A Process for Generating Fitness Measures

Anne Etien and Colette Rolland

Centre de Recherche en Informatique – University Paris 1,
90 rue de Tolbiac, 75013 Paris, France
{aetien, rolland}@univ-paris1.fr

Abstract. It is widely acknowledged that the system functionality captured in a system model has to match organisational requirements available in the business model. However, fitness measures are rarely integrated in design methodologies. The paper proposes a framework to ease the generation of fitness measures adapted to a given methodology in order to quantify to which extent there is fit between the business and the system. The framework comprises a generic level and a specific level. The former provides generic evaluation criteria and metrics expressed on the basis of business and system ontologies. The specific level is dealing with a specific set of metrics adapted to specific business and system models. The paper presents the process for generating a specific set of measures from the generic set, illustrates it with two specific models and shows how the use of the generated metrics can help in making design decisions in the development of a hotel room booking system.

1 Introduction

Fitting information systems (IS) to business processes (BP) that they support, is equally considered important by researchers and by professionals [1], [2]. Recent field surveys seem to demonstrate this importance. For example, a 2001 study conducted in 226 companies [3] clearly proofs that alignment of IS to BP significantly improve business performance. Complementarily, Henderson and Venkatraman [4] show that the lack of fit of information systems to business strategies is the reason why business processes fail in providing the return on IT investments.

Researchers are interested by mechanisms to get the alignment done. Most IS development methodologies propose a step-wise process to ensure that the designed IS matches the business needs and strategies. Old methodologies such as the participative method [5], more recent object oriented methodologies [6] and the entire requirements engineering community [7] promote approaches based on goal models to capture the business strategies and on transition rules to operationalise goals into IS solutions. However, these methodologies do not provide means to evaluate if there is fit and to which extent.

P. Soffer [8] suggests that identification of unfit requires the application of a fit measurement method. Measurement is indeed a way to avoid a subjective evaluation of the degree of fit. We follow this line and our concern is to define a set of fit measures that could be easily incorporated in any existing methodology. This raises

O. Pastor and J. Falcão e Cunha (Eds.): CAiSE 2005, LNCS 3520, pp. 277 – 292, 2005.

two issues: (a) the definition of the concepts of fitness and fitness measurement and, (b) the production of fitness measures for a specific methodology.

In dealing with issue (a) we adopt the view of Regev [9], who defines the concept of fitness "as the correspondence between a set of components". In the case of BP/IS fitness evaluation, this view implies a precise identification of the types of correspondence between components of the business model (BM) and the system model (SM). The measurement of BP/IS fit is therefore, based on the degree of correspondence between BM and SM components. We propose the use of fitness criteria and associated metrics to measure these.

To addressing issue (b) we base the process of producing fitness measures for a specific methodology on the framework shown in Fig. 1. The specific set of measures is derived from a generic set of measures. The former is based on correspondences established between components of a specific business model and a specific system model whereas the latter are associated to correspondences between generic constructs found in the Wand and Weber [10] and Soffer and Wand [11] ontologies, respectively. These two ontologies are adaptations of Bunge's ontology [12], [13] which is largely recognized for its theoretical foundations. We believe that there are a number of advantages of proceeding in this way, (1) the generic measures are based on a solid theoretical ground provided by the Bunge's ontology (2) the generic measures serve as a guide to define the specific ones: the latter is just a specialisation of the former, (3) the process of producing the specific measures is easier and less error prone and, (4) specific sets of fit measures are consistent with each other as they are generated from the same mould and this facilitates comparisons across methods.

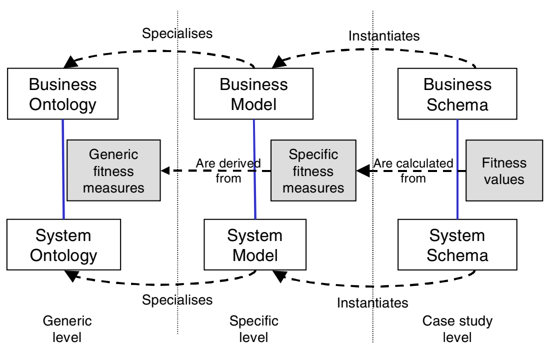

Fig. 1. Framework for generating specific fit measures

In this paper, we illustrate the use of our generic set of fitness measures to generate a specific set of measures. For this purpose, we propose a three steps process. In the two first steps, a correspondence between constructs of the specific business model (respectively, system model) and those of the business ontology (respectively, system ontology) is established. The third step consists in the specification of the generic metrics based on the correspondences identified in the two previous steps.

The rest of the paper is organized as follows. Section 2 provides an overview of the ontologies and of the generic set of fitness criteria and associated metrics. Section 3 presents the process to generating specific metrics and illustrate it with the MAP [14] and O* [15] models. In section 4 the use of the specific metrics generated in section 3 is discussed in a case of a hotel room booking. Finally, conclusions are drawn in section 5.

2 Generic Level: Overview of the Fitness Measurement System

This section provides an overview of the generic set of criteria and metrics that we defined to measure to which extent there is fit between the software system and the business it supports. We first, recall the Soffer and Wand (SW) and Wand and Weber (WW) ontologies, which we use to represent system and business components, respectively. We then, present our view of the fit as the degree of correspondence between SW and WW elements computed by metrics. We finally sum up the fit criteria and associated metrics.

2.1 Ontologies Overview

The Soffer and Wand ontology (SW) [11] and the Wand and Weber (WW) [10] ontology are summed up in the meta-models of Fig. 2. Both ontologies are specialisations of the Bunge ontology [12] and therefore, share a number of constructs. The core concept is the one of *thing*. A thing has some *properties* that are perceived in terms of *attributes*. For a given thing, the set of values of all its attribute functions is called its *state*. Properties can change and therefore, things undertake state changes called *events*. There exist rules governing possible states and possible state changes called *state laws* and *transition laws*, respectively.

The SW ontology differs from the WW ontology by emphasizing the constructs of *goal* and *process*. A goal is defined as a set of *stable states* and a process as a sequence of *unstable states* leading to a goal.

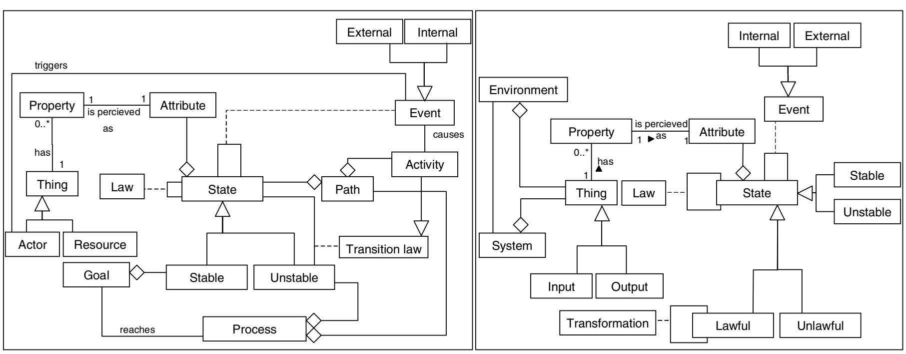

Fig. 2. Meta-model of the SW (left) and the Wand and Weber (right) ontologies

2.2 Correspondences Between SW and WW Constructs

In line with Regev [9], we view the fit between the system and the business as the degree of correspondence between SW and WW components. We found that two types of correspondence links were relevant, namely *maps* and *represents*. The former expresses equality between SW and WW identical constructs. The latter specifies that a WW construct has an impact on a SW construct. Thus, two constructs of different nature, for example a WW thing and a SW property or a WW event and a SW activity can be linked by a *represents* link.

A SW construct X *maps* ($\mathcal{M}$) a construct Y of the same nature if there exists a function f such as the set of elements f(X) equals the set of elements f(Y)

$$X \mathcal{M} Y \Leftrightarrow f(x) = f(y)$$

In the case of things for example, f(X) corresponds to the set of properties of the thing X. Between two states, f(X) corresponds to set of values of X. The *maps* link between a state X at the business level and a state Y at the system level implies that (i) the set of values of all the attribute functions of one thing equals the set of values of all the attribute functions of the other thing but also that (ii) these two sets of attribute functions are identical and thus that the two things X and Y *map* each other.

A WW construct *represents* ($\Re$) a SW construct if the existence of the former affects the behaviour, the value or the existence of the latter.

$$X \Re Y \Leftrightarrow X \triangleright Y, \text{ where } \triangleright \text{ signified that X acts on Y.}$$

Notice that if X *maps* Y, Y *maps* X and vice versa. There is no reflexivity for the *represents* link.

These two links *maps* and *represents* allow to define correspondence between constructs. They are used in the definition of the fitness metrics.

2.3 Fitness Criteria and Metrics

In order to measure the degree of correspondence between components of the two ontologies we use fitness criteria and metrics. We adapted the Cavano and McCall framework [16] and organized the fitness measurement system in three levels, *factors, criteria* and *metrics*. As shown in Table 1 we identified four factors along which the fit can be measured namely, the *intentional factor*, the *informational factor,* the *functional factor,* and the *dynamic factor*. Each factor has associated *criteria*, which are in turn, related to *metrics* that allow the actual computation of the degree of fit. As highlighted in Table 1, the criteria and metrics are based on the *maps* and *represents* links between components of the SW and WW ontologies. Components are made explicit in the third and fourth column of the table. They are marked in italics in the short definition of the metrics whereas the type of link used in metrics is shown in bold.

Along the intentional dimension, the objective is to measure to which extent the system is meeting the business purpose. This is achieved by providing four associated to the *intentional factor* dealing, respectively, with the business activity and the goal support, and the actor and resource representation.

Table 1. Generic Fitness metrics

Factors	Criteria	SW construct	WW construct	Metrics
Intentional	Support ratio	Activity	Event	Number of *business activities* **represented** by *system events* / Number of *business activities*
	Goal satisfaction	Goal	States	Number of *goals for which each state constituing them* **maps** a *state* in the system / *Number of goals*
	Actor presence	Actor	Thing	Number of *business actors* **mapping** a system *thing* / Number of *business actors*
	Resource presence	Resource	Thing	Number of *business resources* **mapping** a system *thing* / Number of *business resources*
Informational	Information completeness	Thing	Thing	Number of business *things* **mapping** a system *thing* / Number of business *things*
	Information accurracy	States	States	Number of business *states* **mapping** a system *state* / Number of business *states*
Functional	Activity completeness	Thing	Thing	Number of business *things* of a given activity **mapping** a system *thing* / Number of business *things* of this activity
	Activity accurracy	States	States	Number of business *states* of a given activity **mapping** a system *state* / Number of business *states* of this activity
Dynamic	System reliability	Law	Law	Number of *business laws* for which each *business state* **maps** a system *state* and the transformation between business states are possible between system states / Number of *business laws*
	Dynamic realism	Path	States	Number of *paths* for which each *business state* **maps** a system *state* and the succession of these system states is possible / Number of *paths*

The *informational factor* complements the intentional factor by supporting a deeper analysis of the way activities are supported in the system. In order to provide a good fit between the system and the business processes, the system must (i) manipulate all the business process objects and (ii) support all the business process object states associated to the business processes. Two criteria have been defined in order to permit such an evaluation, the *Informational completeness* and the *Informational accuracy*, respectively.

The *functional factor* aims to measure the degree to which activities in the system correspond to business activities. The correspondence is based on involvement of things and their states in business and system activities, respectively. Each individual activity of a business process is so analysed separately using the *Activity completeness* and *Activity accuracy* based metrics.

The fourth factor, the *dynamic factor* aims to evaluate the extent to which the dynamicity of business processes is reflected in paths of system state transitions. It has two criteria namely, the *System reliability* and the *Dynamic realism* criterion.

All metrics are formally defined. As an example, let us present the *Support ratio* based metric:

$$\text{Support ratio (Sr)} = \frac{\text{Number of activities represented by system events}}{\text{Number of activities}}$$

A business activity is supported by the system if there exists an event in the system that *represents* it. Let:

- A_b be the set of business activities (i.e. activities present in the business process), card(A_b) = the number of elements contained in A_b.
- E_s be the set of system events

- A_b^r be the set of business activities for which there exists a system event representing it; $A_b^r = \{a,\ a \in A_b \mid \exists\ e \in E_s \wedge e\ \Re\ a\}$ and card(A_b^r) = number of elements contained of A_b^r

  Using these notations, the metric associated to this criterion is:

$$Sr = card(A_b^r) \ /\ card\ (A_b)$$

  A complete definition of the generic fit measurement system can be seen in [17].

3 Specific Level: Generating a Specific Fit Measurement System

In this section, we show how the generic measurement system overviewed in the previous section guides the generation of a specific set of metrics. Specific metrics involve the correspondence between components of two specific models, to capture the business and the system, respectively. We selected the MAP representation formalism [14] for the former and the O* model [15] for the latter. We present first, the generation process and secondly illustrate it in the case of MAP and O*.

3.1 The Generation Process

The generic fit measurement system presented in section 2 has two key components: (a) the two SW and WW ontologies, which identify components of interest in the representation of the business in one hand, and the system which supports it, on the other hand; (b) the set of criteria, which identifies correspondences between components of the WW and SW ontologies that are relevant to measure the fitness and metrics which compute the degree of correspondence and thus, the degree of fit.

The use of ontologies in this fitness measurement system is a way of being independent of the business and system models, thereby leading to a generic expression of the component correspondences and their associated metrics. Obviously, the generic system can serve as a mould to define a specific fitness measurement system thus, avoiding to redefine the relevant component correspondences and metrics for each specific set of models. This requires to establish the liaison between the set of specific models and the ontology set and then, derive the specific formulation of metrics.

This leads to the following three-steps generation process:

(a) Relate constructs of the chosen business model to those of the SW ontology.
(b) Relate constructs of the chosen system model and those of the WW ontology.
(c) Adapt the generic metrics.

It shall be noticed that step 1 and 2 concentrate on finding the concepts of a specific model which correspond to the ontology constructs involved in one (or several) fitness criteria. In other words, the instantiation of the ontology for a specific model can be limited to those parts which are relevant to perform step 3 of the generation process. Given the correspondence between an ontology construct and the specific model concept, the metric formulae can be adapted easily. We illustrate this generation process in the following.

3.2 Generating the MAP/O* Fitness Measurement System

Relating MAP to SW. The MAP representation system allows to represent a process model expressed in intentional terms. Goals (intentions) to be accomplished are explicitly represented in the process model together with the different alternative ways (strategies) for achieving them. MAP provides a representation mechanism based on a non-deterministic ordering of *intentions* and *strategies*. As shown in Fig. 6, a map is a labelled directed graph with intentions as nodes and strategies as edges between intentions. The directed nature of the graph shows which intentions can follow which one. An edge enters a node if its strategy can be used to achieve the intention of the node.

The key concepts of MAP are *intentions* (goals to achieve or maintain), *strategies* (means or manners to attain a goal) and *sections* which are triplets $<I_i,I_j,S_{ij}>$ where I_i is the source intention, I_j the target intention and S_{ij} the strategy to attain when I_i has been achieved. MAP includes a refinement mechanism by which a section in a map can be modelled as a map in its own. This leads to the representation of a business as a hierarchy of maps.

Formally, an intention I is defined as a set of *desirable states* G_I and every section has an *initial condition* and a *final condition*, both expressed in terms of states. A section S from intention I to intention J starts in a subset of states $I_S \subseteq G_I$ and ends on a subset of states $F_S \subseteq G_J$.

MAP and SW share a goal-oriented view of a business process. However the latter does not employ a goal construct as an integral part of the model but as an external property whereas in the former goals are integral parts of the process model.

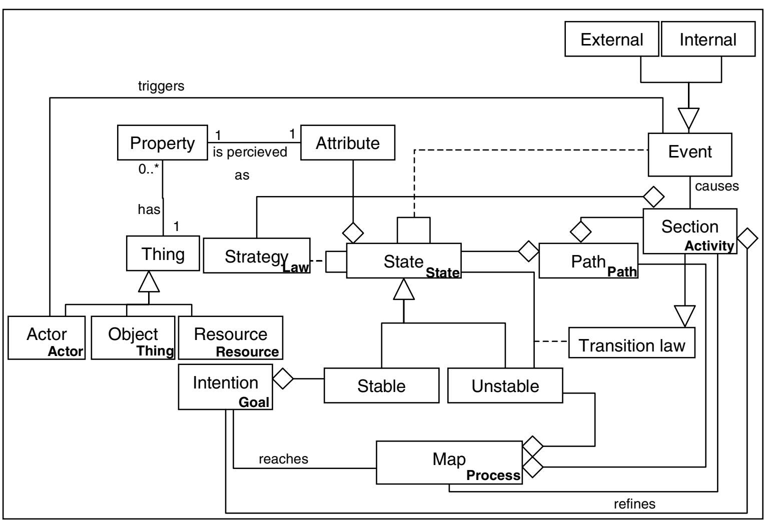

Fig. 3. Relating MAP to SW

Fig. 3 shows the instantiation of the MAP representation system in SW terms and highlights the correspondence between SW constructs and MAP concepts. To facilitate the reading of this correspondence in Fig. 3, we noted the names of the most important SW constructs (in particularly, those involved in metrics) in the right corner of the boxes that represent the equivalent MAP concept in the figure. It can be seen that the *map* component in MAP corresponds to the *process* component in SW and that the *section* concept of MAP relates to the SW notion of *activity*. In both models the process is viewed as a *path* (of sections from Start to Stop in MAP and activities in SW). The MAP *strategy* involved in a section ensures a mapping between subsets of states, hence it specifies the SW *law.* A process model expressed as a map contains discontinuity related to *events* that can be *external* (a map is triggered by an *external event* arising in a thing and resulting from the action of some other thing called *actor)* or *internal* (section triggering). R*esources* (i.e. some things which do not take further actions) and *objects* appear in the map specification as parameters of the intention and strategy linguistic formulation.

Relating O* to WW. O* is a model which allows a conceptual representation of the system to be developed in an object oriented manner. In O* an *object* is viewed has undertaking changes due to *events*. The specification of an object class therefore, goes beyond the traditional description with attributes and methods to include the description of events as state changes of objects which trigger *operations* on other objects, change their *states* and then, generate other events. O* is based on a causal behavioural paradigm: events trigger operations which change states of object and generate state changes that maybe events which in turn trigger operations etc. Fig. 4 (a) illustrates this in a graphical mode. Fig. 4 (b) sketches the specification format of an O* Class.

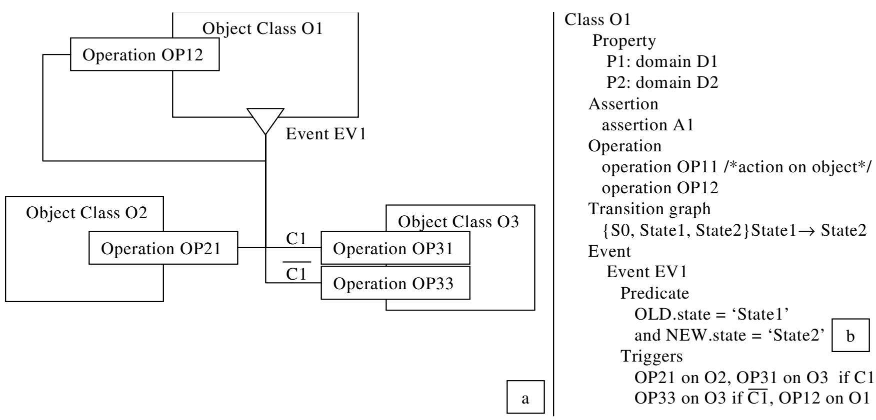

Fig. 4. Description of an object class

The WW ontology and the O* model both allow to describe a system with a static and a dynamic point of view. The static part provides description of durable links between constructs (such as composition), where as the dynamic part focuses on behavioural interactions between constructs or with the environment in response to events.

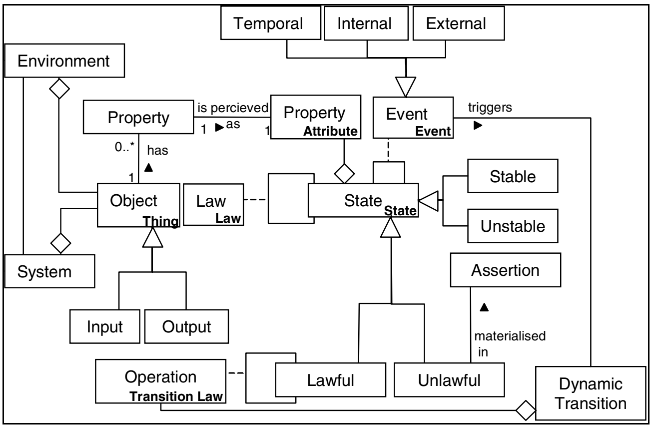

Fig. 5. Instantiation of the WW ontology with the O* model

Fig. 5 presents the instantiation of the O* model in WW terms and highlights the relationship between WW constructs and O* concepts. As for the MAP instantiation, the names of WW constructs and particularly those involved in metrics are noted in the right corner of the boxes that represent the equivalent O* concepts.

The *object* component in O* relates to the WW *thing* construct. They both have *properties* and see their *states* change in response to *events*. The *event* in O* can be *external* (an external event has for origin a stimulus coming from the environment of the system. It is associated to an actor), *internal* (it responds to a particular state change of a system object) or *temporal* (if it occurs at a foreseen point of time). The O* notion of *operation*, which changes states, correspond to the *transition law* construct in the WW ontology. An O* *assertion* corresponds to the WW construct of *unlawful state*.

MAP/O* Fit Measurement System. Based on these relationships between the generic constructs of SW and WW ontologies and the MAP and O* concepts the conversion of generic metrics into specific ones is easy to carry out.

Table 2 informally presents the ten metrics to measure the fit between a business expressed in MAP terms and the system specification expressed with the O* language.

Let us considered the specific *Support ratio* metric in comparison to the generic one given in section 2.

In generic terms, the support ratio metric measures the degree of correspondence between the number of activities represented by system events and the total number of activities in the business process. At the specific level, the measure is established between the number of *map sections* ***represented*** by *events* and the total number of *map sections*. The generic formula provided in section 2 is adapted as follows:

Table 2. Specific metrics for measuring business/ system fit modelled in MAP and O* terms

Criteria	MAP constructs	UML constructs	Specific metrics
Support Ratio	Section	Event	number of *sections* **represented** by *events* / number of *sections*
Goal Satisfaction	Intention	State	Number of *intentions* for which each state **maps** a *state* in the system / Number of *intentions*
Actor Presence	Actor	Object	Number of business *actors* **mapping** a system *class* / Number of business *actors*
Resource Presence	Resource	Object	Number of business *resources* **mapping** a system *class* / Number of business *resources*
Information Completeness	Object	Object	Number of business *objects* **mapping** system *class* / Number of business *objects*
Information Accuracy	State	State	Number of business *states* **mapping** to system *states* / Number of business *states*
Activity Completeness	Object	Object	Same as Information Completeness but for one given section
Activity Accuracy	State	State	Same as Information Accuracy but for one given section
System Reliability	Law	State	Number of business laws for which each business *state* **maps** a system *state* and the transformation between business states are possible between system states / Number of business *laws*
Dynamic Realism	Path	State	Number of *paths* for which each business *state* **maps** a system *state* and the succession of these system states is possible / Number of possible paths

Let:

- S_b be the set of business sections, card(S_b) = the number of elements contained in S_b.
- E_s be the set of events
- S_b^r be the set of business sections for which it exists event representing them; $S_b^r = \{ s, s \in S_b \mid \exists\, e \in E_s \wedge e\, \Re\, s \}$ and card(S_b^r) = number of elements contained in S_b^r

Using these notations, the metric associated to the Support Ratio is:

$$Sr = card(S_b^r) / card(S_b)$$

All the metrics have been adapted in a similar manner. A brief summary is as follows.

The generic *Goal satisfaction* metric compares the number of goals supported by the system to the number of business goals. The goal as defined in the SW ontology corresponds to the MAP intention. An intention I is supported by the system if each state constituting the goal set G_I *maps* to a state of an object in the O* model.

At the generic level, the *Actor presence* metric calculates the ratio of business actors present in the system on the total number of business actors. The construct of actor exists in the MAP model and is present in the system if it *maps* a system thing that triggers actions on another thing.

The generic *Information completeness* allows to measure to which extent a business thing *maps* a system thing. The SW and WW constructs of thing are related to the MAP object and O* object respectively. A MAP object is supported by the system if there exists an O* object that *maps* it.

The generic *Information accuracy* brings SW and WW states into play. These two constructs respectively correspond to MAP and O* states. At the specific level, the Information accuracy metrics allows to compare the number of MAP states that *map* an O* state to the total number of MAP states.

At the generic level, the *Activity completeness* and *Activity accuracy* provide information for a given activity on thing and states, respectively. The SW activity construct corresponds to the MAP section. Thus, at the specific level, these criteria allow the analysis of a given section by calculating (1) the number of objects in the MAP section that *maps* to an O* object by comparison with the total number of objects in the section and (2) the ratio of states occurring in the section that individually *maps* an O*state.

The generic *System reliability* metric compares the number of business laws implemented in the system to the number of business laws. A business law is implemented in the system if each business state occurring in the law *maps* a system state and the transformations between these business states are possible between system states. The SW and WW constructs of state correspond to the MAP and O* concept of state respectively. The System reliability metric is then identical to the generic metric but using MAP and O* states.

The purpose of the generic *Dynamic realism* is to compare the number of paths present in the system to the number of paths. The path, as defined in the SW ontology corresponds to the MAP path. A path is present in the system if each state constituting it *maps* an O* state and the succession of these system states is possible.

4 Applying Fitness Metrics in the Hotel Room Case Study

In this section, we illustrate the usage of the specific fitness measurement system in a hotel room booking case study.

4.1 Description of the Case Study

Competition with international hotel chains being always harder, the owners of several small hotels made the decision to become partners in order to offer attractive products and provide better services to their clients. They believe that offering packages of products combining room booking, sport activities and cultural manifestations will give them a competitive advantage. They consider important to facilitate the booking process as much as possible and to offer multiple different sale channels. Finally, they opted for both proactive and reactive strategies in order to attract new customers and to utmost satisfy the customers' needs.

These objectives are reflected in the business process modelled with MAP and presented in. Fig. 6.

The map comprises two intentions: "*Offer packages*" and "*Manage customer relationship*" that are in line with the business decisions made. There are a number of strategies associated with each of these two intentions, particularly with the "*Manage customer relationship"*. These strategies reflect the desire to concentrate the business towards satisfying the customer, facilitating his/her booking and being proactive to ensure customer loyalty. The ' *by offering booking facilities'* strategy for example, is a cluster showing that booking can be done on the spot, by Internet or through an agency. '*By proactive offering*' is a strategy which aims at selling a new booking to an old customer whereas the '*by rewarding*' strategy contributes evidently to keep a customer loyal to the hotels group. The process terminates only if the client withdraws his booking or by necessity because his/her behaviour is reprehensible.

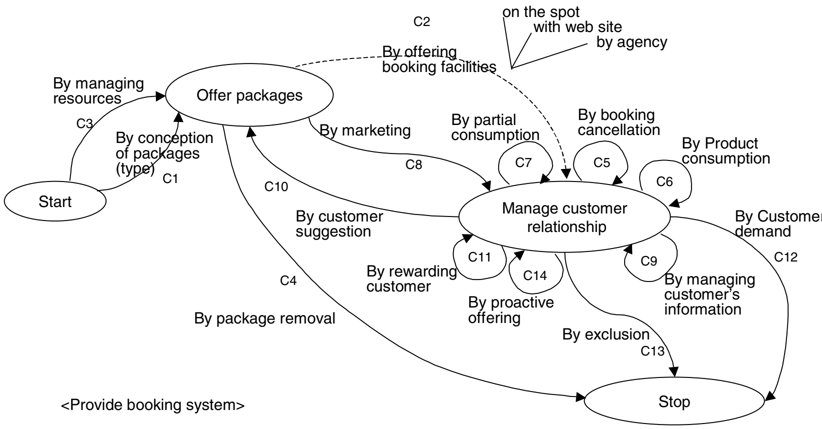

Fig. 6. The room booking business as a map

In order to get a complete understanding of business intentions and strategies, it was necessary do refine a number of sections of the above map. In total, we modelled five maps organised in two levels of abstraction. The complete specification includes 39 sections, 3 actors (the hotel keeper, the partner and the client), 6 objects (Hotel, Destination, Demand, Booking, Client, and Package) and 21 states.

4.2 Measuring the Degree of Fitness

To develop the supporting information system, the hotel owners were having a restricted budget. They decided to adapt a legacy information system and to cope with their budget; they considered the three following options:

- Option 1: the system offers different sale channels to book a package and maintains the customer data over time. But the system does not manage pending requests. Thus, requests are dealt in real time and either transformed into bookings or abandoned.
- Option 2: the system handles pending requests but does not keep customer data. Clients must register at every booking.
- Option 3: combines the management of pending requests and customers data. However, the system does not manage automatically the reorganisation of a booking affected by events such floods or typhoons that make the hotel resources temporarily unavailable.

In order to facilitate the choice of one of the three design options, we proposed to the hotel owners to measure the degree of fit in each of the three cases. We modelled the three options with O* and then, applied the 10 metrics. Results are shown in Table 3 (note that the Activity completeness and Activity Accuracy criteria have been measured for the <*Define, customer request, Management of the pending request, Through wait-listing*> section).

Table 3. Fitness measures

Criteria	Design alternative 1	Design alternative 2	Design alternative 3
Support Rate	0,9(35/39)	0,9(35/39)	1 (39/39)
Goal Satisfaction	0,8 (4/5)	0,6 (3/5)	0,6 (3/5)
Actor Presence	1 (3/3)	1 (3/3)	1 (3/3)
Resource Presence	1 (2/2)	0,5 (1/2)	1 (2/2)
Information Completeness	1 (7/7)	0,86 (6/7)	0,86 (6/7)
Information Accuracy	0,91 (20/22)	0,86 (19/22)	0,86 (19/22)
Activity Completeness	1 (5/5)	0,8 (4/5)	1 (5/5)
Activity Accuracy	0,75 (3/4)	0,75 (3/4)	1 (4/4)
System Reliability	0,89 (54/61)	0,93 (57/61)	0,79 (48/61)
Dynamic Realism	0,79 (53/67)	0,53 (36/67)	0,84 (56/67)

4.3 Discussion

Table 3 considered at the glance, shows that none of the options provides a complete fit as a number of measures are inferior to 1. Option 3 is the only one showing a full system support of all business activities (support ratio = 1) but none of the three options completely supports the satisfaction of business goals (Goal satisfaction <1). The business actors representation is good in the three options (Actor presence =1) but the resource fit is low in option 2. Thus, measures demonstrate difference in the *Intentional* fit provided by the different options. Vice versa, measures shows that the three options deal in a similar manner with the *Informational factor* with an advantage to option 1 where all business objects are represented and managed by the system (Information completeness =1). Along the *Functional factor*, option 3 is the most fitting solution for the given section as the Activity completeness measure and the Activity accuracy equal 1. Finally, measures along the *Dynamic factor* are all inferior to 1. In all options some business states do not exist in the system (Goal satisfaction < 1) thus implying low measures of the fit related to dynamic aspects (System reliability and dynamic realism).

Let us complement this overall evaluation of options by a more in depth reasoning based on the fitness measures. Option 3 is appealing because the support ratio equals 1, i.e. the system supports every business activity. However, other measures have to be considered because each criterion brings a different viewpoint on the degree of fit. Two design options can have the same value for a fitness criterion (e.g. *Support ratio* equals 34/39 in option 1 and 2) and different ones for other criteria (five criteria have different values for these two options). Option 3 has against it the low measure of Goal satisfaction fit which in turn, implies a lower value of dynamic fitness measures compared to option 1.

The decision about the option to implement can be based on its ability to evolve in the future and the fitness metrics can help in this long term perspective. A better fit requires either a business adaptation or a system change. For example, it can happen that some planned strategy in the map of Fig. 8 reveals inefficient in practice and will be abandoned. Vice versa, a better Information completeness measure in option 3 can be achieved by adding the representation of one or more business objects. Thus, taking into account the cost of adding new system objects and its subsequent impact on the improvement of measures in the future can help making the decision now in favour of option 3.

There are dependencies between criteria and these have to be taken into account during this selection phase. For example, if some SW things do not *map* WW things, the states of these things cannot *map* WW states. Therefore, the *Information completeness* value influences the *Information accuracy* value. In the same way, the absence of *mapping* of states influences *Goal satisfaction*, *System reliability* and *Dynamic realism* measures. The improvement of the Goal satisfaction criterion in Option 3 will contribute to raise the value of the dynamic fit.

The introduction of thresholds for measures can facilitate decisions. Thresholds can be determined by stakeholders in order to avoid a situation of unacceptable unfit. In our case, assume that the threshold for the Dynamic realism criterion has been established at 0.8. Options 1 and 2 will be eliminated on this basis.

Finally, it is possible for stakeholders to allocate *weights* to the different activities involved in the business to reflect priority given to certain activities against others. Priority can be given for example, to client satisfaction, profitability, activity frequency, etc. Weighting activities related to customer satisfaction in our case showed that option 3 was the best over the three options and decision was made to implement it. Indeed, option 3 was having a competitive advantage as the business parts weakly represented in the system have no impact on clients. An analysis of the Activity completeness and Activity accuracy criteria strengthens this position. Furthermore, by introducing weighting depending on activity frequency confirmed the choice for option 3. Indeed, the measures help stakeholders realise that exceptional events which have to be handled manually in option 3 are relatively rare and that the low fit due to these can be accepted.

5 Conclusion

In this paper, a process for generating metrics to evaluate the fit between specific business and system models was presented and illustrated. This process uses a set of generic criteria and metrics as a mould for producing the specific fit measurement system. The criteria and metrics developed adopt fit measurement that takes the business view as a reference and compare the system view with it. Therefore in any metric, the denominator always refers to constructs of the system model. This process has been used to generate fitness metrics for the MAP and O* models that respectively represent the business and the system.

We used the generated metrics to show how fitness measures during system design can feed back to improve the fit of the system-under-construction. We considered three design options in the construction of a system to support hotel room booking and based the choice of the option to be implemented on the fit measures. We showed that or each criterion, it is possible to define a threshold value: If the metric determines a value lower than the associated threshold, the business process and supporting software systems are misfiting, motivating corrective action. This action can be a modification of either the business model or the system. Thus thresholding leads to a beneficial cycle of design-measurement-design for better fit.

In order to better take into account the characteristics of each project in the calculation of the fitness measures, we intend to explore the weighting technique that we illustrated in the case study. This allows to attribute relative importance to the different constructs of the SW ontology, according to, for example, the added value, the customers satisfaction, the frequency… For example, the definition of the *Support ratio* considers the number of automated activities and ignores the relative value addition of activities in the business. Thus, it can happen that the support ratio is high but the most value adding activities are not automated. Appropriate weighting obviates this problem.

Our research agenda relies on two key issues: (i) the use of the fitness measurement system in a context of evolution and (ii) the development of a tool to support the proposed process and the calculation of the fitness measures for a given project.

References

[1] Giaglis GM (2001) A Taxonomy of Business Process Modelling and Information Systems Modelling Techniques. Journal of Flexible Manufacturing Systems 13 (2), pp. 209-228.

[2] Fifth Workshop on Business Process Modeling, Development, and Support BPMDS'04 (2004), Riga, Latvia.

[3] Sabherwal, R. and Y. E. Chan (2001). Alignment Between Business and IS Strategies: A Study of Prospectors, Analyzers, and Defenders. Information Systems Research, March, 12(1): 11-33.

[4] Henderson, J. C. and N. Venkatraman (1993). Strategic Alignment: Leveraging Information Technology for Transforming Organizations. IBM Systems Journal, 32(1): 4-16.

[5] Munford, E. (1981) Participative Systems Design: Structure and Method systems, Objectives, Solution, Vo. 1, North-Holland, 5-19.

[6] Rubin KS, Goldberg A (1992) Object Behavior Analysis, Communications of the ACM, vol 35, N°9.

[7] Dardenne A., Lamsweerde A., Fickas, S. (1993): *Goal-directed Requirements Acquisition*, Science of Computer Programming, 20, Elsevier, pp.3-50.

[8] Soffer P (2004) Fit Measurement: How to Distinguish Between Fit and Misfit, note for BPMDS'04, Riga, Latvia

[9] Regev G, Wegmann A (2004) Remaining Fit: On the Creation and Maintenance of Fit. Proceedings of BPMDS'04, Riga, Latvia, 2004.

[10] Wand Y, Weber R (1992) An Ontological Model of an Information System, IEEE Transactions on Software Engineering, November, pp. 1282-92

[11] Soffer P, Wand Y (2004) Goal-Driven Analysis of Process Model Validity. Proceedings of CAiSE'04, Riga, Latvia.

[12] Bunge, M (1977) Treatise on Basic Philosophy: Ontology I. The Furniture of the World, Reidel.

[13] Bunge, M (1979) Treatise on Basic Philosophy: Ontology II. A World of Systems, Reidel.

[14] Rolland C., Prakash N. (2001) Matching ERP System Functionality to Customer Requirements, Proceedings RE'01, Toronto, Canada, pp. 66-75.

[15] Lee S.P., Rolland C., Brunet J.. Abstraction in an Object-Oriented Analysis Method. in Malaysian Journal of Computer Science, Vol. 10, No 1, June 1997, p. 53-63.

[16] Cavano J.P., McCall J.A (1978) A Framework for the Measurement of Software Quality. Proceedings of the Software Quality and Assurance Workshop, San Diego, pp. 133–139,.

[17] Etien A. and Rolland C. (2005) Measuring the Fitness relationship, submitted to the special issue Coordinated Development of Business Processes and their Support Systems of the Requirements Engineering Journal