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Aligning ERP systems with companies' real needs: an “Operational Model Based” method

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Abstract: Enterprise Resource Planning (ERP) systems offer standard functionalities that have to be configured and customized by a specific company depending on its own requirements. A consistent alignment is therefore an essential success factor of ERP projects. To manage this alignment an “Operational Model Based” method is proposed based on the design and the matching of models, and which conforms to the modelling views and constructs of the ISO 19439 and 19440 enterprise-modelling standards. It is characterised by: (i) a pre-defined design and matching order of the models; (ii) the formalization, in terms of modelling constructs, of alignment and misalignment situations; and (iii) their association with a set of decisions in order to mitigate the misalignment risk. Thus, a comprehensive understanding of the alignment management during ERP projects is given. Unlike existing methods, this one includes decisions related to the organizational changes an ERP system can induce, as well as criteria on which the best decision can be based. In this way, it provides effective support and guidance to companies implementing ERP systems, as the alignment process is detailed and structured. The method is applied on the ERP project of a Small and Medium Enterprise, showing that it can be used even in contexts where the ERP project expertise level is low.

Keywords: ERP project, alignment, model based engineering, enterprise modelling

1. Introduction

In the current context of fierce competition, manufacturing companies' Information Systems (IS) are increasingly based on "off-the shelf" products such as ERP - Enterprise Resource Planning systems (Beheshti and Beheshti 2010). These products enable firms to reduce the transaction costs of business and earnings management, and to improve productivity, customer satisfaction and profitability (Vipola 2008, Beheshti and Beheshti 2010, Tsai et al. 2012). The ERP market is constantly growing in the software industry. A report by Aptean (Aptean 2012) projected growth of the global ERP market to reach the 25 billion dollar range by 2012. However, the implementation of such software presents a high rate of failure (Gajic et al. 2012, Zeng and Skibniewski 2012). According to the 2012 ERP report of the Panorama Consulting Group (Panorama Consulting Group 2012), 56 % of ERP projects took longer than expected; 54% exceeded the budget and 44% achieved less than 50% of the expected profits. According to (Zhou, Collier D.A. and Wilson 2008, Millet, Schmitt and Botta-Genoulaz 2009, Sumner 2009), one the main reasons for failure lies in the inability to achieve a "fit" between the company's real needs and the ERP standard functionalities. In this case, these functionalities do not meet the requirements, and misalignment occurs during the ERP system's use.

As a result, alignment management, and particularly its construction during the ERP project, is an essential factor of the project's success. Alignment management takes place during the ERP deployment and particularly in the adequacy stage, once the ERP system has already been selected. Constructing alignment consists in configuring and, if necessary, customizing the ERP system. This task is either performed from scratch, leading to poor alignment management, or else is supported by model-based engineering methods. The latter ensure the formalisation of potential alignments and misalignments through the design and matching of the AS-WISHED and MIGHT-BE models, and the construction of the TO-BE model through decision-making. The AS-WISHED model represents the business processes that the company wishes to implement inside the ERP system, the MIGHT-BE model refers to the underlying standard business processes of the ERP system, and the TO-BE model corresponds to the business processes as they will effectively be implemented within the ERP system.

An alignment situation is identified when a construct of the AS-WISHED model exists as well in the MIGHT-BE model. In this case, the ERP functionalities satisfy the company's needs. The TO-BE model corresponds to both matched models and the ERP system can be configured accordingly. A misalignment situation is identified when a construct of the AS-WISHED model does not exist in the MIGHT-BE model. In this case, the ERP system does not meet the requirements. There are two alternatives to achieve alignment: (i) the TO-BE model is defined according to the AS-WISHED model, meaning that the company sticks to its requirements by customizing the ERP system; and (ii) the TO-BE model is defined according to the MIGHT-BE model, meaning that the company adapts itself to the ERP system that is configured.

In this paper an "Operational Model-Based" method is given. This is an extension of the decision algorithm proposed in (Mamoghli, Goepp and Botta-Genoulaz 2011), to ensure the construction of alignment. It is based on the traditional activities of modelling, matching and decision-making that are proposed in existing engineering model-based methods. However, since these methods do not fully explain how to execute these three traditional activities, operational means to improve it are proposed. The proposed method is characterised by a predefined modelling and matching order of the AS-WISHED and MIGHT-BE models, conforming to the ISO 19439 and 19940 enterprise modelling standards (ISO/DIS 19440 2004, ISO 19439 2006). In this way, the alignment and misalignment situations are formalized in terms of modelling constructs. Then, on the basis of evaluation criteria, a set of decisions is associated with these situations, in order to progressively design the TO-BE model. This association of decisions takes into account the potential difficulties related to organisational issues described in (Vipola 2008, Escobar-Rodriguez, Escobar-Pérez and Monge-Lozano 2012).

The paper is structured as follows. Section 2 aims at highlighting and analysing the traditional activities provided in the literature in order to construct the alignment. Section 3 presents the “Operational Model Based” method. Then, in Section 4, the method is applied to the ERP project of a SME. Finally, Section 5 concludes and proposes some research perspectives.

2. Related works

In this section, the main activities that allow for alignment to be achieved are, first, identified in the literature. Then, the difficulties linked to the implementation of these activities are highlighted.

2.1 Overview of related works

According to the model-based engineering methods (Prakash and Rolland 2001, Soffer, Golany and Dori 2003, Darras 2004, Zoukar 2005, Wu, Shin and Heng 2007, Millet, Schmitt and Botta-Genoulaz 2009, Tserng et al. 2010, Mamoghli, Goepp and Botta-Genoulaz 2011), alignment is traditionally achieved through three main activities.

- First, for each functional domain of the company, the AS-WISHED and MIGHT-BE models are designed. To identify the specific modelling views that the methods deal with, the ISO 10439 standard on enterprise modelling (ISO 19439 2006) and the requirement engineering works of (Dardenne, Van Lamsweerde and Fickas 1993, Engelsman et al. 2010, Niu, Jin and Cheng 2011) are used. A modelling view is “a selective perception or representation of an enterprise model that emphasizes some particular aspects and disregards others” (ISO 19439 2006). The modelling views considered depend on the method. All methods take at least the functional view into account. This view allows the representation of the enterprise process, activity and object view constructs. This last construct corresponds to the input/output (I/O) attributes involved in the activities at time T (ISO/DIS 19440 2004). The object views construct is not modelled in any of the studied methods. The enterprise process and activity constructs are modelled in various ways: activities and processes in (Darras 2004, Wu, Shin and Heng 2007, Tserng et al. 2010), strategies in (Prakash and Rolland 2001, Zoukar 2005) or sub-processes and options in (Soffer, Golany and Dori 2005). Additionally, apart from the method proposed in (Darras 2004), other methods consider either the intentional (Prakash and Rolland 2001, Zoukar 2005) or the informational view (Soffer, Golany and Dori 2005, Millet, Schmitt and Botta-Genoulaz 2009, Tserng et al. 2010). The intentional view allows for the representation of the functional goal construct. It “underlies services that the system is expected to deliver” (Van Lamsweerde 2001). The informational view allows for the representation of the “enterprise object” modelling construct. When several views are considered in the quoted methods, they are modelled simultaneously. For example in (Mamoghli, Goepp and Botta-Genoulaz 2011), the modelling activity is not treated explicitly. We assume that the goals (intentional view), strategies (functional view) and data formats (informational view) of the AS-WISHED and MIGHT-BE models are modelled simultaneously before the matching activity (see Figure 1 representing the macroscopic alignment process proposed in (Mamoghli, Goepp and Botta-Genoulaz 2011)).
- The models are then matched in order to identify the alignment and misalignment situations. This matching consists of verifying if the constructs of one of the models exist in the other model. For example, if an activity exists in the AS-WISHED and not the MIGHT-BE model, it corresponds to a misalignment situation. Traditionally, the matching is done visually. In the methods proposed in (Soffer, Golany and Dori 2005, Zoukar 2005, Millet, Schmitt and Botta-Genoulaz 2009), alignment degrees between the models and the models’ constructs are computed. For example, if the AS-WISHED and MIGHT-BE models have seven out of ten activities in common; they are aligned at seventy per cent. In (Mamoghli, Goepp and Botta-Genoulaz 2011), for instance, the matching process is divided into three sub-processes, that are executed sequentially. The first one concerns the matching of the equivalent processes that

the company would like to have. First the goals are matched. Then, for the processes that have equivalent goals in the AS-WISHED and MIGHT-BE models, the strategies are matched. The second sub-process concerns the matching of the processes discovered in the MIGHT-BE model. The third sub-process concerns the matching of the data formats of the processes that the company would like to implement (see Figure 1).

- Finally, a decision is associated with each alignment and misalignment situation in order to design the TO-BE model. An aligned construct (that exists in both models) is always added to the TO-BE model and the ERP “configuration” decision is recommended. A misaligned construct (existing only in the AS-WISHED model) may be added to the TO-BE model or not. If it is added, it corresponds to the decision of “specific development inside the ERP system”. Otherwise, it is a “manual support” of the construct. Finally, a construct absent from the AS-WISHED model and discovered by the company in the MIGHT-BE model can be added in the TO-BE model if considered to be interesting. For example, in (Mamoghli, Goepp and Botta-Genoulaz 2011) four decisions are possible: the ERP system configuration, the ERP system adaptation, the addition of an applicative component, and the manual supported process. The authors link these decisions to eight situations of alignment and misalignment (S1 to S8, see Figure 1). Four situations are related to processes that the company would like to have, that is, present in the AS-WISHED model: one situation is related to discovered processes, that is, present in the MIGHT-BE model and not in the AS-WISHED one; and three situations are related to the informational view. For example, the situation S4 concerns goals of a given AS-WISHED process that have no equivalence in the MIGHT-BE model. In this case, the company can either adapt the ERP system, or add an applicative component, or else support the process manually. The choice between these decisions is not guided. The situation S5 concerns MIGHT-BE strategies discovered that are in the company's interests. In that case, the ERP configuration has to be applied.

2.2 Analysis of the modelling activity

Concerning the modelling activity, its implementation requires to define what is wished to model (modelling constructs, model refinement), in which form (modelling formalism) and how (modelling processes).

The goals, enterprise processes and activity constructs of the intentional and functional views are well formalized. This is not the case of the object view construct of the functional view and the enterprise object construct of the informational view. Indeed, in (Wu, Shin and Heng 2007) and (Mamoghli, Goepp and Botta-Genoulaz 2011), the format of the object view attributes have to be modelled. This is difficult without having modelled the corresponding object views. Besides, the methods consider the “enterprise object” without detailing it through its corresponding attributes. Furthermore, the way to take into account the model refinement required to define the granularity of activity modelling is only suggested. As a result, no rule is proposed to define the level of granularity required to design the AS-WISHED and MIGHT-BE models. There is therefore a risk of matching a couple of models that do not represent the same level of detail.

As the modelling is supported by the use of well-developed formalisms (MAP, UML, OPM etc.), the choice of the form represents no particular difficulty.

Finally, the modelling processes are not really guided. The views of the AS-WISHED and MIGHT-BE models are traditionally modelled simultaneously. This way of modelling implies a waste of time. Only in the (Wu, Shin and Heng 2007) method, there is a predefined order of modelling proposed, but with some inconsistencies. In (Wu, Shin and Heng 2007) the intentional view is first modelled and then the functional and informational views are designed simultaneously.

2.3 Analysis of the matching activity

The modelling itself requires tools to match the models, and a process to guide the matching and to formalize alignment and misalignment situations precisely.

The similarity tools proposed in quoted methods and used to support the matching activity are well developed and guided.

The matching processes remain coarse. Apart from the one proposed in (Mamoghli, Goepp and Botta-Genoulaz 2011), all the methods propose to match the modelling views and constructs simultaneously, without any order. In this way, this activity is not structured at all. For example, in the method of (Soffer, Golany and Dori 2005), each model construct is matched to all the constructs of the other model. The activity of matching is consequently time consuming. Furthermore, no guideline is provided for choosing or giving priority in the matching order of the business processes. As a result, the alignment construction is not very efficient. Finally, the alignment and misalignment situations are seldom formalized. These situations remain too coarse and fuzzy. In general, they are not detailed in terms of goals, enterprise processes, activities, attributes of the object views or either formats of the attributes. For example, in (Mamoghli, Goepp and Botta-Genoulaz 2011) the situations of the discovered and desired for processes are not detailed in terms of goals and strategies. Because of this lack of formalization, not all the misalignment situations are clearly identified. This increases the likelihood of misalignment occurring.

---- Insert Figure 1 here ----

2.4 Analysis of the decision-making activity

We analyse the difficulties linked to decision-making in terms of situation / decision associations and guidance to the right decision.

First, the proposed associations are traditionally basic. The situations are not formalized enough and the methods exploit only a part of the potential decisions (see Table 1) described in (Davenport 1998, Scott and Kaindl 2000, Soh, Kien and Tay-yap 2000, Brehm, Heinzl and Markus 2001). Furthermore, the methods do not distinguish the decision-making in each modelling view. This lack of distinction leads to inconsistencies: for example, manually executing an enterprise object makes no sense. The “manual support” of an enterprise object has to be applied to an activity or a process associated with its enterprise object (I/O), rather than to enterprise objects.

Second, since no evaluation criteria are proposed, it remains difficult to make the right decision in the case of several possibilities for one situation. Only the (Soffer, Golany and Dori 2005) method introduces the notion of the TO-BE model consistency, which is evaluated with a logic reasoning algorithm. This consistency could also be evaluated on the basis of the process interdependencies.

3. A new “Operational Model Based” method for ERP alignment

In light of the above difficulties experienced in executing the three traditional activities required to ensure alignment, an “Operational Model Based” method, based on existing methods and completed by operational means, is proposed.

3.1 Overview of the method

The “Model-Based – ERP Alignment” method is a “classical” AS-WISHED and MIGHT-BE model alignment process, dedicated to work out the TO-BE model for each functional domain of the ERP system one after the other. It conforms to the dimensions of the ISO 19439 standard enterprise-modelling cube:

- Firstly, the functional and informational views comply with their definition in (ISO 19439 2006) and with the related modelling constructs defined in (ISO/DIS 19440 2004).
- Secondly, each model-matching activity involves a particular model - AS-WISHED - and a partial one - MIGHT-BE.
- Thirdly, the alignment process enables us to carry out the requirements definition and design specification phases of the ISO 19439 model life cycle. Figure 2 represents the macroscopic alignment process proposed.

---- Insert Figure 2 here ----

Contrary to existing methods, it recommends a predefined order (model, match and make decision) to deal with each modelling view: intentional, functional and informational. The handling of a given modelling view can thus benefit from the one(s) previously treated. This enables us to effectively guide the expert through a structured alignment process and to improve its consistency:

- Beginning with the intentional view allows for an overview of the remaining alignment process, which can thus be managed effectively. Since one goal is associated to one business process in the functional view, this allows for quick identification, at the beginning of the alignment process, of the most critical business processes from the misalignment point of view. More precisely, the matched goals are classified according to the following three situations quoted in their order of criticality: the goals that the company would like to meet but which are unmet in the ERP system; the equivalent goals; and the goals discovered by the company in the ERP system. Based on this classification, the company is able to organise the alignment process by choosing the order of the business processes it wants to treat through the functional view. The unmet goals are considered first. Then, for the equivalent goals, the company has the following options: verifying, through the functional view, if the way it wants to reach these goals is satisfied by the ERP system; or deciding to follow the ERP system configuration, without modelling and matching the other views. Finally, the functional view treatment of the business processes associated to the discovered goals is optional. These business processes represent additional functionalities.
- The functional view is the core of the enterprise modelling and is the way that stakeholders intuitively express their wishes. The efficiency and consistency of the treatment of this view is itself improved through the following two recommendations. First, the possibility to choose the most appropriate level of granularity of the activities is allowed, if the recommended higher one is not sufficient. Second, once the design of the AS-WISHED model is complete, the interdependent activities are tagged. They are thus highlighted so that they can be considered during the decision-making process, to ensure consistency.
- The informational view focuses on the features of the inputs/outputs designed in the functional view. Therefore, the treatment of this view after the functional one is proposed. This modelling view is particularly useful when the company wishes to keep specific data features. In this case, the expert must check if the ERP system corresponds to those features.

The main actors involved in these activities are the key-users that are able to formulate the needs of the company, the vendor, and eventually external consultants that support the key-users. Each of the three main activities guide is, furthermore, proposed. More precisely:

- Concerning the modelling activity, Table 2 sums up the formalisms used to represent each modelling view. The design of the AS-WISHED and MIGHT-BE models is based respectively on the knowledge of the software consultant and/or vendors and of the enterprise members.
- Concerning the matching activity, the alignment and misalignment situations are formalized in terms of aligned and misaligned modelling constructs for each modelling view. Beginning the matching process with the most critical business processes is recommended. They correspond to the ones that have the highest risk of being misaligned. The model matching is

done visually. A construct is either aligned or not. No alignment degrees are considered. This judgement is based on the expert opinion. The potential risk of misunderstanding between the method's users is reduced by the working out of the AS-WISHED and MIGHT-BE models. Indeed, formalizing the business processes that the company wishes and the standard business processes through models help the actors understand each other. Otherwise, expressing those business processes orally or textually is riskier in that it makes the communication more difficult. To reduce even more this misunderstanding risk, an ontology can be designed for each functional domain. Methods to create ontologies, like the one proposed in (Noy and McGuinness 2001), exist and can be applied.

- Concerning the decision-making activity, a set of criteria and decisions is associated with each situation in order to design the TO-BE model progressively. Six decisions and four criteria are proposed, as described respectively in Table 1 and Table 3. The four first decisions (D1 to D4), for which the most appropriate denomination has been chosen, borrow from the literature. On this basis, decision variants are also defined. The last two decisions (D5 and D6), to “give up” and “change management support” are additional. The last one (D6) is taken in conjunction with the five other decisions (D1 to D5). This decision is linked to the fact that implementing an ERP system leads to changes in the enterprise business environment (new activities, new workflows, new screens and so on). Those changes can impact the way the end-users work. We posit that the company, while designing its AS-WISHED model, has planned the change management required to manage this impact. However, the decisions made during the alignment process can imply an adjustment to the change management initially forecast. That is why this pre-defined change management has to be completed and/or updated when the TO-BE model differs from the AS-WISHED model. The D6 decision can consist in organizing new training sessions on new concepts, on writing the documentation concerning new components or new interfaces, or on managing the impact of new roles. In the worst case, the analysis of the proposed criteria can prompt the company to review the ERP system chosen. This is usually the case when the unmet needs that the company absolutely wants to satisfy involve high costs.

---- Insert Table 1 here ----

---- Insert Table 2 here ----

---- Insert Table 3 here ----

In the following sections the activities of modelling, matching and decision-making are detailed, for each modelling view. An example for each modelling view is also given.

3.2 Intentional view

The **modelling** of the intentional view of the AS-WISHED and MIGHT-BE models concerns the functional goal construct. These models are represented through the KAOS language goal model (Dardenne, Van Lamsweerde and Fickas 1993). This language is chosen because it is: (i) intuitive, (ii) expressive, (iii) allows a semi-formal representation of goals, and (iv) enables one to easily make the link with the enterprise activity construct of the functional view.

For the intentional view, the AS-WISHED and MIGHT-BE model **matching** consists in verifying whether the goals modelled in the AS-WISHED model are also modelled in the MIGHT-BE one and inversely. Matching all the goals and then classifying them according to the following situations is recommended:

- Unmet goals: the goal exists only in the AS-WISHED model.
- Equivalent goals: the goals exist in both the AS-WISHED and the MIGHT-BE models.
- Discovered goals: the goal exists only in the MIGHT-BE model.

The **decision-making** is done goal by goal in each group of situations. In this way, the intentional TO-BE model with the chosen goals of each group is designed progressively. The equivalent goals are added in the intentional TO-BE, as are the discovered ones, if the company is interested. Finally, concerning the unmet goals, based on the cost and interest criteria, either they are added in the intentional TO-BE model or the “giving up” decision D5 is taken. In this case, the goal is not added to the intentional TO-BE model. The “change management supplement” decision D6 has to be taken in conjunction with D5.

The example illustrates the case of a module, which can be used to treat a customer's appointment request. The corresponding intentional AS-WISHED and MIGHT-BE models are represented in Figure 3. The matching of these two models allows for the identification of two equivalent goals - “Achieve Appointment scheduled” and “Achieve Response provided” - and one unmet goal - “Maintain appointment”. The equivalent goals are both added to the intentional TO-BE model (see Figure 3). We consider that the company values as reasonable the “cost” of the implementation of the business process associated with the unmet goal. Moreover, this business process seems “interesting”, as automatically maintaining a customer's appointment in case of unforeseen events (like the absence of a person in charge of the appointment) could be a way to satisfy them. This goal is also added to the intentional TO-BE (see Figure 3).

---- Insert Figure 3 here ----

3.3 Functional view

The **modelling** of the functional view of the AS-WISHED and MIGHT-BE models concerns the “enterprise activity” construct and the “object view” construct with its attributes. The processes modelled are related to the goals modelled in the intentional TO-BE model. The UML activity diagram and object flows are used to model respectively the enterprise activities and the object views. Other formalisms - like EPC (Event-driven Process Chain, (Aris Community 2014) or BPMN (Business Process Model and Notation, (OMG 2014)) - that support the representation of the two functional modelling constructs could also be used, depending on the modelling habits of the method's users. UML has been chosen because: (i) it is intuitive, (ii) it is expressive enough for the purpose of the method, (iii) and contrary to EPC or BPMN, it can also be used for the informational view, enabling to use one sole formalism. The functional AS-WISHED model related to a discovered goal designed in the intentional TO-BE does not exist. In this case, only the functional view of the MIGHT-BE model is designed. The same logic is applied to the unmet goals modelled in the intentional TO-BE. The corresponding processes are modelled for the functional AS-WISHED model only.

The **modelling** of the functional view is supported by the definition of granularity levels which enable us to model enterprise activities at different levels of detail. The higher granularity level is recommended to design the process models. It allows us to obtain sequences of activities that are easier to match. It is also suited to activity modelling for which the code source is closed. The lower level of granularity corresponds to the concept of “atomic activity” based on the UML notion of “action” (OMG 2011). An “atomic activity” has either no input, or one input attribute that does not influence the output, or two input attributes to which an elementary action is applied. Atomic activities can be aggregated into higher levels of activity:

- *Atomic activity sequences*: each of them has one attribute as output corresponding to the data entered. The higher level corresponds to data input activities without input and with several output attributes.
- *Atomic activities linked by “decision node(s)”*: this aggregation is based on the “decision node” notion of UML (OMG 2011). Each of those activities has one output attribute with one possible value. This value depends on a combination of the input attribute values. The higher level corresponds to activities with several attributes as input. The combination of their values influences the value of the output attribute.
- *Atomic activities linked by “join node(s)”*: this aggregation is based on the “join node” notion of UML (OMG 2011). Each of them has two input attributes that are computed to obtain the output attribute value. The higher level corresponds to activities with several attributes as inputs that are computed to obtain the output attribute value.

Once the AS-WISHED and MIGHT-BE models have been designed for a functional domain, The tag of the interdependent activities of the AS-WISHED models is proposed, in order to consider them during decision-making. This makes it possible to maintain the consistency of the TO-BE model under construction. Business process activities can be interdependent with the object view construct or the event construct (Malone and Crowston 1993, Attie et al. 1996, Chapron et al. 2008). First, the attributes of the object views in the output of one activity can be the input of another activity. Second, the execution of an activity can generate an event leading to the execution of another activity. From this point of view, the TO-BE model can become inconsistent when a shared construct is modelled differently for two interdependent business processes.

The **matching** of the AS-WISHED and MIGHT-BE models is represented in Figures 4, 5, 6, 7, 8, 9 and 10. Dealing first with the processes that generate interdependencies is recommended. They are the ones that have the most tagged activity, and in the following order of situations:

- first those associated with the unmet goals (see Figure 4) of the intentional TO-BE,
- then those associated with the equivalent ones (Figure 5, 6, 7, 8, 9),
- and finally those associated with the discovered ones (Figure 10).

Matching on after another the activities of the processes associated with the equivalent is proposed in order to make their matching easier. Then, the inputs (I) and outputs (O) of equivalent activities (activities existing in each model matched) are all matched and classified according to the following three situations:

- Equivalent I or O (I and O that exist in both the AS-WISHED and the MIGHT-BE models),
- Unmet I or O (I and O that exist only in the AS-WISHED model),
- Discovered I or O (I and O that exist only in the MIGHT-BE model).

The **decision-making**, which is also represented in Figures 4, 5, 6, 7, 8, 9 and 10, is done situation by situation in each group of situations. For each instance of decision-making, the criteria that must be evaluated are highlighted in the figures. If the granularity level is not sufficient to make a decision, the matched activities can be broken down into a lower level of granularity. When a tagged activity is matched, the consistency criterion must be taken into account. To do so, matching the interdependent processes in parallel is proposed, in order to take the decisions together.

The functional TO-BE model is designed progressively in the following way:

- The D1 (“configuration”), D2 (“specific development inside the ERP system”) and D3 (“addition of an applicative component”) decisions cause the concerned construct to be added into the functional TO-BE model.
- The D6 (“change management supplement”) decision is taken in conjunction with D2, D3, D4 (“manual support”) and D5 (“giving up”) decisions; and with the D1 decision. This is the case when the company configures a construct that is not modelled in its AS-WISHED model.

---- Insert Figure 4 here ----

---- Insert Figure 5 here ----

---- Insert Figure 6 here ----

---- Insert Figure 7 here ----

---- Insert Figure 8 here ----

---- Insert Figure 9 here ----

---- Insert Figure 10 here ----

The functional AS-WISHED and MIGHT-BE models in the previous example (concerning the customer's appointment request case) are represented in Figure 11 and Table 4. The business processes illustrated through those models are both associated with the "Achieve Appointment scheduled" equivalent goal.

The first activity "enter the information concerning the Appointment" is aligned: it exists in both matched models. The attributes of the corresponding output object view "Appointment" are then matched (see Table 4): (i) 5 output attributes are aligned and will be configured (D1 decision); (ii) 2 output attributes are then discovered: "appointmentOffice" and "appointmentDetails". We consider that the company finds them "interesting". Consequently, the activity and the 6 output attributes (aligned and discovered) of the object view "Appointment" are added to the functional TO-BE (see Figure 11).

The second activity "generate automatically the appointment in the schedule" is unmet. We consider that the company decides to manually support this activity because the "cost" of its implementation is too high versus its benefit ("interest" criterion). The activity is thus not added to the functional TO-BE (see Figure 11).

---- Insert Figure 11 here ----

---- Insert Table 4 here ----

3.4 Informational view

The **modelling** of the informational view of the AS-WISHED and MIGHT-BE models concerns the enterprise object construct. The modelling of the attributes' formats of the enterprise objects that have been modelled in the functional TO-BE model is proposed. The UML structural constraints are used to model them. Indeed, traditional modelling business processes languages such as EPC (Event-driven Process Chain) or BPMN (Business Process Model and Notation) formalisms do not allow representing the attributes' format.

The informational MIGHT-BE model exists only for the configured (D1 decision) attributes and for those associated with activities supported by an additional component (D3 decision). In this case, the MIGHT-BE model represents the format that the additional component provides.

The **matching** of the AS-WISHED and MIGHT-BE models is represented in Figure 12. To make the matching easier, the matching of all the formats and the classification of them according to the following three situations is proposed:

- Equivalent format (formats that exist both in the AS-WISHED and MIGHT-BE models and are related to equivalent I or O),
- Unmet format (formats that exist only in the AS-WISHED model and are related to equivalent I or O),
- Format designed only in the AS-WISHED model (formats that exist only in the AS-WISHED model and are related to an unmet I or O).

The **decision-making**, which is also represented in Figure 12, is made situation by situation in each group of situations. The criteria that must be evaluated are highlighted in Figure 12. The informational TO-BE model is designed progressively in the following way:

- Based on the D1 (“configuration”) and D2 (“specific development inside the ERP system”) decisions, the chosen format is built into the informational TO-BE design.
- The D6 (“supplement to a change management”) decision is taken in conjunction with the D1 and D2 decisions but only in the case where a format misalignment is identified. In the first case, communication on the new format must be planned. In the second case, editor documentation must be updated.

---- Insert Figure 12 here ----

In the example concerning the case of a module for treating a customer's appointment request, the case of the “idCustomer” attribute is illustrated. The informational AS-WISHED and MIGHT-BE are represented in Figure 13. The company would like to be able to enter a customer identification number consisting of 20 characters. However, the system only allows a length of 10 characters. In this case, the “interest” criterion takes precedence over the “cost” one. This length allows the company to include in the customer identification number some important information about the customer (part of his/her name, his/her location and so on). An employee using this identification number can thus easily characterise the customer without checking the database. Moreover, this does not disturb the “integration integrity”. In this case, we consider that the company will decide to develop the ERP system specifically to support this format (D2). The informational TO-BE is updated with a length format of 20 characters for the attribute “idCustomer” (see Figure 13).

---- Insert Figure 13 here ----

4. Case study

4.1 Context and methodology

The case study concerns a Small and Medium Enterprise (SME) of 120 persons, specialised in the manufacturing and marketing of height access and personal safety equipment for the building and manufacturing industries. The company decided in 2008 to change its ERP system (see Figure 14); as the as-is system had reached “the end of life”, its maintenance was no longer insured. At the end of 2008, the company selected a new ERP system for which the adequacy stage began in January 2009 and ended in June 2009.

--- Insert Figure 14 here ---

We focus here on the Customer Service module of its new ERP system. Implementing this module was an important issue for the company in order to ensure the safety of the products' users. It was moreover an opportunity to improve its customer relations by adding new services, such as a guarantee contract, customer site interventions, and so on. The "as-is" customer service software was specifically developed. It was not interfaced with the legacy ERP system and consisted of a simple human-computer-screen with few fields like "demand reason", "targeted date" or "complementary information".

We apply the proposed method "afterwards" to the adequacy stage (see Figure 14). This "afterwards" approach consists in identifying the decisions the company took unintentionally during the adequacy meetings, by:

- "redesigning" the "original" AS-WISHED and MIGHT-BE models thanks to: (i) documents initially used during the adequacy phase; (ii) handling of the ERP system and (iii) interviews with the concerned actors (CEO, Customer Service's head, systems integrator), who validate both models;
- "redesigning" two versions of the TO-BE models: (i) the Vintegrator version based on an adequacy study provided by the integrator, (ii) the Venterprise version based on another adequacy document provided by the company;
- monitoring the proposed alignment process to match the AS-WISHED and MIGHT-BE models and progressively design a TO-BE model corresponding to the real decisions that have been made.

The gaps existing between the $V_{integrator}$ and $V_{enterprise}$ TO-BE models completed by interviews with the stakeholders allow us to point out decisions unintentionally taken. The alternative decisions that we recommended are also highlighted.

This approach was an opportunity for the company to analyse the way it constructed the alignment during the adequacy stage. Since the integration stage had not yet begun at the time, the company took advantage of the proposed alternative decisions. The approach also highlights the various change supplements to apply in order to manage the real decisions taken.

4.2 Implementation of the method

The following two sections present the main results of the method implementation on both intentional and functional views.

4.2.1 Intentional view

The **modelling** of the intentional view enables us to identify 15 goals for the AS-WISHED model (see first column of Table 5 and Table 6 and see Figure 15) and 17 goals for the MIGHT-BE model (see second column of Table 5 and Table 6 and see Figure 16). To build these models, the KAOS modelling techniques are applied. They distinguish goals achievable by a business process (sequence of activities) and parent goals that can be refined through "decomposition" or "why" refinements. For example, for the AS-WISHED model, six goals are identified: five achievable by a business process, and one parent goal. The parent goal is refined using a KAOS pattern (see Figure 17) that has been instantiated to this case study. This pattern is chosen because it refined a goal related to the satisfaction of a request, which, in this case study, was the service demand. The parent goals of the pattern were then refined until goals were obtained that could no longer be refined and that were achievable by a business process. For example, "Achieve Customer Agreement achieved" was refined by the "Why?" refinement into the "sub-goal" "Achieve Responsibility identified".

Among the goals of the AS-WISHED and MIGHT-BE models there are:

- Nine alignment situations corresponding to the presence of the goals in both the AS-WISHED and the MIGHT-BE models (see Table 5).
- Fourteen misalignment situations:

- 6 unmet goals present only in the AS-WISHED model (see Table 6),
- 8 discovered goals present only in the MIGHT-BE model (see Table 7).

---- Insert Table 5 here ----

---- Insert Table 6 here ----

---- Insert Table 7 here ----

---- Insert Figure 15 here ----

---- Insert Figure 16 here ----

---- Insert Figure 17 here ----

For all the 17 aligned and discovered goals, the company would be advised to analyse the “interest” criterion. The company would be able to analyse the extent of the improvement it wanted to apply to the Customer Service module. The company would be advised to analyse both the “cost” and “interest” criteria for the 6 unmet goals.

As the company has not modelled the intentional view, the 23 goals are added in the intentional TO-BE model so that a detailed study can be made of the decisions taken on the functional view.

4.2.2 Functional view

We respect the higher level of granularity for the **modelling** of the functional view of:

- the AS-WISHED model associated with the 9 equivalent and 6 unmet goals of the intentional TO-BE model and
- the MIGHT-BE model associated with the 9 equivalent and 8 discovered goals of the intentional TO-BE model.

For example (see Figure 18 and Table 8), this is the case of the activity “enter the information concerning the expert’s report” (associated with the “Achieve Responsibility identified” goal). Its output attributes and possible values are: (i) “idReport”, (ii) “wearType” (“abnormal wear”, “use wear”), (iii) “responsible” (“under guarantee”, “billable”) and (iv) “compInfo”. This activity can be broken down into the following sequence of data entry activities: (i) “enter the wear type”, (ii) “enter the responsibility”, and (iii) “enter complementary information”. Each of these activities has one attribute as output. The first and third activities are atomic. The “enter the responsibility” activity can be broken down further into two atomic activities linked by a “decision node” (see Figure 19 and Table 9). The value of the “responsible” output attribute (“under guarantee” or “billable”) depends on the value of the “wearType” input attribute. If it is an “abnormal wear”, the “responsible” attribute takes the “billable” value.

---- Insert Figure 18 here ----

---- Insert Table 8 here ----

---- Insert Figure 19 here ----

---- Insert Table 9 here ----

The AS-WISHED and MIGHT-BE models obtained for each business process are simplified because of the use of: (i) the higher level of granularity and (ii) the intentional view allowing the functional view treatment of each business process in a separate model. These principles improve the matching efficiency. If they are not applied, the business process models obtained are more complex and their matching is more time-consuming and difficult. Equivalent, discovered and unmet processes are not highlighted. This complexity is illustrated through the Figures A-1 and A-2 of the Appendix (see Section 8). They represent respectively the business process sequences associated to the AS-WISHED and MIGHT-BE goals that refine the parent goal “Achieve Demand Satisfied”.

All the interdependent activities are tagged in grey. This is the case of the “enter the information concerning the expert’s report” activity (see Figure 20). Its output attribute “responsible” is also the input attribute of the “create an estimate of costs” (associated with the “Achieve Customer agreement reached” goal). In fact, if the customer is not responsible, the cost estimate is not necessary.

---- Insert Figure 20 here ----

Concerning the functional view matching, the tables 10, 11 and 12 detail the method implementation on the business processes associated to the unmet, equivalent and discovered goals. These tables highlight: (i) the decisions made by the company and the corresponding functional TO-BE building, (ii) the “change management supplement” the company would be advised to set up; and (iii) the criteria and decisions the company would be advised to follow.

---- Insert Table 10 here ----

---- Insert Table 11 here ----

---- Insert Table 12 here ----

We present here the first matched process. It is the process associated with the “Achieve Responsibility identified” goal because it is linked to an unmet goal that generates interdependencies.

This process is present neither in the $V_{\text{integrator}}$ nor in the $V_{\text{enterprise}}$ TO-BE model. It has unintentionally been supported manually (D4). In fact, this need was not formulated during the adequacy meetings in 2009. Therefore, it is not modelled in the TO-BE model that has been designed progressively. The manual on the expertise identification can lead to errors. A “change management supplement” (D6) is, therefore, recommended in order to formalize the corresponding manual procedure and avoid errors.

To satisfy this process, a “specific development inside the ERP system” (D2 decision) could have been decided. This would consist in adding the “type” attribute to the “Intervention” object view to generate an “analysing” intervention and not a “solving” one. The “cost” criterion associated to this development could have been evaluated and compared with the “interest” one: the addition of an attribute to an object view would not imply a high cost, and in return this addition would improve the consistency and the efficiency of the expertise identification. The D2 decision could also be associated to the updating of the editor documentation (D6 decision).

If the company “gave up” (D5 decision) this unmet business process, the evaluation of the “TO-BE model construction consistency” criterion would obviously be recommended. If this process is not supported, not even manually, it will adversely affect the consistency of the TO-BE model under construction, due to the interdependencies. The “create an estimate of costs” activity (see Figure 20) can be achieved only if the responsibility is identified. This identification, through the “enter the information concerning the expert’s report” activity, has to be done automatically or at least manually. Otherwise it reduces the consistency of this activity. Thus, giving up the responsibility identification without simultaneously taking into account the two interdependent processes would cause the TO-BE model design to be inconsistent, as the “create an estimate of costs” activity requires the expert’s identification.

4.2.3 Informational view

Among the 158 I/O attributes of the enterprise objects modelled in the functional TO-BE:

- The following four attributes were specifically developed inside the ERP system (D2 decision): “NeedCustomerService” of the enterprise objects “PurchaseOrder” and “Purchase”, and “InterventionPeriodicity” of the enterprise object “ServiceContract” and “GuaranteeContract”. Thus, there were no informational MIGHT-BE and AS-WISHED dedicated to the format of these attributes. The specific development of these attributes inside the ERP system (D2 decision) implied the creation of their format: “Boolean” for the former and “Integer” for the latter.
- Concerning the 154 other attributes, the company formulated no specific needs. It accepted the format set by the ERP system for both the discovered and the aligned attributes. This situation is linked to the fact that the “as-is” Customer Service of the company was not developed enough. Hence, the data formats concerning this module were not specific to the company or even normalized. The company wanted to adapt to the best practices embedded in the ERP system.

4.3 Discussion

Several conclusions can be drawn from the “Operational Model Based” method application. It is efficient to identify in detail the potential misalignment situations that the company did not identify during its adequacy stage. Fifty six per cent of all decisions have been identified as taken unintentionally (see Table 13). The application also highlights the decisions that the company can take afterwards to manage these decisions.

---- Insert Table 13 here ----

More precisely, the six decisions concerning the processes associated with unmet goals have been taken unintentionally. Among them, four are supported manually (D4 decision), one is given up (D5 decision) and one is concerned with a specific development inside the ERP system (D2 decision). Supporting business processes manually can lead to a waste of time or to the risk of executing the business processes in the wrong way and without any traceability. However, to avoid these situations, the D2 decision (“specific development inside the ERP system”) can still be taken. Otherwise, the recommended D6 decision highlights the change complements that must be established in order to avoid mistakes or a waste of time. The update of the software vendor documentation, the writing of manual procedures, and the organization of new training sessions (D6 decision) are recommended.

Concerning the nine processes associated with the equivalent goals, the decision made can be analysed at the activity and attribute levels. Such a detailed analysis is possible because of the fine alignment and misalignment situations the method allows us to formalize. The two unmet activities were given up (D5 decision). There were no discovered activities. Concerning the attributes of the aligned activities:

- Fifteen were unmet: among them 12 were given up (D5 decision) unintentionally, the 3 others were the subject of a specific development inside the ERP system (D2). This decision was intentional for one attribute.
- Forty-three were aligned: these were of course all configured (D1 decision), even if only 27 were configured intentionally.
- Eighty-five were discovered: among these, only one was given up (D5 decision) intentionally, the others were configured (D1 decision). The configuration decision was intentional for 37 attributes. For all these attributes, the D6 decision is recommended to properly manage the changes induced.

Concerning the eight processes associated with the discovered goals, five decisions were made unintentionally: four of them led to the corresponding process being given up (D5 decision) and one was configured (D1 decision). Two others processes associated with discovered goals were configured intentionally. The new ERP system was an opportunity for the company to improve its customer relations. The application of the proposed method at the beginning of the project would make it possible to add more new functionalities than the ones that had effectively been implemented.

5. Conclusion and perspectives

During the adequacy stage of ERP projects, alignment between the processes desired by the company and the ERP system's standard processes must be worked out. In this paper, an "Operational Model Based" method that addresses this problem is proposed.

It follows a "classical" AS-WISHED and MIGHT-BE model alignment process, dedicated to working out the TO-BE model that finely guides the three main activities of modelling, matching and decision-making. Even if the MIGHT BE Model remains difficult to elaborate because it is mainly based on the truthfulness of the ERP vendor or integrator, the proposed method provides a safeguard against the difficulty for the company to understand the ERP vendor or integrator.

The method key principles help increase the alignment process efficiency and decrease its heaviness:

- It recommends a predefined order to deal with the modelling views in accordance with the ISO 19439 standard: intentional view, functional view and, finally, informational view. This order helps in identifying in detail the alignment and misalignment situations. Contrary to existing methods that propose to design all the modelling views simultaneously, the working out of a modelling view benefits from the ones dealt with previously. The results of the intentional view handling - allowing distinguishing business processes associated to unmet, equivalent or discovered goals - are a base to structure the functional view treatment. One can choose the business processes to be treated and their treatment order. The results of the functional view enable to manage the handling of the informational view. Having the implemented attributes list available enables to choose the attributes for which the corresponding format will be modelled and matched through the informational view.
- Furthermore, the method proposes different modelling granularity levels enabling, if necessary, the refinement of the models. The use of these granularity levels principles coupled with use of the intentional view enables the matching of simplified and linear processes, modelled in separate models. Otherwise, the business process models obtained are more complex and their matching is more time-consuming and difficult.

The "Operational Model Based" method also guides finely the association of decisions with alignment/misalignment situations. This takes into account a set of four criteria and six decisions. Among them, the "change management" complementary decision helps a company to tackle the difficulties it can face during the use of the ERP system, like end-users' resistance. Interdependencies between processes are integrated in order to design a consistent TO-BE model.

This “Operational Model Based” method constitutes real progress for alignment problem resolution. It guides researchers in the formalization of the alignment and misalignment situations and in their identification and treatment. Even for the ERP selection, the modelling and matching of the intentional view could be useful to choose the best system between several alternatives.

Apart from its research implications, the method can help a company to efficiently manage the alignment problem. This has been illustrated through the application on a specific module of a small company ERP project. This application highlighted misalignment situations that the company had not identified, even with the support of the system integrators and external consultant during the adequacy stage. In this context, use of the method could even help the company to save money by increasing its internal expertise and limiting external expertise support. Since the integration stage of the company’s ERP project was not over, the application also highlighted the decisions the company could take, at the time, to deal with the identified misalignments. In particular, the D6 additional decision emphasized the complementary change management supplements the company had to lead.

The application of the method to other ERP projects will allow its consolidation and enhance its benefits for companies.

From a research point of view, this method is a first step towards a Model Based– ERP Alignment optimisation method: completing the evaluation criteria with metrics on the basis of the evaluation measures proposed in (Millet, Schmitt and Botta-Genoulaz 2009) and automating the matching and decision-making activities would increase decision-making efficiency. Further research also has to be done in order to improve guidance to design the MIGHT-BE model. This guidance depends on the ERP system chosen: open or closed source. For closed-source ERP, the user has to rely on the knowledge and experience of the software vendors or consultants, whereas for open-source ERP, the processes supported by the system are more accessible (Lee, Olson D.L. and Lee 2009, Olson and Staley 2012).

Once the alignment is achieved, maintaining it over time will be another aspect to research. Companies could make the most of dynamic alignment management tools, using for example the notion of a model co-evolution logic proposed in (Etien 2009), in a rapidly changing context.

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8. Appendix

---- Insert Figure A-1 here ----

---- Insert Figure A-2 here ----

9. Tables

Table 1. Decisions and their variable

Table 2. Formalisms used for each modelling view

Table 3. Criteria

Table 4. I/O of the process associated with “Achieve Appointment Scheduled” goal

Table 5. Equivalent goals for Customer Service module

Table 6. Unmet goals for Customer Service module

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Table 8. I/O of the process associated with “Achieve Responsibility identified” goal at the higher granularity level

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Table 10- Summary of the method implementation on the business processes associated with unmet goals

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Table 13 - Synthesis of the alignment decisions-made for the Customer Service module

10. Figures

Figure 1. Macroscopic alignment process of the method proposed in (Mamoghli, Goepp and Botta-Genoulaz 2011)

Figure 2. Macroscopic alignment process of the “Operational Model Based” method

Figure 3- Intentional view of the AS-WISHED, MIGHT-BE and TO-BE models for the Appointment example

Figure 4. Construction of the TO-BE model of the unmet processes

Figure 5. Overview of the construction of the functional TO-BE model of the equivalent processes

Figure 6- Breakdown management (construction of the functional TO-BE model of the equivalent processes)

Figure 7. Discovered activity management (construction of the functional TO-BE model of the equivalent processes)

Figure 8. Unmet activity management (construction of the functional TO-BE model of the equivalent processes)

Figure 9. Equivalent activity management (construction of the functional TO-BE model of the equivalent processes)

Figure 10. Construction of the functional TO-BE model of the discovered processes

Figure 11- Functional view of the AS-WISHED, MIGHT-BE and TO-BE models of the Appointment example

Figure 12. Construction of the informational TO-BE model

Figure 13- Informational view of the AS-WISHED, MIGHT-BE and TO-BE models of the Appointment example

Figure 14. The ERP project of the company

Figure 15. Intentional view of the AS-WISHED Model

Figure 16. Intentional view of the MIGHT-BE Model

Figure 17. KAOS Pattern refining the goal “Achieve request satisfied”

Figure 18. Functional view associated with “Achieve Responsibility identified” goal at the higher granularity level

Figure 19. Functional view associated with “Achieve Responsibility identified” goal at the lower granularity level

Figure 20. Interdependent processes illustration

Figure A-1. Functional view of the AS-WISHED complex model

Figure A-2. Functional view of the MIGHT-BE complex model

Tables

Decisions (description)	Variants	“Original” decision vocabulary
D1: Configuration (consists in choosing one of the ERP alternatives concerning activities, objects, screens or reports)	/	“ <i>configuration s</i> ” (Davenport 1998), « configuration » (Glass 1998, Brehm, Heinzl and Markus 2001), “ <i>customization</i> ” (Glass 1998), “ <i>screen masks</i> ” (Brehm, Heinzl and Markus 2001), “ <i>Workflow</i> ” (Brehm, Heinzl and Markus 2001)
D2: Specific development inside the ERP system (can concern activities, objects, screens, reports or conditions on those elements; the modification is only feasible for open source code)	Source code modification	“ <i>modifications</i> ” (Glass 1998), “ <i>code modification</i> ” (Davenport 1998), “ <i>core customization to amend the base code</i> ” (Soh, Kien and Tay-yap 2000), “ <i>package code modification</i> ” (Brehm, Heinzl and Markus 2001)
	Code source addition	“ <i>bolting on customized programs</i> ” (Scott and Kaindl 2000), “ <i>programming</i> ” (Brehm, Heinzl and Markus 2001)
D3: Addition of an applicative component (consists in interfacing an additional component with the ERP system; the additional component can provide or not the interface or can be specifically developed)	Interfacing a component with the interface provided	“ <i>extension</i> ” (Glass 1998), “ <i>non-core customization</i> ” (“ <i>interfacing with add-on module</i> ”) (Soh, Kien and Tay-yap 2000), “ <i>standard interface</i> ” (Scott and Kaindl 2000), “ <i>bolt-ons</i> ” (Brehm, Heinzl and Markus 2001)
	Interfacing a component without the interface provided	“ <i>customization</i> ” (Glass 1998), “ <i>use existing system and build interfaces between It and the ES</i> ” (Davenport 1998), “ <i>ERP programming</i> ” (Brehm, Heinzl and Markus 2001)
	Interfacing a specific developed component	“ <i>interface development</i> ” (Brehm, Heinzl and Markus 2001)
D4: Manual support (consists in supporting a need without the intervention of the ERP system (manually, more or less formalized or thanks to an office software): it can concern activities or conditions on activities)	/	“ <i>manual support of the process</i> ” (Soh, Kien and Tay-yap 2000)
D5: Giving up (consists in totally giving up a need)	/	
D6: Change management supplement (see Section 3.1)	/	

Table 1. Decisions and their variables

Modelling views	Description
Intentional view	KAOS goal model
Functional view	For the “enterprise activity” construct : UML activity diagram For the “object view” construct: UML object flows used to represent the state of each “object view” For the attributes of the “object view”: tables which sum up the state of each “object view” and the attributes, with their potential values
Informational view	For the format of the attributes of the enterprise objects : UML structural constraints

Table 2. Formalisms used for each modelling view

Criteria	Description
Cost	The company has to evaluate the cost of a given decision in terms of time, money or resources. In case of a specific development inside the ERP system or applicative component addition, the enterprise has to negotiate with the integrator. Cost evaluation methods, like the one proposed in (Yahia, Aubry and Panetto 2012), dedicated to the IS interoperability, can be used.
Interest	An alternative is interesting for the company if it contributes to its performance. To evaluate the interest of an alternative, business processes performance evaluation methods like ECOGRAI (Ducq and Vallespir 2005) can be used.
Integration integrity	The company must check that the system integrators evaluate the potential disruption of the native ERP integration integrity caused by specific developments inside the ERP system or the addition of new applicative components. Moreover, those developments rarely match with the ERP system upgrades.
TO-BE model construction consistency	The TO-BE model has to be consistent for all the processes considered. If the TO-BE models of two interdependent processes are not worked out simultaneously, the risk exists that the decisions made for these two processes contradict each other. Therefore, the integration of an interdependency analysis into the treatment of the functional view is proposed.

Table 3. Criteria

	Object views	Attributes
AS-WISHED, Output	Appointment entered	idAppointment, idCustomer, responsibleAppointment, dateAppointment, hourAppointment, PostalCodeAppointment
MIGHT-BE, output	Appointment entered	idAppointment, idCustomer, responsibleAppointment, dateAppointment, hourAppointment, PostalCodeAppointment, <u>appointmentOffice, appointmentDetails</u>
TO-BE output	Appointment entered	idAppointment, idCustomer, responsibleAppointment, dateAppointment, hourAppointment, PostalCodeAppointment, <u>appointmentOffice, appointmentDetails</u>

Table 4. I/O of the process associated with “Achieve Appointment Scheduled” goal

AS-WISHED and MIGHT-BE models
“Achieve Guarantee contract created”
“Achieve Service contract created”
“Achieve Demand recorded”
“Achieve Consumption entered”
“Achieve Intervention planned”
“Achieve Intervention closed”
“Achieve Monitoring product created”
“Achieve Invoice sent”
“Achieve Command recorded”

Table 5. Equivalent goals for the Customer Service module

AS-WISHED model
“Achieve Customer Service demand analysed”
“Achieve Quality treated”
“Achieve Customer agreement achieved”
“Maintain Intervention at time”
“Achieve Responsibility identified”
“Achieve Purchase Order sent”

Table 6. Unmet goals for the Customer Service module

MIGHT-BE model
“Achieve Contract cancelled”
“Achieve Contract renewed”
“Achieve Contract closed”
“Achieve Billing contract history service updated”
“Achieve Guarantee demand validated”
“Achieve Solution archived”
“Achieve Demand time stamped”
“Achieve Resources booked”

Table 7. Discovered goals for the Customer Service module

	Object views	Attributes
AS-WISHED, input	ExpertReport	wearType (abnormal wear / use wear)
AS-WISHED, output	ExpertReport entered	<u>idReport</u> , wearType (abnormal wear / responsible), responsible (under guarantee / billable), compInfo

Table 8. I/O of the process associated with “Achieve Responsibility identified” goal at the higher granularity level

	Object views	Attributes
AS-WISHED, output	ExpertReport entered 1	<u>idReport</u> , wearType (abnormal wear / use wear)
AS-WISHED, output	RapportExpertise entered 2	Responsible: billable
AS-WISHED, output	RapportExpertise entered 3	responsible: under guarantee
AS-WISHED, output	RapportExpertise entered 4	compInfo

Table 9. I/O of the process associated with “Achieve Responsibility identified” goal at the lower granularity level

Goal associated	Decisions of the company (in italic and bold face: taken unintentionally)	Add to the functional TO- BE (/ : not added)	(D6) “Change management supplement”	Advised decisions	
				Criteria	Decisions
“Achieve Responsibility identified”	<i>(D4) Manual support</i>	/	Formalize the corresponding manual procedure and avoid errors	Cost, interest and integration	(D2) Specific development inside the ERP system (D6) change management supplement to update the editor documentation
“Achieve Customer agreement reached”	<i>(D4) Manual support</i>	/			
Achieve Customer Service demand analyzed”	<i>(D5) Giving up</i>	/	Face the giving up and correct the eventual inconsistencies		
“Achieve Quality treated”	<i>(D4) Manual support</i>	/	Formalize the corresponding manual procedure and avoid errors		
“Maintain Intervention at time”	<i>(D4) Manual support</i>	/			
“Achieve Purchase Order sent”	<i>(D2) Specific development inside the ERP system</i>	3 activities and 1 attribute	Update the editor documentation	/	/
Total		3 activities + 1 attribute			

Table 10. Summary of the method implementation on the business processes associated with unmet goals

Goal associated	Activities matching	Attributes matching	Decisions of the company (in italic and bold face: taken unintentionally)	Add to the functional TO-BE (/ : not added)	(D6) “Change management supplement”	Advised decisions	
						Criteria	Decisions
Achieve Guarantee contract created”	3 aligned	2 unmet	<i>1 : (D2) Specific development inside the ERP system</i>	1 attribute (+ the 3 activities)	Update the editor documentation	/	/
			<i>1 : (D5) Giving up</i>	/	Face the giving up and correct the eventual inconsistencies	Cost, interest and integration	(D2) and (D6)
		6 aligned	<i>6 : (D1) Configuration</i>	6 attributes	/	/	/
		8 discovered	<i>8 : (D1) Configuration</i>	8 attributes	Training on the new concepts	/	/
“Achieve Service contract created”	3 aligned	1 unmet	<i>1 : (D2) Specific development inside the ERP system</i>	1 attribute (+ the 3 activities)	Update the editor documentation	/	/
		5 aligned	<i>5 : (D1) Configuration</i>	5 attributes	/	/	/
		17 discovered	<i>17 : (D1) Configuration</i>	17 attributes	Training on the new concepts	/	/
“Achieve Demand recorded”	3 aligned	1 unmet	<i>1 : (D5) Giving up</i>	/	Face the giving up and correct the eventual inconsistencies	Cost, interest and integration	(D2) and (D6)
		8 aligned	<i>8 : (D1) Configuration</i>	8 attributes (+ the 3 activities)	/	/	/
		11 discovered	<i>11 : (D1) Configuration</i>	11 attributes	Training on the new concepts	/	/
“Achieve Consumption entered”	2 aligned	5 unmet	<i>5 : (D5) Giving up</i>	/	Face the giving up and correct the eventual inconsistencies	Cost, interest and integration	(D2) and (D6)
		6 aligned	<i>6 : (D1) Configuration</i>	6 attributes (+ the 2 activities)	/	/	/
		6 discovered	<i>1 : (D1) Configuration</i> <i>5 : (D1) Configuration</i>	6 attributes	Training on the new concepts	/	/

Goal associated	Activities matching	Attributes matching	Decisions of the company (in italic and bold face: taken unintentionally)	Add to the functional TO-BE (/ : not added)	(D6) “Change management supplement”	Advised decisions	
“Achieve Intervention planned”	2 unmet activities		2 : (D5) Giving up	/	Face the giving up and correct the eventual inconsistencies	Cost, interest and integration	(D2) and (D6)
	3 aligned	1 unmet	1 : (D5) Giving up	/			
		8 aligned	8 : (D1) Configuration	8 attributes (+ the 3 activities)	/	/	/
		12 discovered	12: (D1) Configuration	12 attributes	(D6) Training on the new concepts	/	/
“Achieve Intervention closed”	3 aligned	2 unmet	2 : (D5) Giving up	/	Face the giving up and correct the eventual inconsistencies	Cost, interest and integration	(D2) and (D6)
		3 aligned	3 : (D1) Configuration	3 attributes (+ the 3 activities)	/	/	/
		10 discovered	9: (D1) Configuration	9 attributes	Training on the new concepts	/	/
			1 : (D5) Giving up	/	/	/	/
“Achieve Monitoring product created”	3 aligned	1 unmet	1 : (D5) Giving up	/	Face the giving up and correct the eventual inconsistencies	Cost, interest and integration	(D2) and (D6)
		5 aligned	5 : (D1) Configuration	5 attributes (+ the 3 activities)	/	/	/
		21 discovered	21 : (D1) Configuration	21 attributes	Training on the new concepts	/	/
“Achieve Invoice sent”	2 aligned	1 unmet	1 : (D5) Giving up	/	Face the giving up and correct the eventual inconsistencies	Cost, interest and integration	(D2) and (D6)
		1 aligned	1: (D1) Configuration	1 attribute (+ the 2 activities)	/	/	/
“Achieve Command recorded”	2 aligned	1 unmet	1 : (D2) Specific development inside the ERP system	1 attribute (+ the 2 activities)	Update the editor documentation	/	/
		1 aligned	1 : (D1) Configuration	1 attribute	/	/	/
Total				24 activities +130 attributes			

Table 11. Summary of the method implementation on the business processes associated with equivalent goals

Goal associated	Decisions of the company (in italic and bold face: taken unintentionally)	Add to the functional TO-BE (/: not added)	(D6) “Change management supplement” for now	Advised decisions	
				Criteria	Decisions
“Achieve Contract cancelled”	<i>(D5) Giving up</i>	/	/	Interest	(D1) Configuration (D6) Training on the new concepts
“Achieve Contract renewed”	<i>(D1) Configuration</i>	1 activity + 1 attribute	(D6) Training on the new concepts	/	/
“Achieve Contract closed”	<i>(D5) Giving up</i>	/	/	Interest	(D1) Configuration (D6) Training on the new concepts
“Achieve Billing contract history service updated”	<i>(D5) Giving up</i>	/	/		
“Achieve Guarantee demand validated”	<i>(D5) Giving up</i>	/	/		
“Achieve Solution archived”	(D1) Configuration	4 activities + 19 attributes	(D6) Training on the new concepts	/	/
“Achieve Demand time stamped”	(D5) Giving up	/	/	Interest	(D1) Configuration (D6) Training on the new concepts
“Achieve Resources booked”	(D1) Configuration	1 activity + 7 attributes	(D6) Training on the new concepts		
Total		6 activities + 27 attributes			

Table 12. Summary of the method implementation on the business processes associated with discovered goals

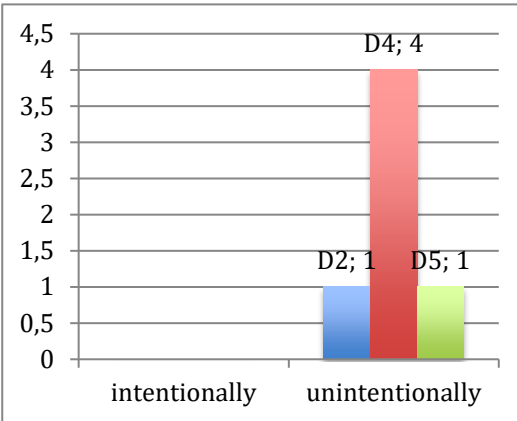
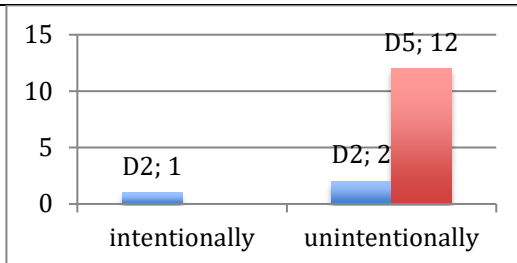
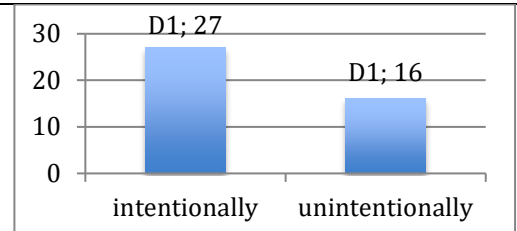
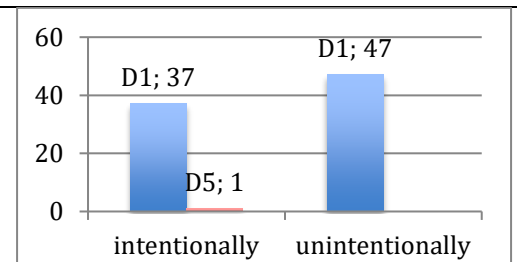
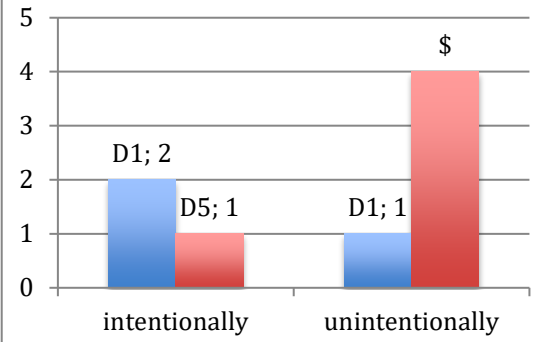
Processes associated with unmet goals	Processes associated with equivalent goals	Processes associated with discovered goals
 <p>Bar chart showing processes associated with unmet goals. The y-axis ranges from 0 to 4.5. The x-axis has two categories: 'intentionally' and 'unintentionally'. There are three bars: a blue bar for 'intentionally' (D2; 1), a red bar for 'unintentionally' (D4; 4), and a green bar for 'unintentionally' (D5; 1).</p>	<p>Aligned activities, unmet attributes</p>  <p>Bar chart showing aligned activities with unmet attributes. The y-axis ranges from 0 to 15. The x-axis has two categories: 'intentionally' and 'unintentionally'. There are two bars: a blue bar for 'intentionally' (D2; 1) and a red bar for 'unintentionally' (D5; 12).</p> <p>Aligned activities, aligned attributes</p>  <p>Bar chart showing aligned activities with aligned attributes. The y-axis ranges from 0 to 30. The x-axis has two categories: 'intentionally' and 'unintentionally'. There are two blue bars: one for 'intentionally' (D1; 27) and one for 'unintentionally' (D1; 16).</p> <p>Alignment activities, discovered attributes</p>  <p>Bar chart showing alignment activities with discovered attributes. The y-axis ranges from 0 to 60. The x-axis has two categories: 'intentionally' and 'unintentionally'. There are two blue bars: one for 'intentionally' (D1; 37) and one for 'unintentionally' (D1; 47). A small red bar is also present for 'intentionally' (D5; 1).</p>	 <p>Bar chart showing processes associated with discovered goals. The y-axis ranges from 0 to 5. The x-axis has two categories: 'intentionally' and 'unintentionally'. There are four bars: a blue bar for 'intentionally' (D1; 2), a red bar for 'intentionally' (D5; 1), a blue bar for 'unintentionally' (D1; 1), and a red bar for 'unintentionally' (D1; 4).</p>

Table 13. Synthesis of the alignment decisions-made for the Customer Service module

Figures

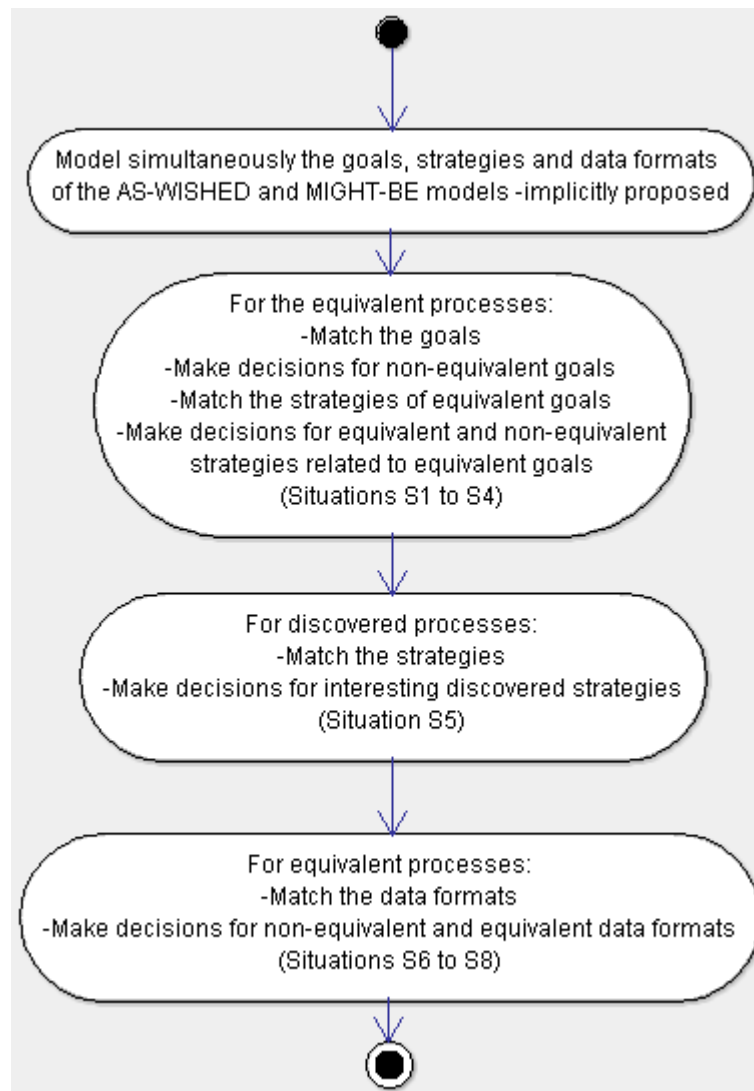


Figure 1. Macroscopic alignment process of the method proposed in (Mamoghli, Goepp and Botta-Genoulaz 2011)

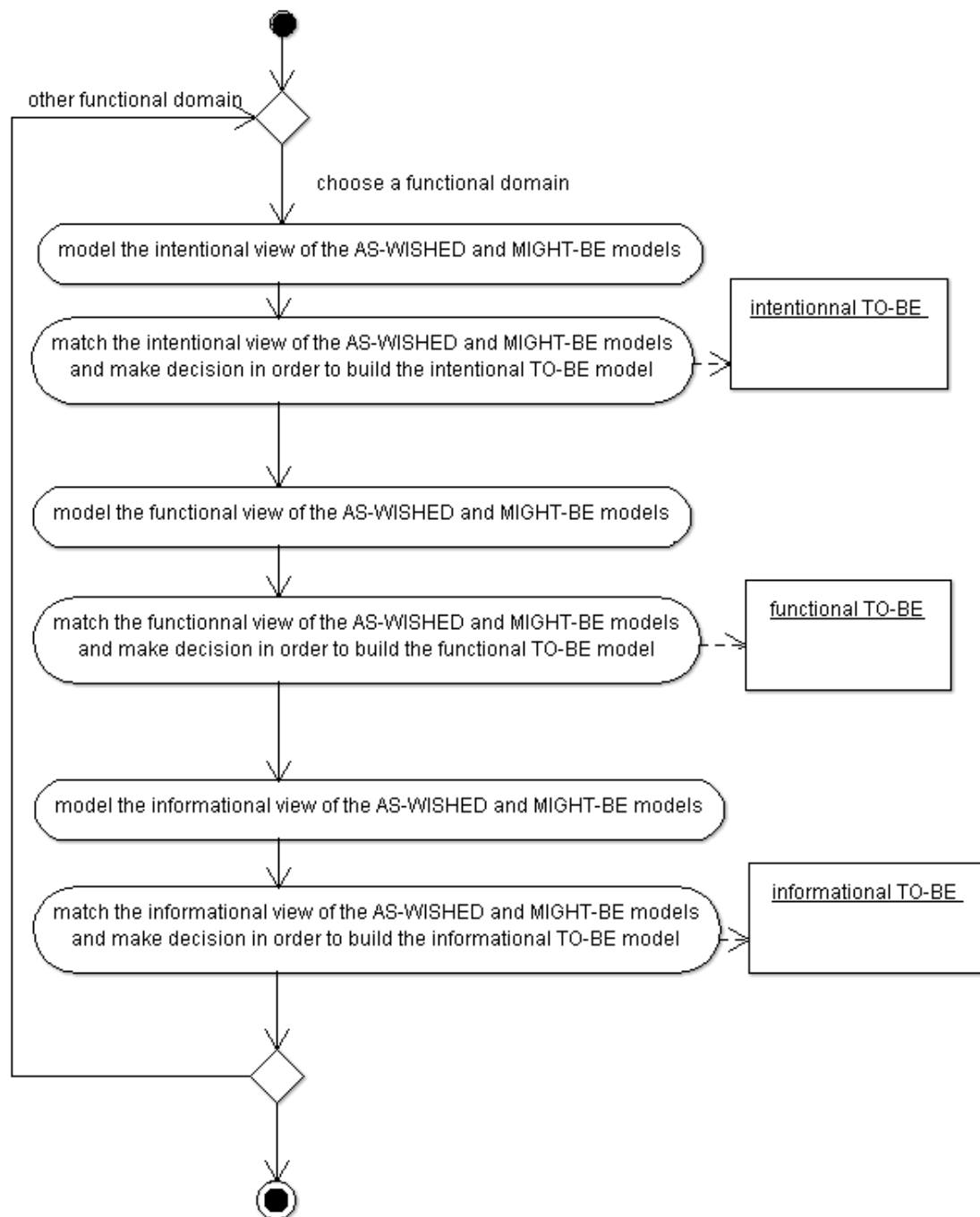


Figure 2. Macroscopic alignment process of the method proposed in (Mamoghli, Goepp and Botta-Genoulaz 2011)

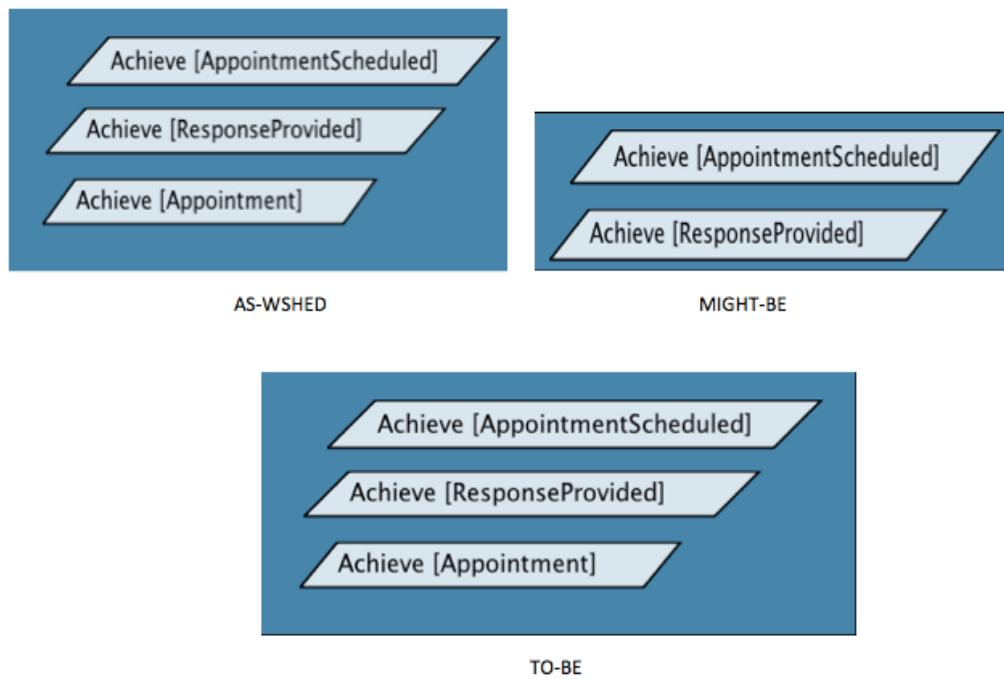


Figure 3. Intentional view of the AS-WISHED, MIGHT-BE and TO-BE models for the Appointment example

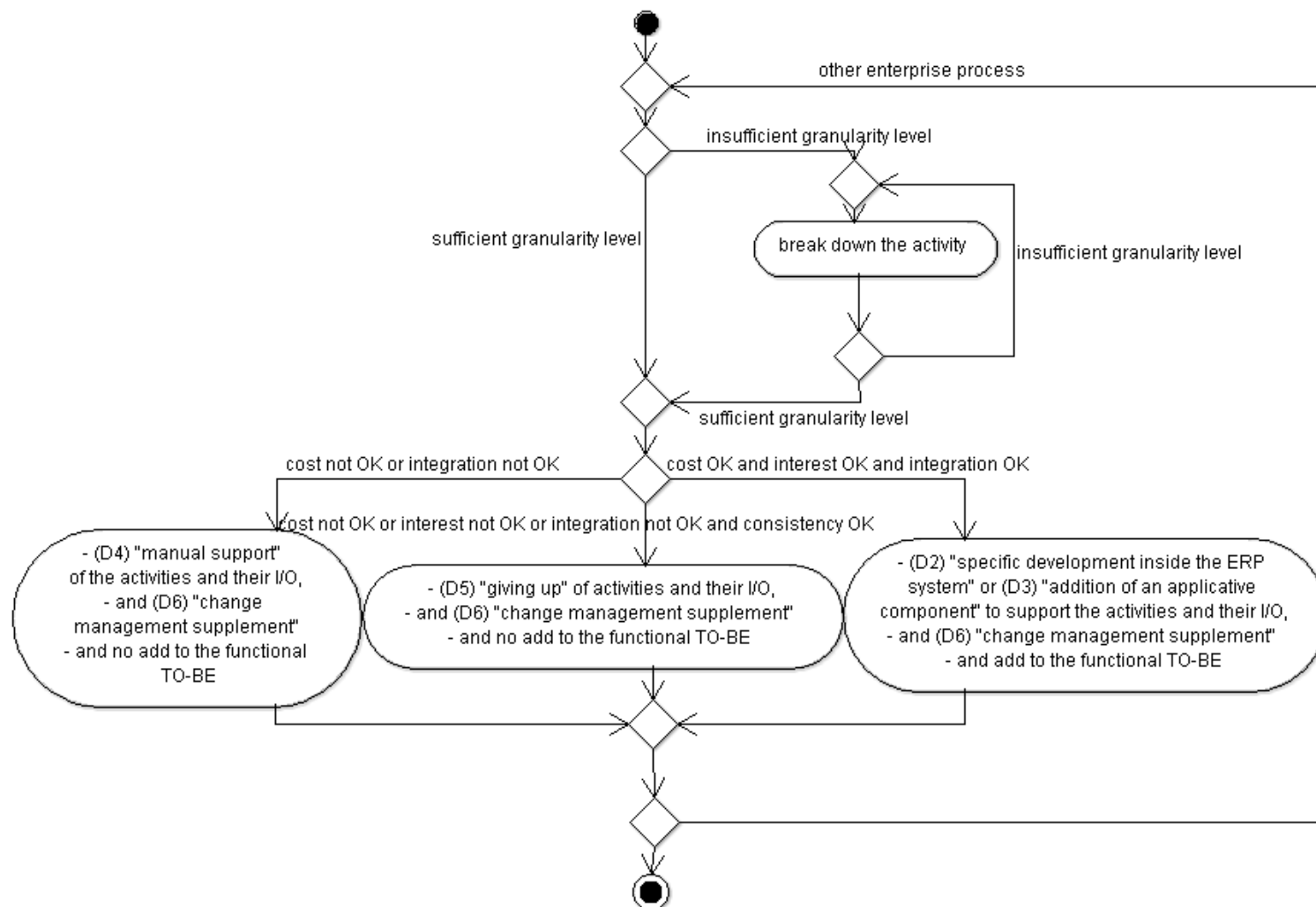


Figure 4. Construction of the TO-BE model of the unmet processes

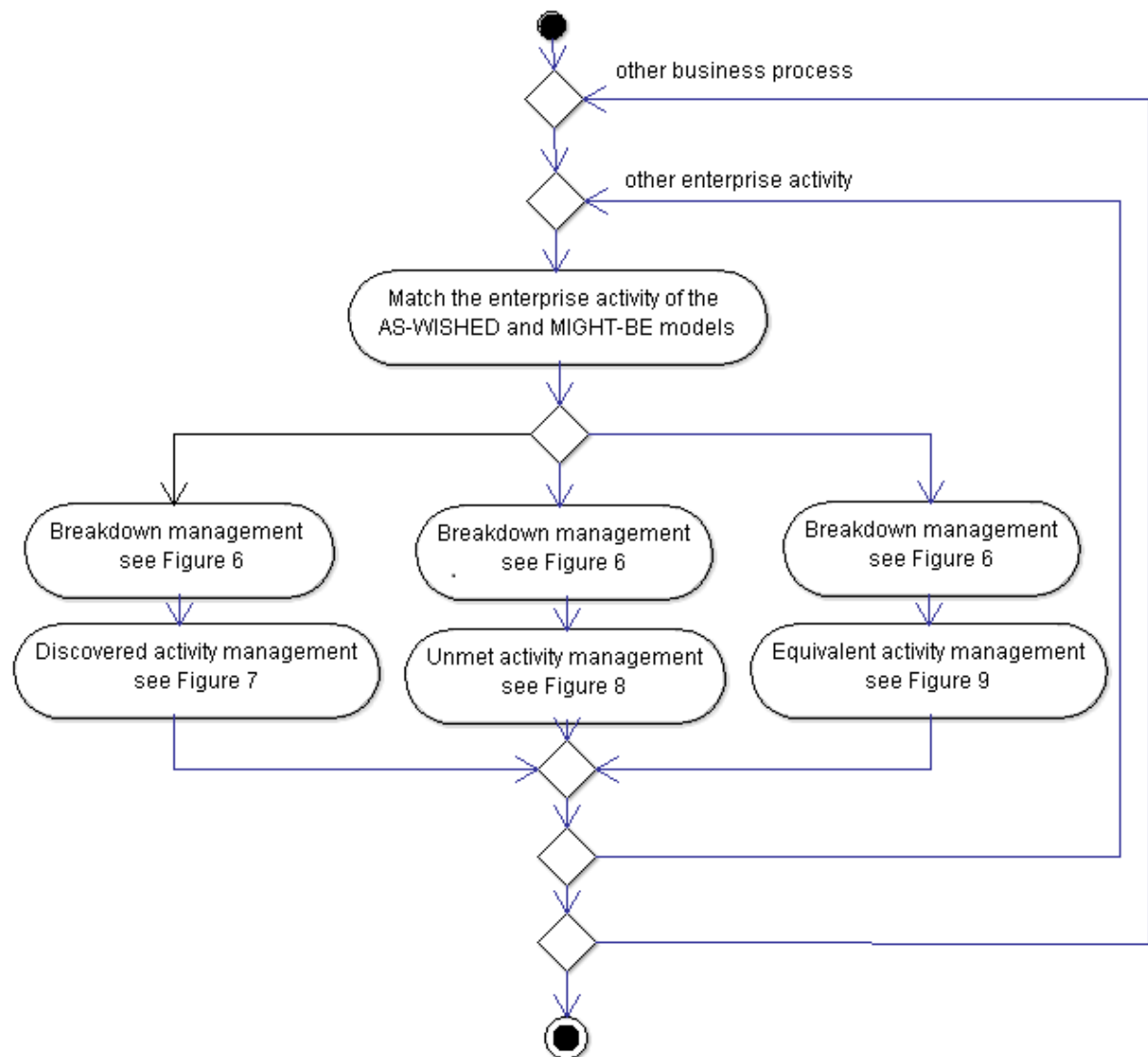


Figure 5. Overview of the construction of the functional TO-BE model of the equivalent processes

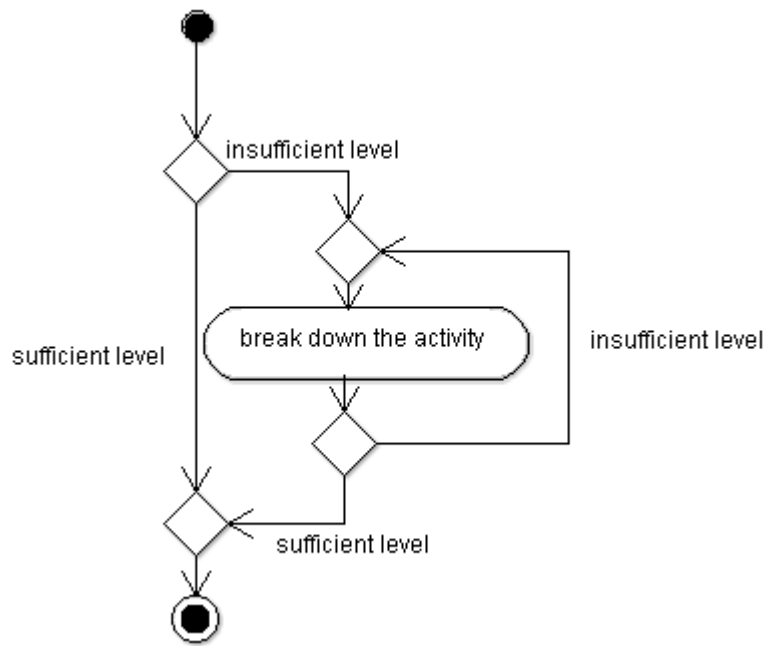


Figure 6. Breakdown management (construction of the functional TO-BE model of the equivalent processes)

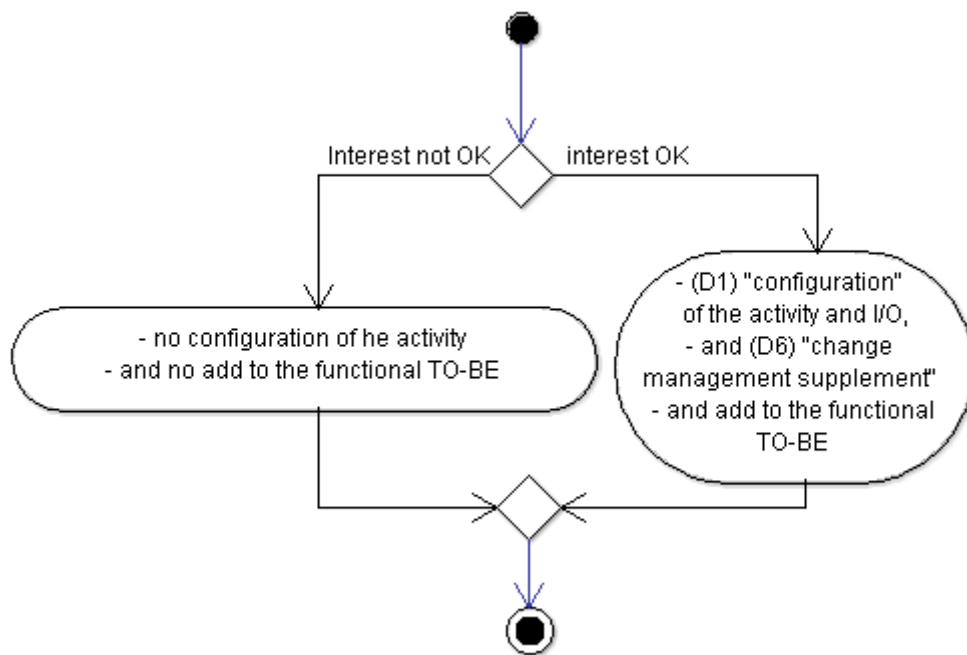


Figure 7. Discovered activity management (construction of the functional TO-BE model of the equivalent processes)

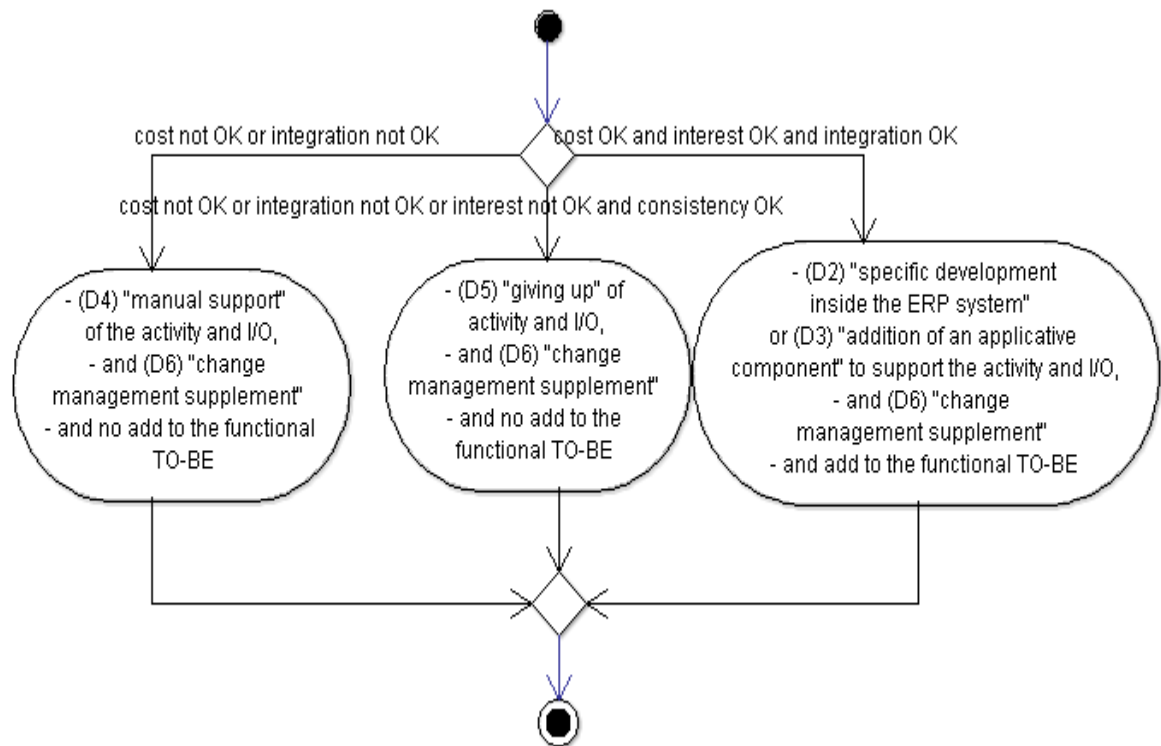


Figure 8. Unmet activity management (construction of the functional TO-BE model of the equivalent processes)

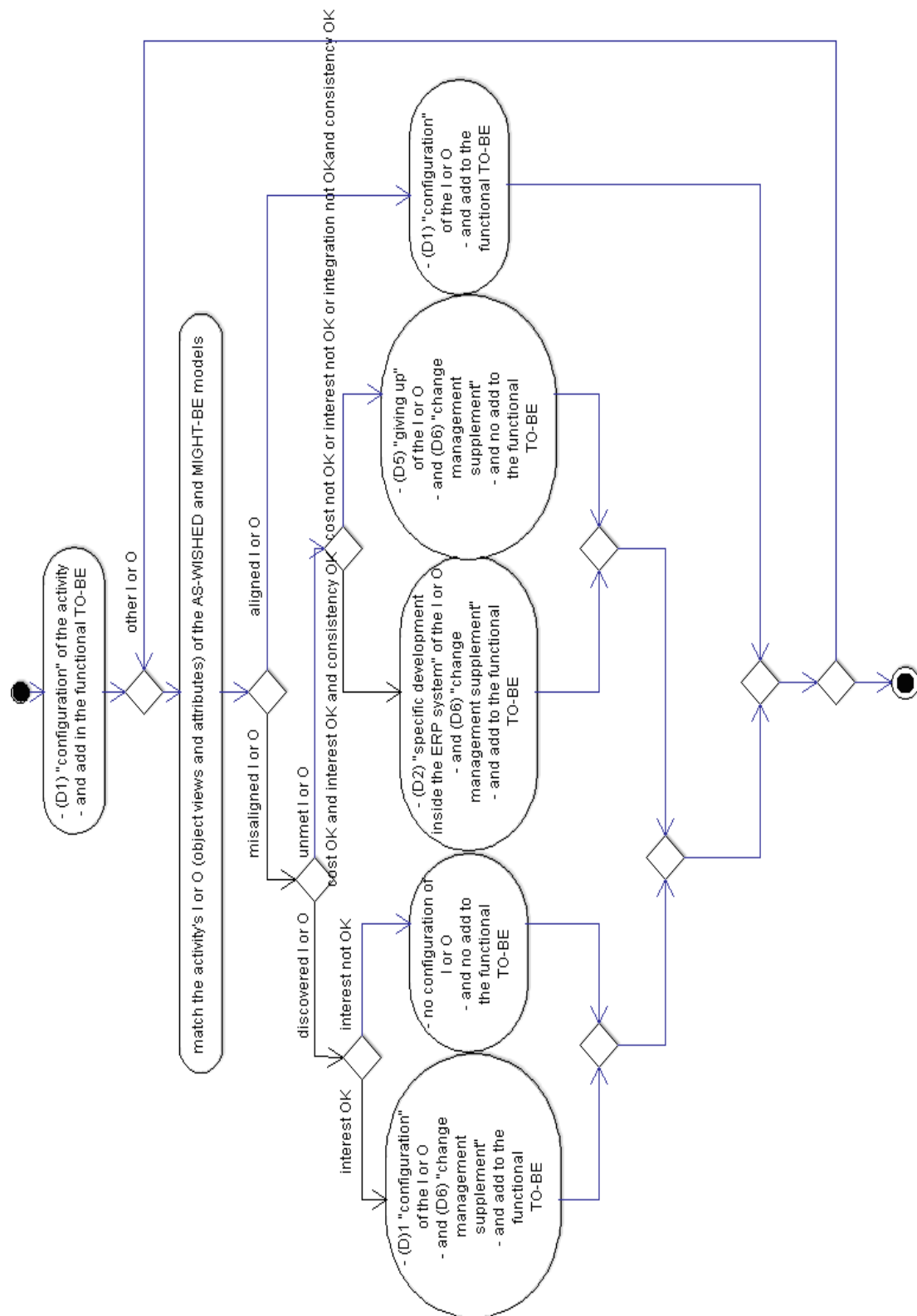


Figure 9. Equivalent activity management (construction of the functional TO-BE model of the equivalent processes)

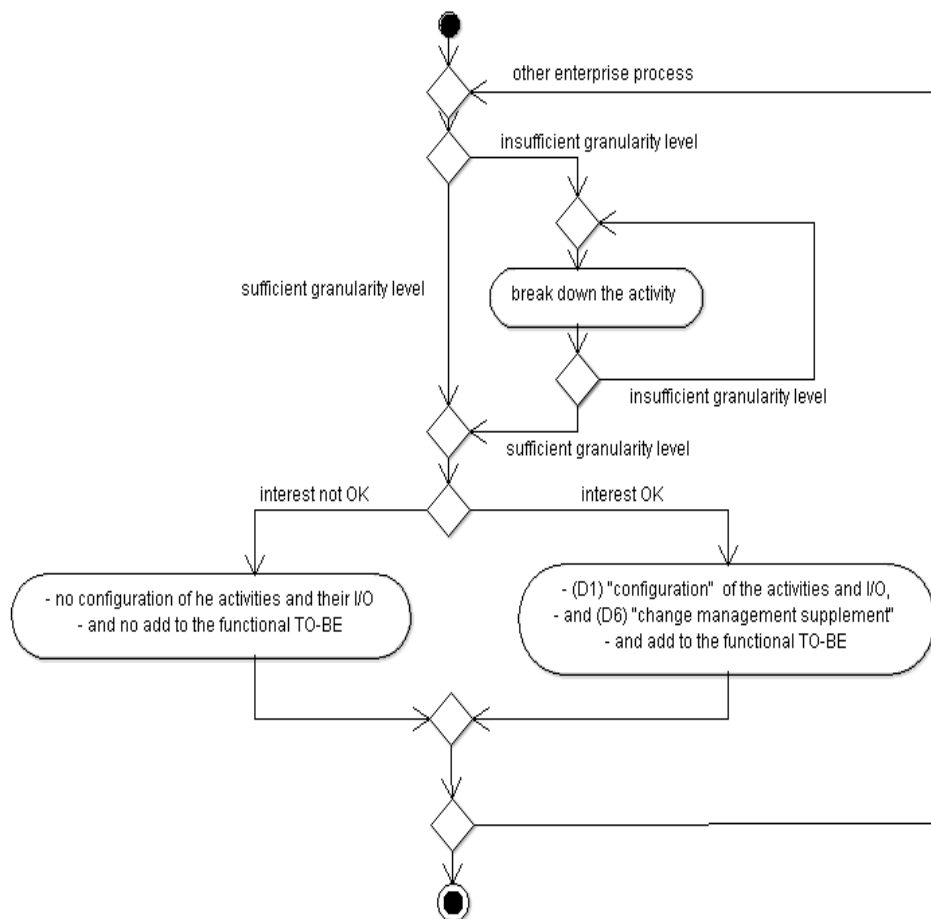


Figure 10. Construction of the functional TO-BE model of the discovered processes

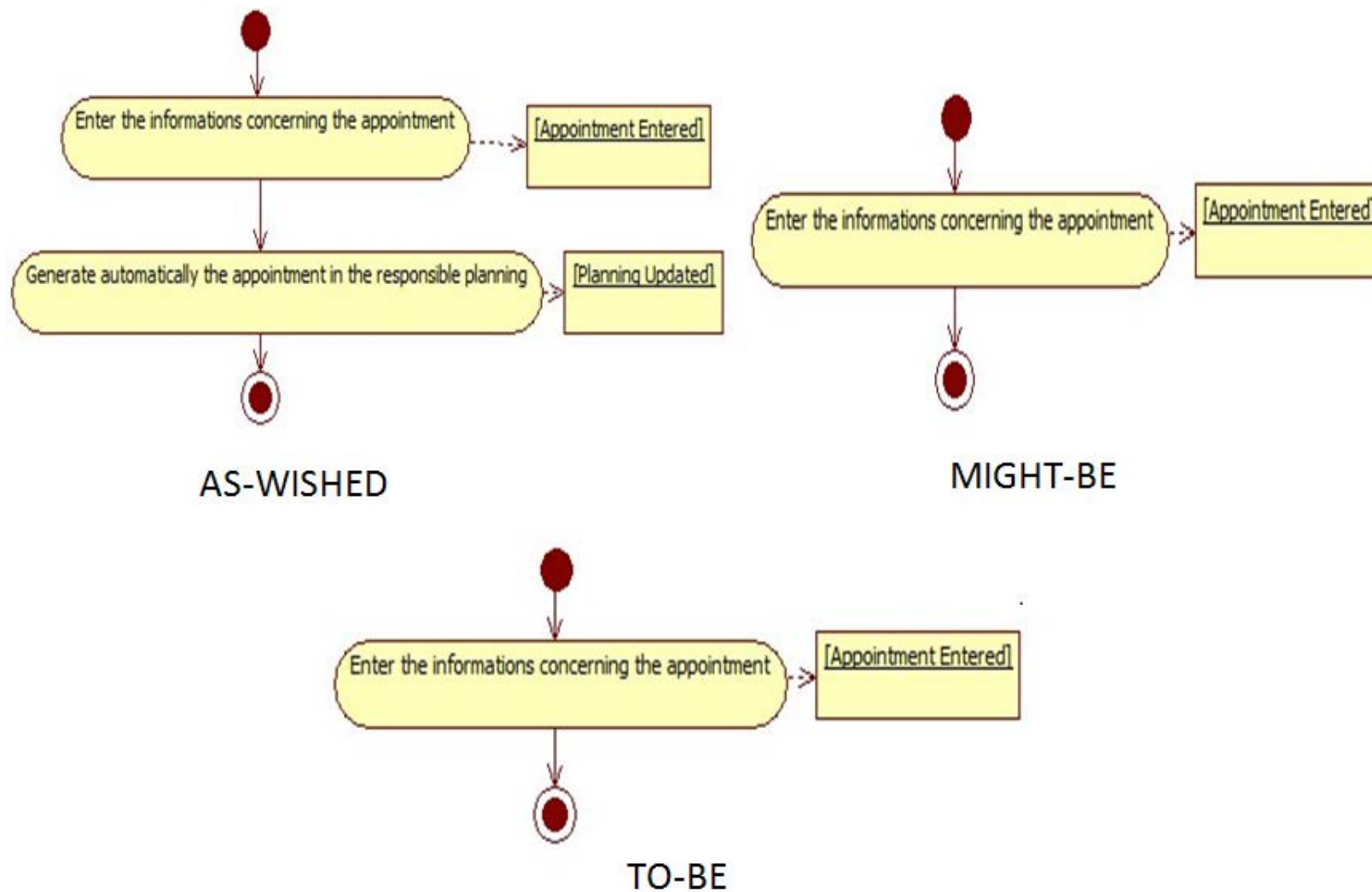


Figure 11. Functional view of the AS-WISHED, MIGHT-BE and TO-BE models of the Appointment example

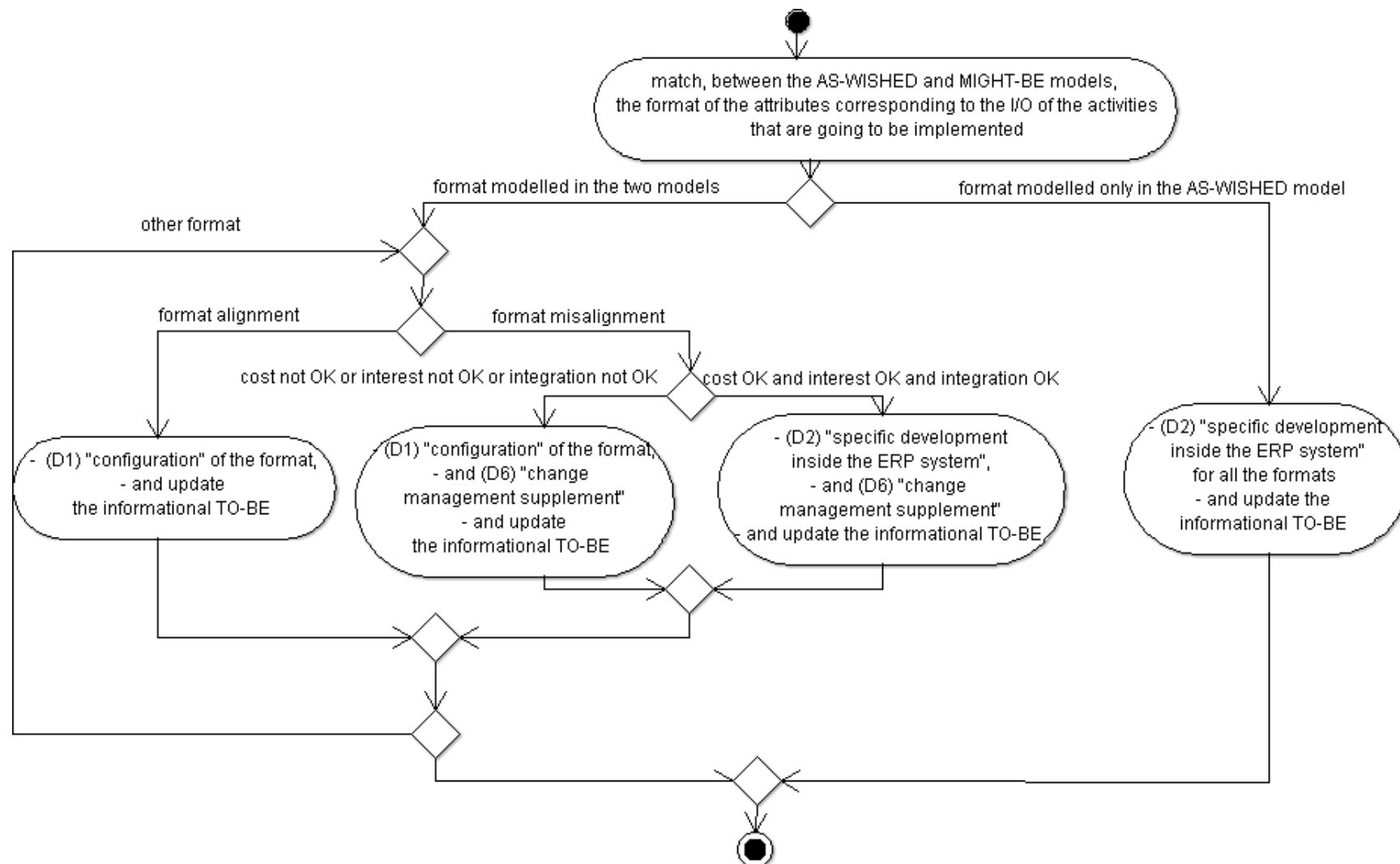


Figure 12. Construction of the informational TO-BE model

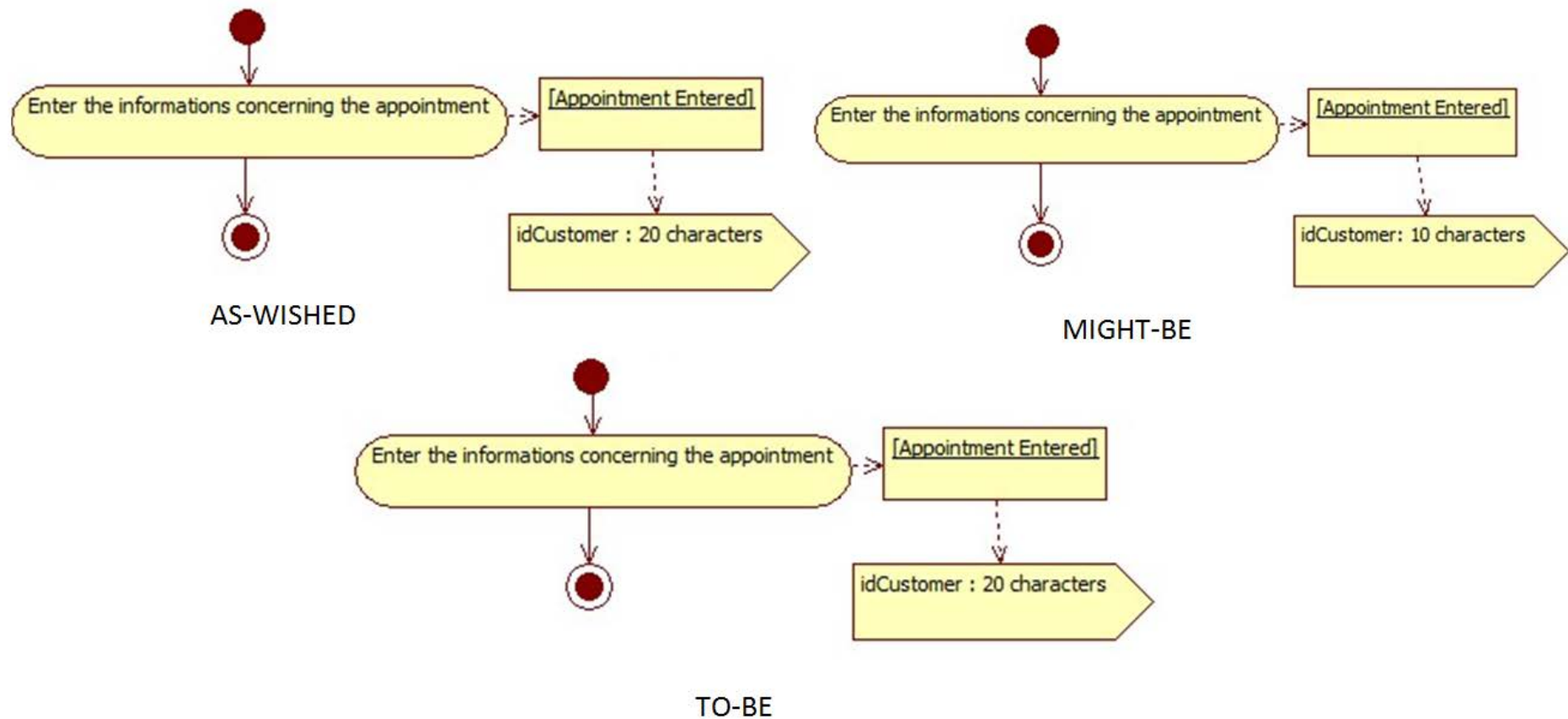


Figure 13. Informational view of the AS-WISHED, MIGHT-BE and TO-BE models of the Appointment example

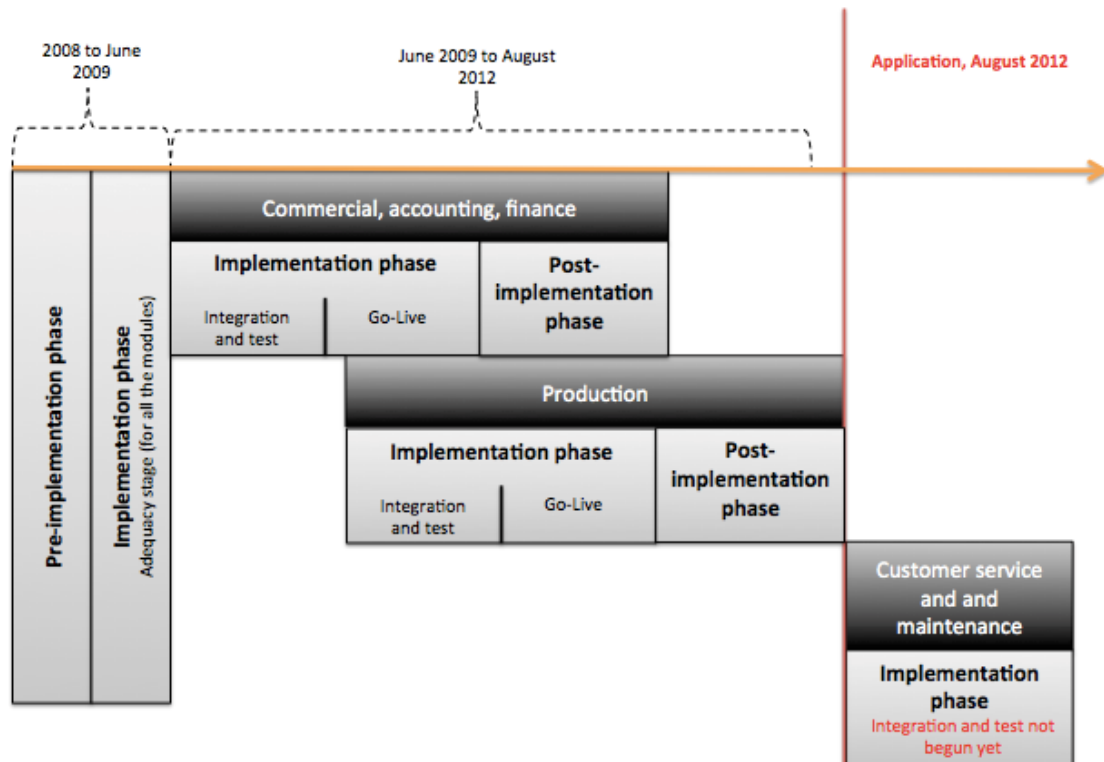


Figure 14. The ERP project of the company

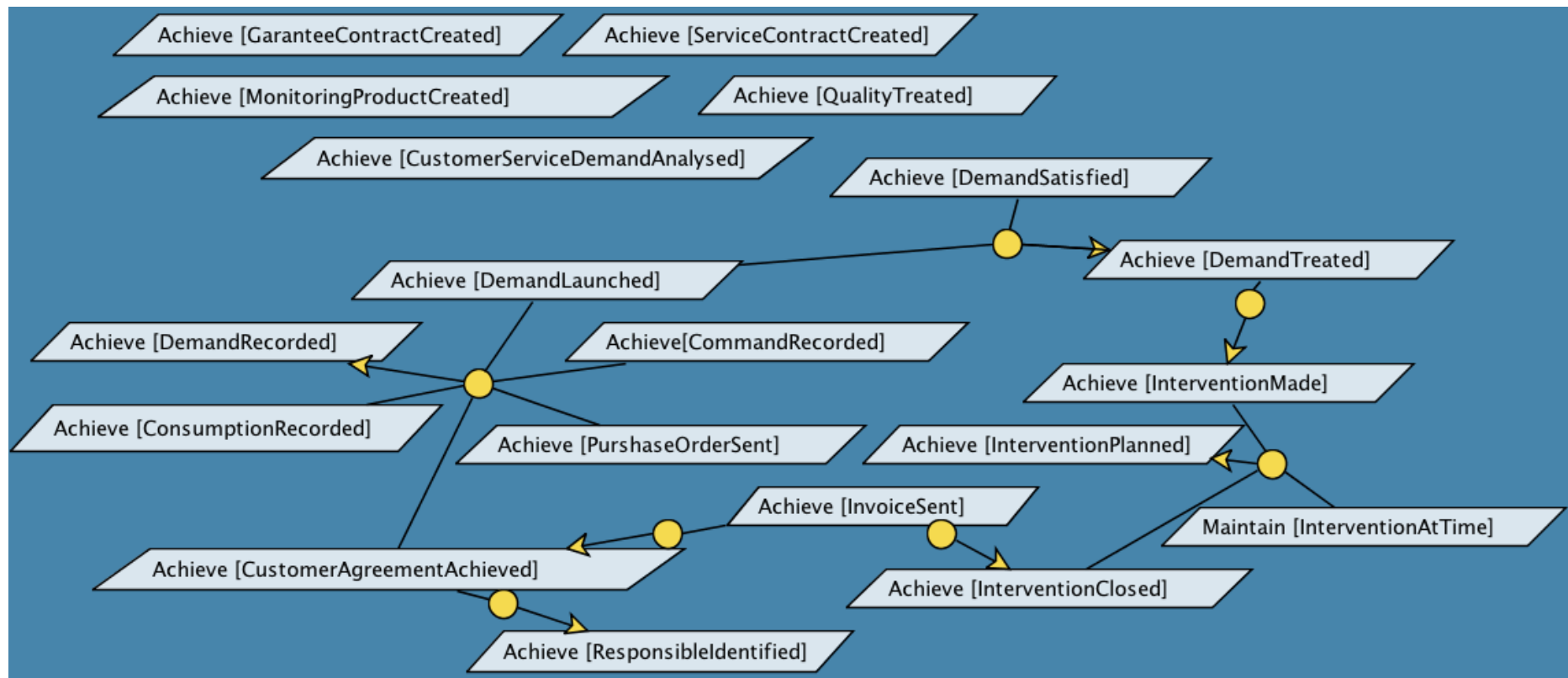


Figure 15. Intentional view of the AS-WISHED Model

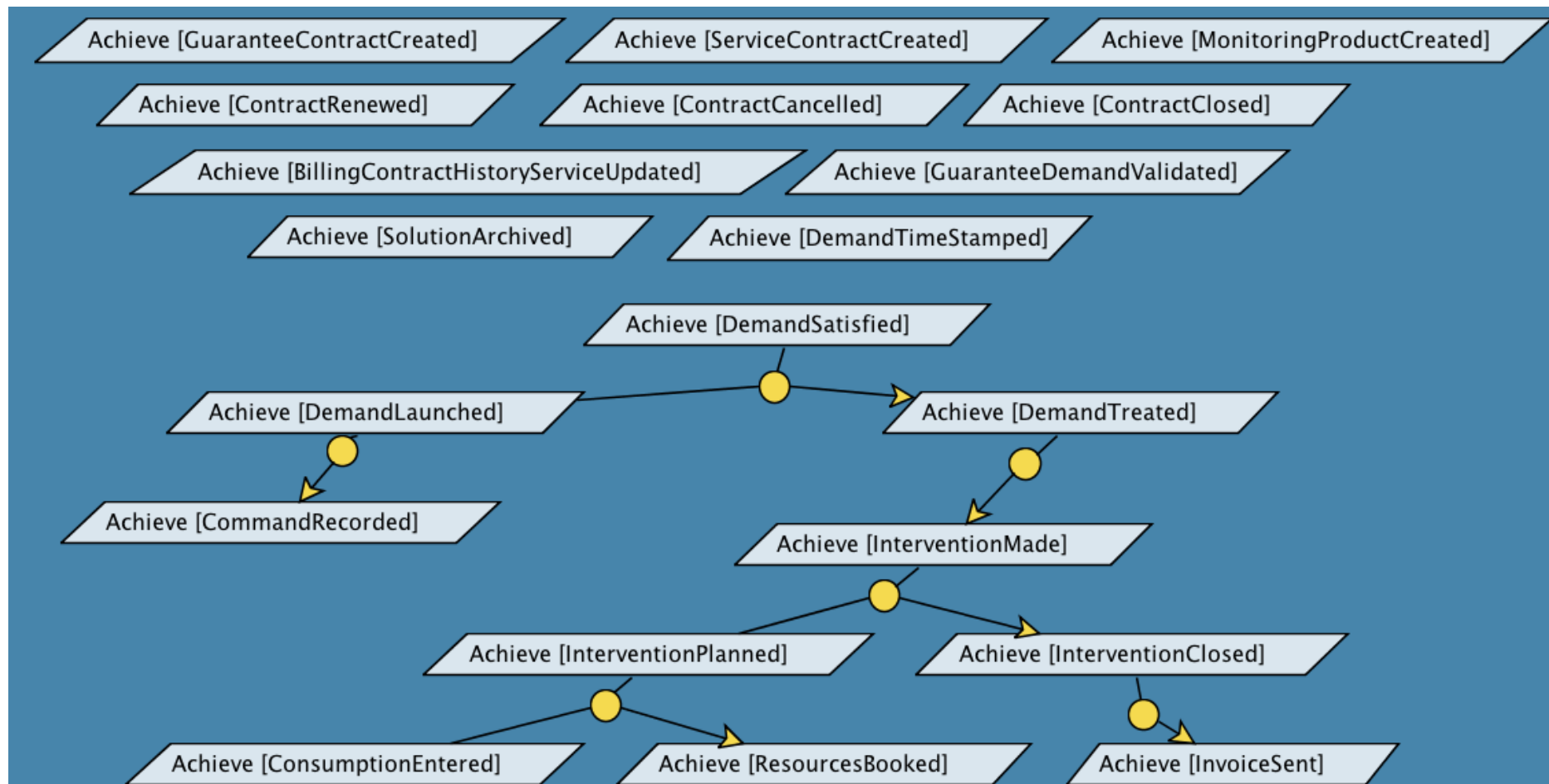


Figure 16. Intentional view of the MIGHT-BE Model

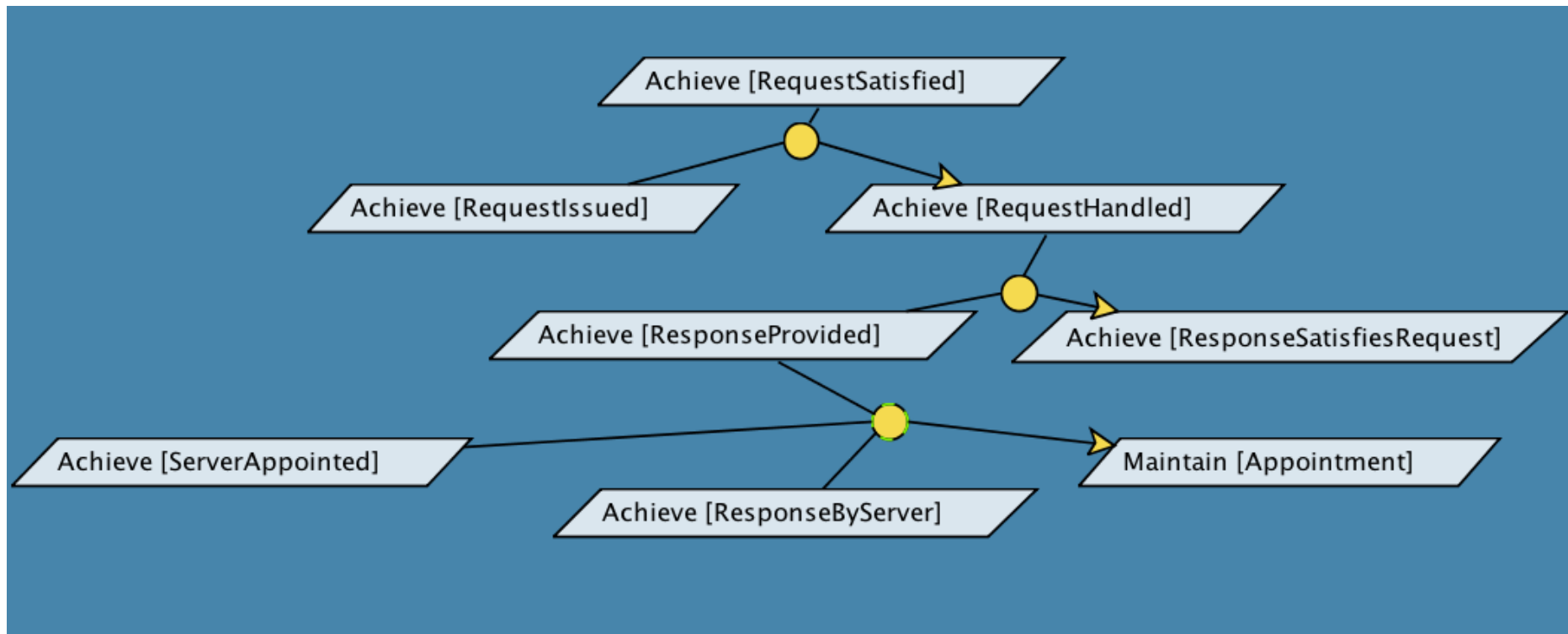


Figure 17. KAOS Pattern refining the goal "Achieve request satisfied"

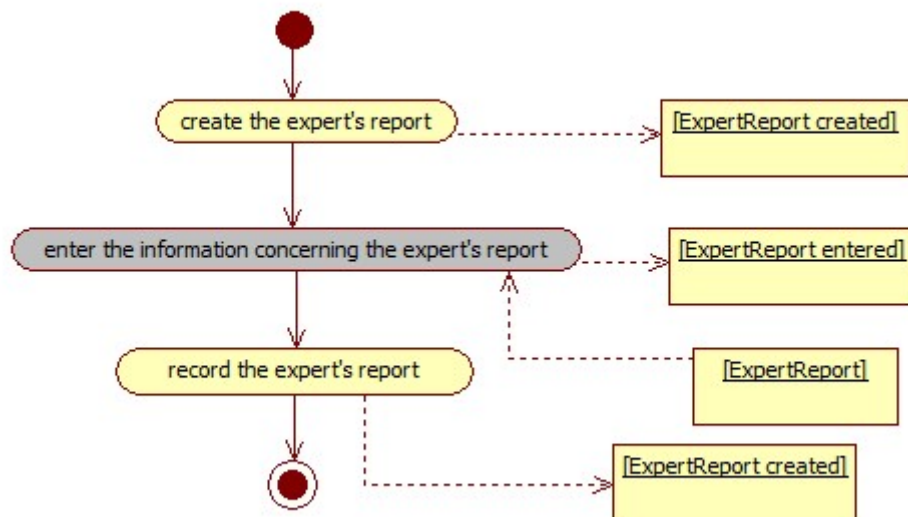


Figure 18. Functional view associated with “Achieve Responsibility identified” goal at the higher granularity level

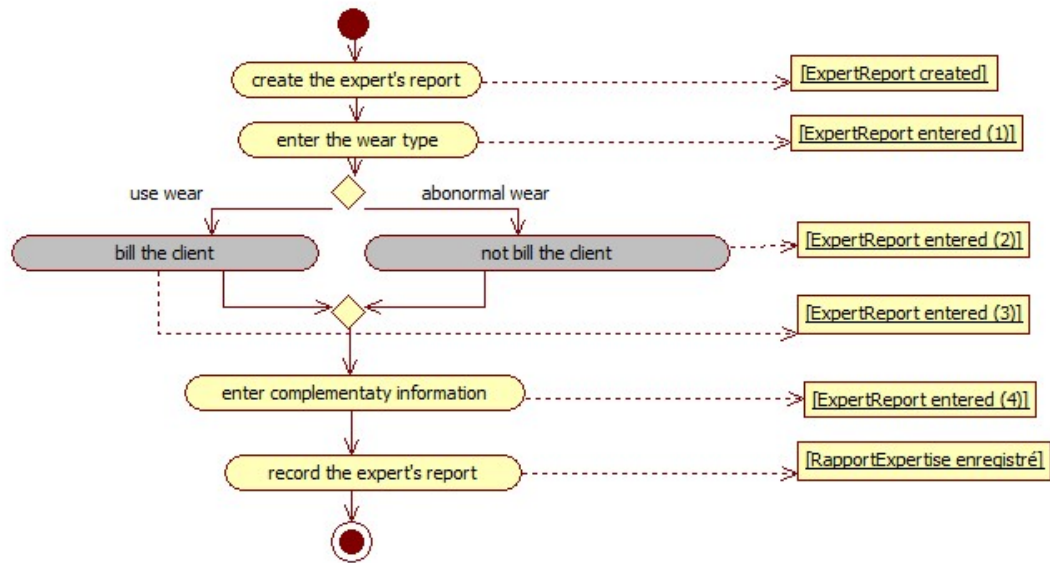


Figure 19. Functional view associated with “Achieve Responsibility identified” goal at the lower granularity level

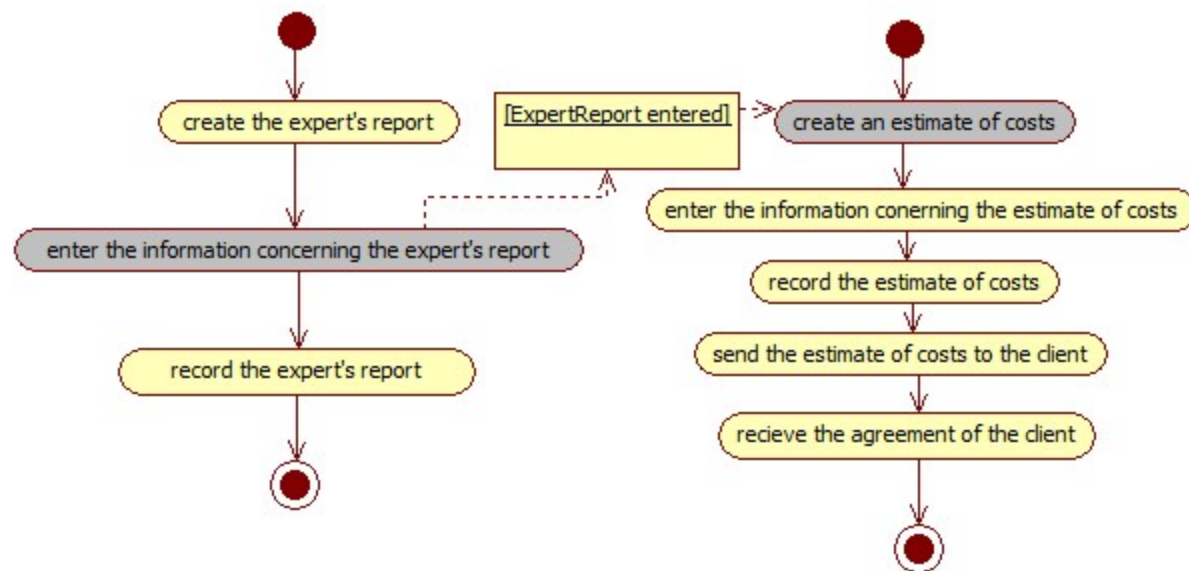


Figure 20. Interdependent processes illustration

Appendix

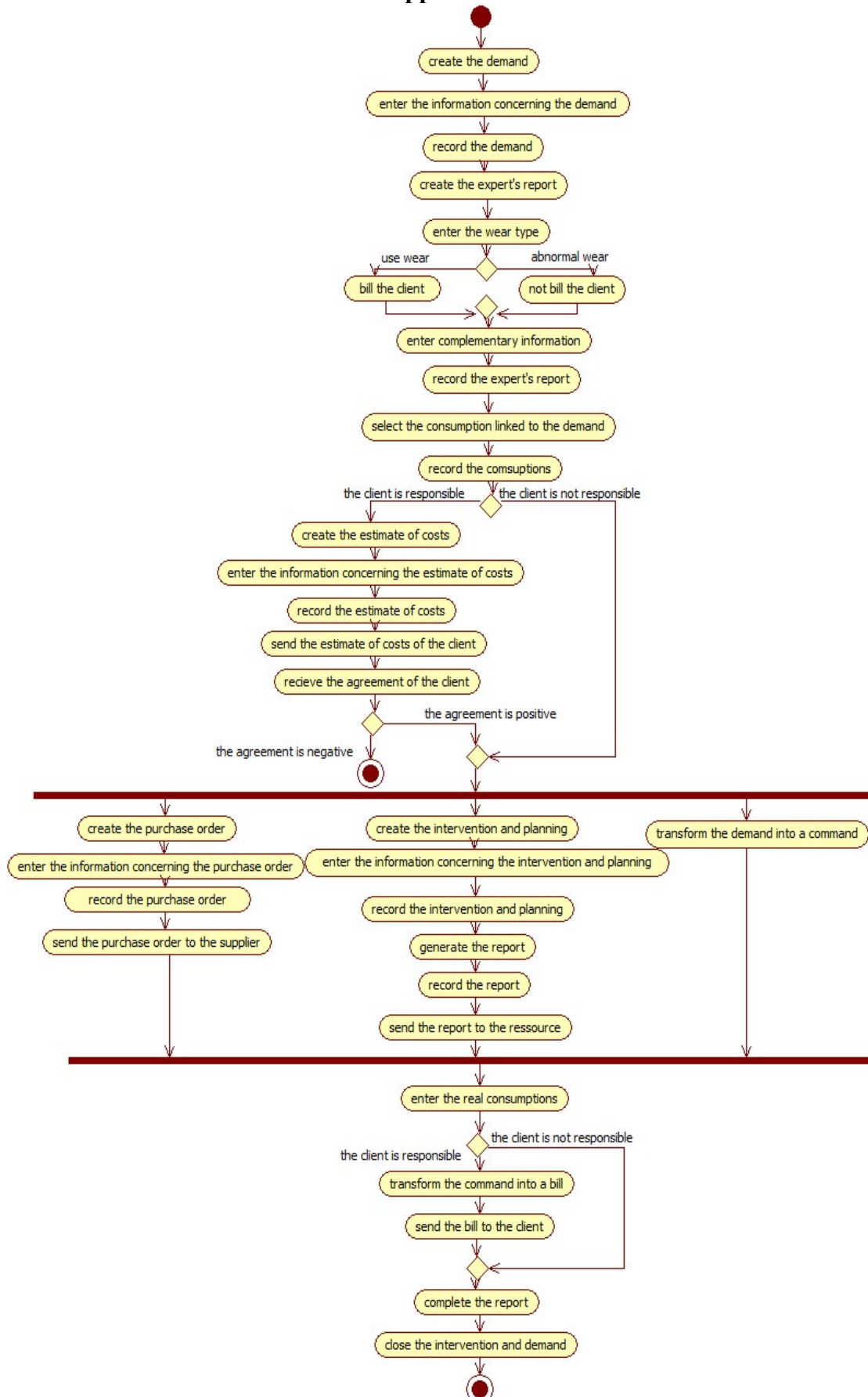


Figure A-1. Functional view of the AS-WISHED complex model

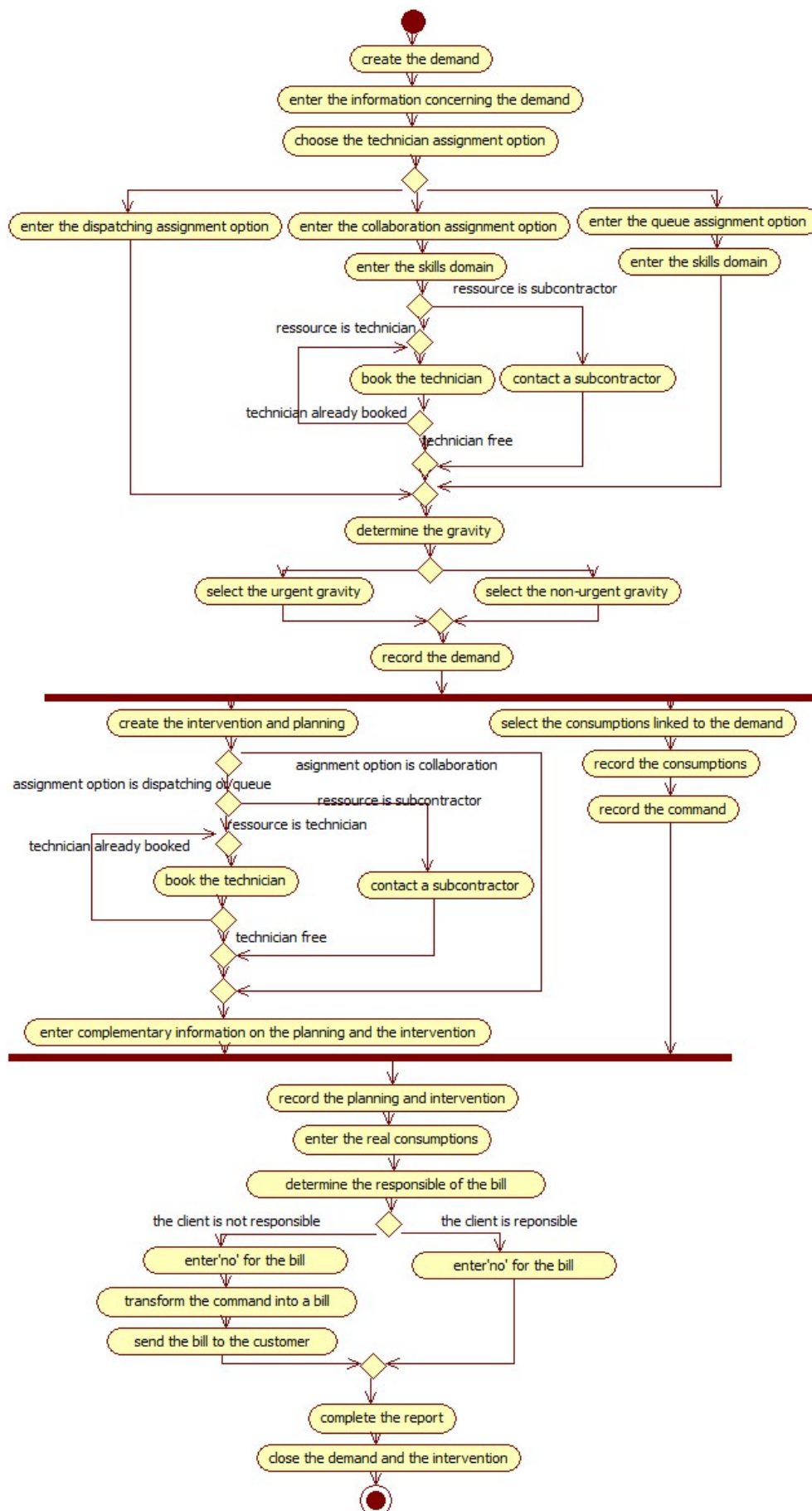


Figure A-2. Functional view of the MIGHT-BE complex model