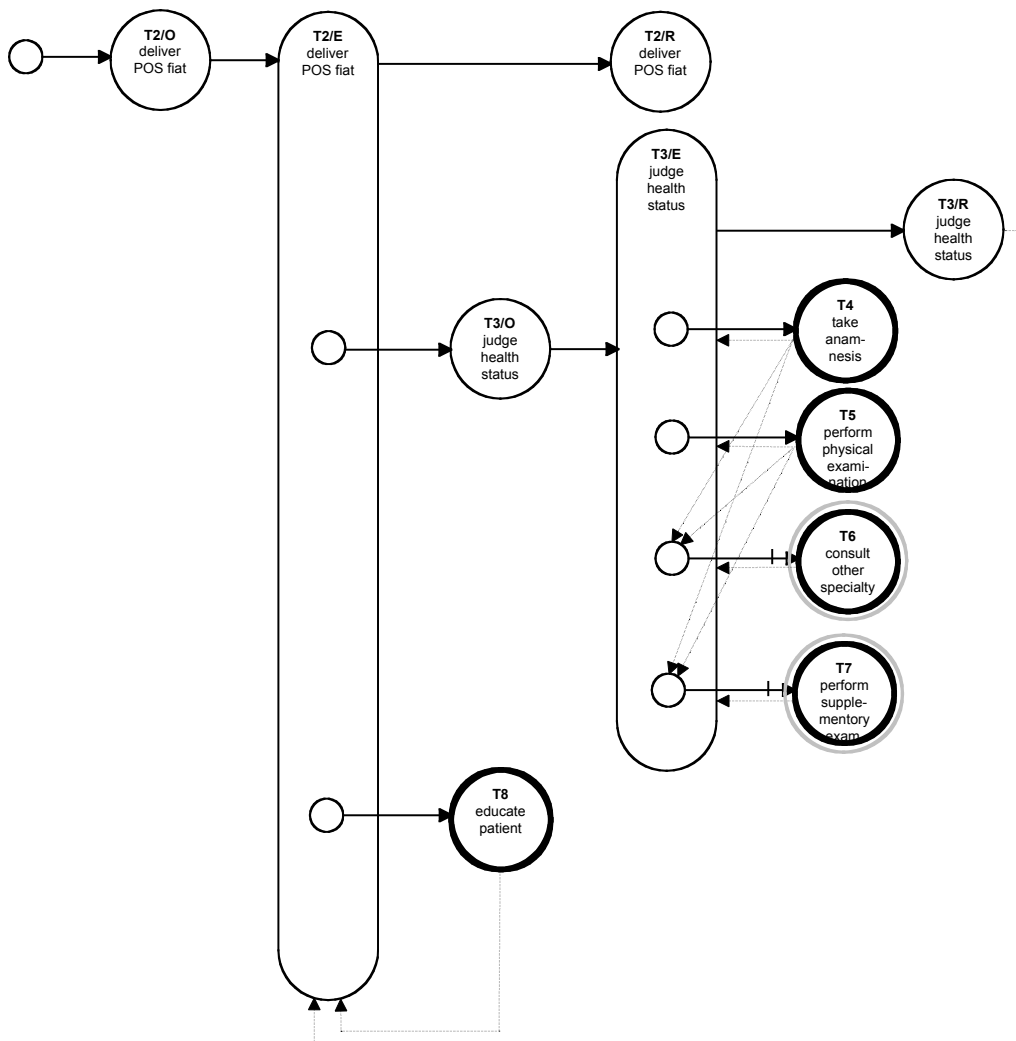


Figure 3: Partial business process model of the POS process. Transaction phases are represented by circles or stretched circles. The different stages of a transaction are represented as a suffix to the identifier of the transaction type. The point of initiation is represented as a small circle. Causal relations are represented as solid lines with arrows, conditional relations as dotted lines with arrows. If a relation is optional, this is indicated with a small vertical line on the causal relationship arrow. Transactions that may be performed more than once for the same case are surrounded by an extra grey circle.

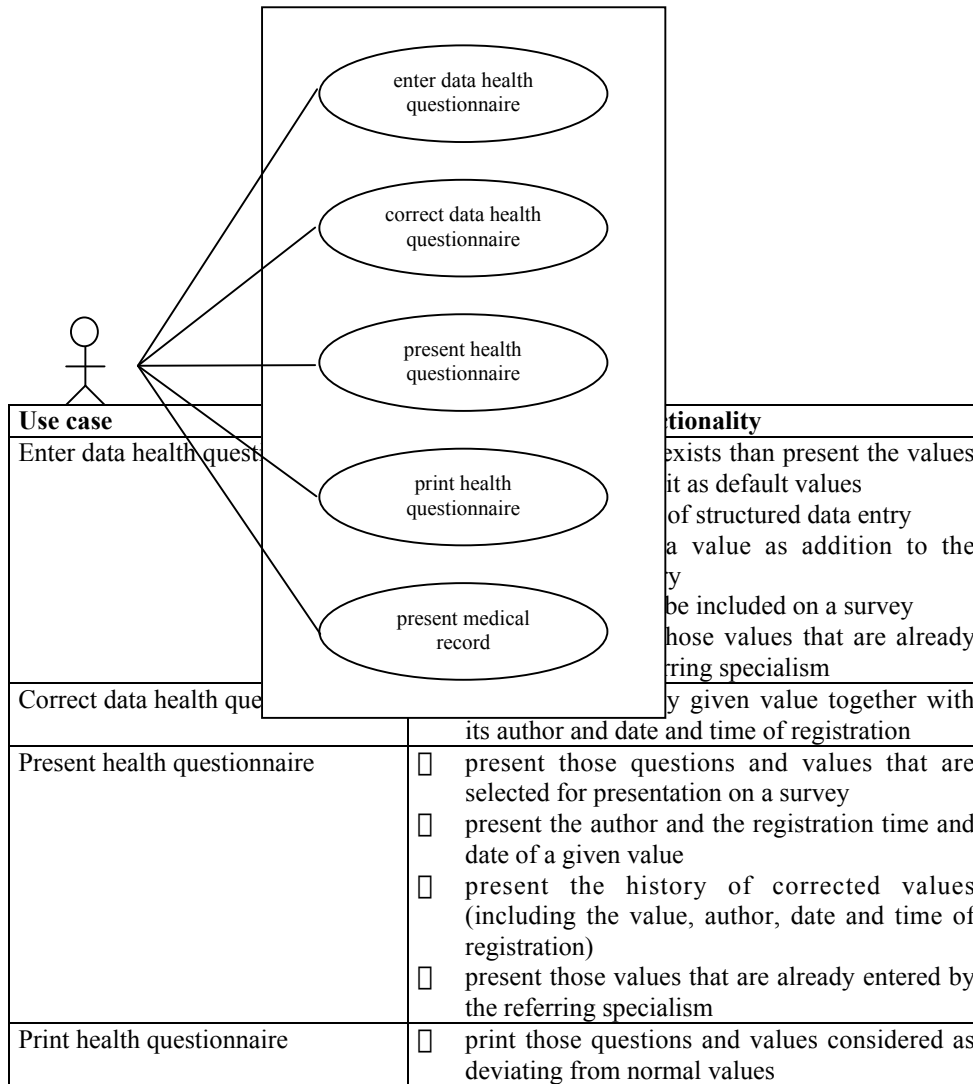


Figure 4: Use case diagram and description for transaction take anamnesis (T4).