

BUSINESS PROCESS MODELLING THROUGH EQUIVALENCE OF ACTIVITY PROPERTIES

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Abstract: Since two decades ago, business processes have been gaining attention from IS' managers, consultants and researchers and are becoming a key element in driving IT innovation. Despite such prominence, the concept of business process is not clear enough and even more unclear is the way to depict organization activities into a process blueprint. We claim that a much more precise and consolidate concept for "business process" is required. In this paper, we explain the constraints that influence business process modelling and we propose a solution based on a multi dimensional representation that decomposes processes into the Zachman Framework dimensions. Upon our solution we build up the concept of process equivalence.

1 INTRODUCTION

Business Process is a common concept in many knowledge domains related with organizations and plays a central role in organization management and design. Many authors consider Business Processes to be one of the most important concepts in an organization (Davenport, 1990; Grover, 1995; Hammer, 2001; Labovitz, 1997; Potter, 1985; Senge, 1990; Dietz, 2006; Eriksson, 2000).

Being a description of organization internal behaviour, business processes are fundamental to understand how companies conduct their business, and therefore how they can improve their efficiency, monitor their operations, adhere to regulatory compliance standards, choose the appropriate skills of their staff to achieve better results, use workflow engines for process automation and so on.

The purpose of business process modelling is the construction of a concise, unambiguous representation of a business or a business area in terms of the activities that take place in the organization, either currently ('AS-IS') or in the future ('TO-BE').

Current business process analyses tools allow several process modelling notations to be used, ranging from simple flow charts to more elaborated models such as UML, BPMN, EPC, IDEF3, amongst others. Most tools also allow a series of analysis (impact analysis, what-if scenario analysis,

and process simulation) to be done upon business process blueprints.

Under such a powerful environment of notations and tools, business process modelling should result into business process blueprints that allow a common understanding and vision of the business amongst all business stakeholders and other staff. Unfortunately, this is not what happens in most situations, where one could find multiple process blueprints for the same "organization process". We found two main reasons for this.

On one hand, different process stakeholders belonging to different organization areas - for example business line, IT, Auditing, Compliance, or Human Resource - have different concerns and look for different perspectives from the same business processes. This issue is not at all a new situation. A very similar situation exists in architectural blueprints, where different architecture stakeholders perceive different blueprints of the same system (IEEE, 2000).

On the other hand, too much of the final process blueprint is dependent of the team that has designed it. Different teams always get different blueprints and it is very hard to assess if they are equivalent or not.

In practice, the existence of multiple process perspectives forces the organizations to maintain various process blueprints, most probably in different repositories. Since there are, to our knowledge, no instruments for assessing the

coherence or the equivalence of different process blueprints, this becomes a major drawback for organizations.

In this paper we address the problem of establishing the grounds for business process equivalence, that can be used both for assessing the equivalence between different process blueprints and for defining the rules for producing different process blueprints based on a give master process blueprint kept in some master process repository.

The outline of the paper is as follows. Section 2 presents the state of the art of different approaches, techniques and notations to business process modelling. Section 3 presents our proposal for the concept of business process in the context of the Zachman Framework. Section 4 presents our proposal for process equivalence. In Section 5 we present our case to validate the applicability of this process modelling approach. Finally, we draw some conclusions and describe ongoing research.

2 STATE OF ART - BUSINESS PROCESS MODELLING

Common definitions of business process concepts include a sequence of activities producing “value”:

- A process is a course of action, a series of operations, or a series of changes (Concise Oxford Dictionary).

- Processes represent the flow of work and information throughout the business. (OMG, 2005).

- A business process is a collection of activities that takes one or more kinds of inputs and creates an output that is of value to the customer (Hammer, 2001).

- Every organization exists to accomplish value-adding work. The work is accomplished through a network of processes. Every process has inputs, and the outputs are the results of the process (ISO, 1995).

- A kind of process that supports and/or is relevant to business organizational structure and policy for the purpose of achieving business objectives. This includes manual and/or workflow processes (W3C, 2002).

- A process is a circle of causality that describes a feed back loop of cause and effect. From the systems perspective, the human actor is part of the feedback process, not standing apart of it (Senge, 1990).

- Business process is a flow of activities, with one or more clear starting points and leading to a clearly defined result (Lankhorst, 2005).

- A Business Process is a coordinated set of activities that is able to add value to the customer, and to achieve business goals (Sousa, 2006).

The above concepts of business process are based on the notion of action and value creation. In fact, these definitions do not address all the aspects of the reality that are critical in business process modelling, such as time, location, motivation and used resources to produce the output.

Since these aspects make all the difference in the business world, business process blueprints are normally represented using specific notations (BPMN, UML, EPC or IDEF3) that address a wider scope of dimensions.

- in BPMN, a business process is a network of ‘doing things’. To model a business process flow, you simply model the events that trigger the processes, the processes that get performed, and the end results of the process flow. Business decisions and branching of flows is modelled using gateways. A gateway is similar to a decision symbol in a flowchart. If a process is not decomposed by sub-processes, it is considered a task – the lowest-level process. As one drive further into business analysis, one can specify ‘who does what’ by placing the events and processes into shaded areas called pools that denote who is performing a process. One can further partition a pool into lanes. A pool typically represents an organization and a lane typically represents a department within that organization (although you may make them represent other things such as functions, applications, and systems).

- In UML a business process consists of one or more related activities that together respond to a business requirement for action. A process defines the results to be achieved, the context of the activities, the relationships between the activities, and the interactions with other processes and resources. A business process may produce events for input to other systems or processes. A business process may also invoke applications to perform computational functions, and it may post assignments to human work lists to request actions by humans. Business processes often involve the assignment of resources, such as human participants, facilities or materials. Resources to be assigned to a managed process are specified by selection criteria to be applied to a defined source of resources. This may be, for example, people in an organization, facilities on a campus or materials in an inventory.

- Event-driven Process Chains (EPC) is a method developed by Scheer, Keller and Nüttgens within the framework of Architecture of Integrated Information System (ARIS) to model business processes. In EPC a business process is a collection of elements that are capable of portraying business information system while at the same time incorporating other important features such as functions, data, organizational structure and information resources as already described before.

- In IDEF3, a business process is an ordered sequence of events involving people, materials, energy, and equipment that is designed to achieve a defined business outcome. They not only define what the business does, but more importantly, they determine how well the business does what it does.

We classify (Table 1) the elements that characterize each notation in 6 dimensions (what, who, where, how, when, and why) that are the common questions to characterize a happening or situation.

Table 1: Notations' Elements into the Zachman Framework's Dimensions.

Notation	Element	Dimension
<i>BPMN</i>	Event	When
	Activity	How
	Gateway	Why
	Swimlane	Where (Who)
	Data Object	What
<i>UML</i>	Activity	How
	Decision Point	Why
	Swimlane	Where (Who)
	Action Object	What
<i>IDEF3</i>	Unit of Behavior (UOB)	How
	Object	What
	Junction	Why
<i>EPC</i>	Event	When
	Function	How
	Organization Unit	Where (Who)
	Information, material, or resource object	What
	Logical connector	Why

Unfortunately, neither the syntax nor the semantics of these notations are well defined. As a result, a business process represented by these notations may be ambiguous. Moreover, it is not possible to check the model for consistency and completeness. The absence of formal semantics also hinders the comparison of models between different notations and prevents the use of powerful analytical techniques.

Looking into formal business processes definitions, they are rather limited in scope,

regardless of their accuracy. The most popular formal technique for business process modelling is the Petri Net which exhibit concurrency, parallelism, synchronization, no-determinism, and mutual exclusion. In this technique the main concern is how the workflow is represented and not considers the others dimensions with the same relevance. In other formal definitions a process is defined mostly by its outputs (Jagannathan, 1995; Linz, 2000).

As an example of formal approaches limitations, if two processes have the same output (results) but use different human skills in different locations and in different moments, would be consider equivalent by formal approaches, whereas there are by no means equivalent in the real world.

Besides the issue of the concept and model of business processes, there is another relevant issue that leads the same real process be depicted as to multiple and different process blueprints.

Although several methodologies or approaches that conduct us to produce a business blueprint within a type of graphical where the methodology for process modelling is understood fundamentally as an art where the experience and common sense are mandatory skills.

Regardless these methodologies could follow top-down approaches (breaking up value creation in to smaller activates), or bottom-up approaches (aggregating activities into value creation granularity) there are no guaranties that the blueprints obtained will be the similar.

In this cycle of breaking processes into activities or aggregating activities into processes and represent them graphically, the boundaries between what can be designate as process or activity is unclear in most of the previous methodologies or notations, and the concept of process equivalence is not applied or formally stated.

In summary, we presented two causes for the importance of having a mechanism to analyze business process equivalence: i) multi-blueprints and ii) modelling skills.

To tackle these issues, this paper proposes using a set of modelling rules derived from the Zachman Framework Dimensions to model business processes.

3 BUSINESS PROCESS MODELLING IN THE CONTEXT OF THE ZACHMAN FRAMEWORK

The Zachman Framework (Zachman, 1987) for Enterprise Architecture is probably the best known framework for describe an architecture of an enterprise. It proposes a logical structure for classifying and organizing the descriptive representations of an enterprise.

The Zachman framework proposes a matrix-like structure for classifying and organizing the representations of an enterprise (Sowa, 1992; Zachman, 1987). The rows consider six different perspectives on the enterprise, representing its major stakeholders: visionary, executive leader, architect, engineer, implementer and the organization worker. The columns specify six contextual dimensions summarized in Table 2.

Table 2: Dimensions of the Zachman Framework.

Dimension	Focus	Purpose
What	Data	The enterprise's information and its dependencies.
How	Function	The process of creating value to the organization into its business and into successive definitions of its operations.
Where	Network	The geographical distribution of the organization's activities and artifacts.
Who	People	Who is related with the major active elements that animate business processes, information and IT. It goes from organizations, to HW servers, passing thought Departments, Roles and People.
When	Time	How each artefact relates and evolves with time.
Why	Motivation	The translation of goals into actions and objectives.

We support our approach in business process modelling through based on thee of the six properties of the Zachman Framework (Inmon, 1997):

- classification: every artifact of the organization can be uniquely classified;
- recursiveness: the whole framework can be applied to further specify the contents of each cell. Usually one applies the Zachman Framework to an enterprise, but every single artefact of the enterprise can be better understood if one applies the whole framework to it.

- cell uniqueness: which tells that each cell of the framework must be described with the sufficient level of detail so that it accomplishes its purpose.

We make use of the Zachman Framework recursively (Figure 1) to express the characterization of business processes, but we will focus on the first two rows of the framework.

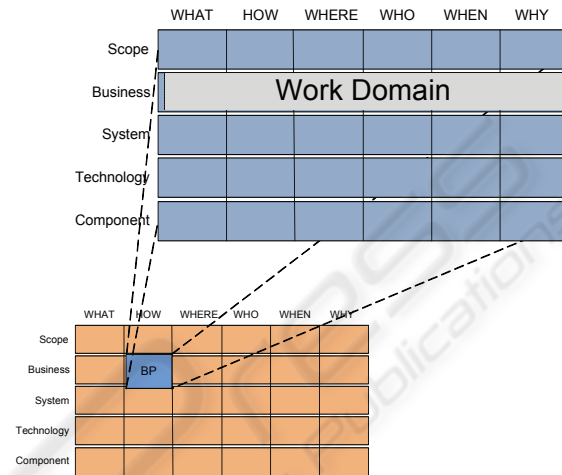


Figure 1: Zachman Framework Recursive Use.

The cell uniqueness is the second rule of the Zachman Framework, So, each dimension of the framework is in fact a hierarchy of concepts/values, typically presented as a tree (Figure 2).

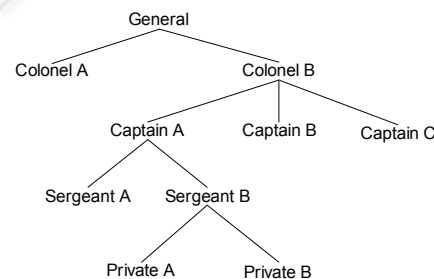


Figure 2: Dimension Tree (Who's Dimension).

Generically, we define G as the hierarchical tree on each dimension (D) of the Zachman Framework:

$$D_i = \{G_1, \dots, G_n\},$$

where i is each one of the six dimension of the Zachman Framework.

In figure 2, we present the tree as show next,

$who = \{General(Colonel A, Colonel B(Captain A(Sergeant A, Sergeant B(Private A, Private B)), Captain B, Captain C))\}$

Therefore, a business process can be defined as a set of connected activities with inputs and outputs, which interact with people, contribute to achieving business goals, take place in a specific location and occur during a period of time (Pereira, 2006).

Applying the previous business process definition, and attending to the dimension hierarchy level (see figure 2), a business process can be represented as a concept which is related to others concepts that belong to a set of elements $\{D[n,i]; \dots; D[n,i]\}$, where n represents the level in the dimension tree (D) and, $i \in \{\text{what, how, where, who, when, why}\}$, as figure 3 presents.

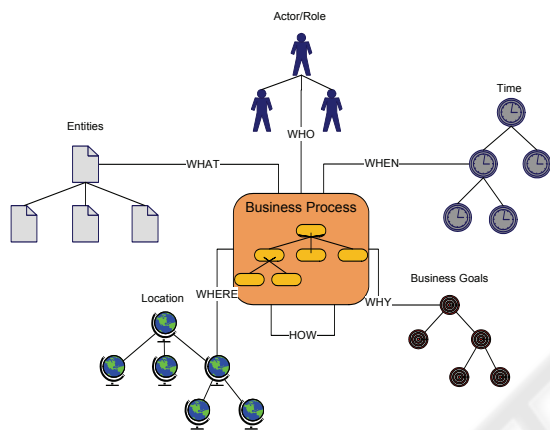


Figure 3: Business Process and the Zachman Framework Dimensions.

Doing this classification we can realize that any concept used to represent processes is as a matter of fact an instantiation of one dimension and, any dimension can be decompose until the level that one thinks that is sufficient enough to describe that process.

For the *how*'s dimension, we model business work using a recursive and hierarchical structure for a single concept which we call *process*. Processes can be decomposed infinitely into other processes. However, we name the leaves of the process tree as *activities*. So, activities are processes that have no further decomposition.

To decompose processes into activities, we will apply a rule for process decomposition (Pereira, 2006). This, which specifies that a process α should be decomposed into two or more distinct discrete activities if one of the following conditions is satisfied:

- α can be decomposed into two activities such that they receive/create different data entities.

- α can be decomposed into two activities such that they are processed using different applications.
- α can be decomposed into two activities such that they occur in different locations.
- α can be decomposed into two activities such that they involve different business actors.
- α can be decomposed into two activities such that they are performed in distinct periods of time.
- α can be decomposed into two activities such that they exist to satisfy different purposes.

So, at this point, we are in conditions to model business process. For example, one could say that if a process as an activity k that involves person $p1$ and $p2$ in such a way that one could state that $p1$ works before $p2$, the one could model k as $k1$ and $k2$, where $p1$ is involved in $k1$ and $p2$ is involved in $k2$. Now, if $p1$ and $p2$ participate in $k1$, then we could not decompose k .

Given the two processes modeled as above, how can we say that two different business blueprints are equivalents? What criteria should be applied to choose one instead of the other? As we previously referred, there are no allusions how to solve this issue on the methodologies or notations for modeling business processes. In next section we present our approach for identify equivalence between business processes.

4 BUSINESS PROCESS EQUIVALENCE

As any other modelling and architecting activity, process modelling is understood fundamentally as an art where the experience in consultancy, knowledge of the business and common sense are mandatory skills.

One could argue that such scenario occurs in any modelling activity and in fact is similar to other modelling domains such as data modelling in database. Indeed the same issues arose, but due to many decades of consolidation and solid theoretical models, data modelling has found means to overcome much of the problems we encounter in business process modelling. Database conceptual models together with the relational model provide sound mechanisms to address such issues.

In fact, in what concerns the first cause presented on the previous section, multi-blueprints, the concept of view is a mechanism that allows having different inspections upon a common and single

canonical model. The coherence amongst the different views is ensured by the canonical model. We claim that a formal mechanism is needed to define process views over a single and canonical business process.

Regarding the second cause, skills for modelling, data models do tend to be very dependent of the modeller, but, despite such dependency, the concept of “model equivalence” is a primitive that allows checking the equivalence between the different models.

In data modelling, a concept - for instance and entity in the Entity Relationship model or a class in the UML class model- is solely defined by the properties of that concept (Batini, 1992). For example, in the case of the Entity Relationship model, the properties of the concept Entity are its attributes, an identifier and the relationships with other entities. Thus two Entities are equivalent if they have the same properties, regardless of their name. In figure 4, we present two equivalent definitions of the same Entity, even though the designer name them differently.

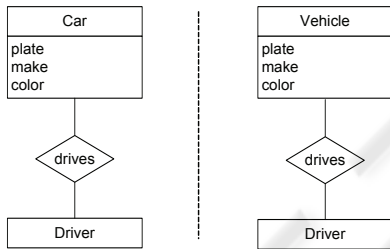


Figure 4: Entity Equivalence Example.

We propose that the same should occur with business process models, as the following example illustrates in figure 5. Consider two simple scenarios (A and B). In scenario A activities were named *Driving* and *Riding*. However, both activities are associated with a *Truck* and have *John* as the driver. In scenario B, both activities were named *Driving*, though the first activity is associated to a *car* with *Paul* as driver, whereas the second is associated with a *Truck* with *John* as driver.

Regardless of the names given to each activity, it is clear that they are equivalent in scenario A, and that they are not equivalent in scenario B.

In database models, equivalence goes a step forward. A database schema S_a (a set of entities and relationships) is functionally equivalent to a database schema S_b if, for each query one may think off for schema S_a , there is a query for schema S_b that produces the same value.

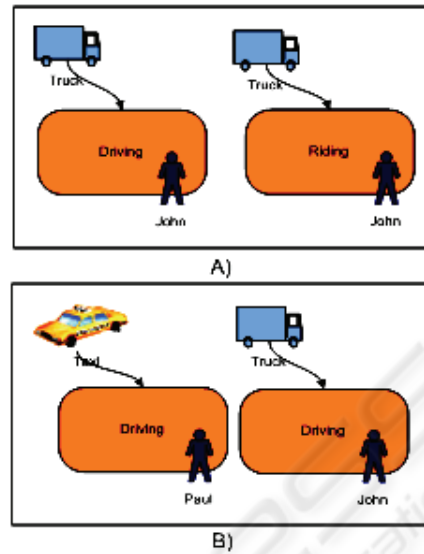


Figure 5: Activity Equivalence Example.

Defining the processes of scenario A of figure 5 as follow:

Driving {*Truck*[1,what]; *John*[1,who]}

Riding {*Truck*[1,what]; *John*[1,who]}.

Is it possible to say that *Driving* is equivalent (\equiv) to *Riding*? To answer this question, we will present a set of principles that will help us to say in which conditions two processes are dimensional equivalents, but at this point, to simplify our presentation, we consider first the simple case of dimensional activity equivalence. Dimensional equivalence is a weak type of equivalence.

$A \equiv A'$: An activity (A) is dimensional equivalent to another (A') when each activity has equal $\{D[n,i]; \dots; D[n,i]\}$ and i is not null.

This means that A and A' have NO DIFFERENTE when, what, where, who, and why

So, we can conclude that in the scenario A, *Driving* is equivalent to *Riding* and, therefore the use of different names for the same meanings could be detected.

Regarding scenario B of the figure 5:

Driving {*Truck*[1,what]; *John*[1,who]}

Driving {*Car*[1,what]; *Paul*[1,who]} .

Applying the previous principle, we can conclude that these activities, despite their equal name, are not equivalent, because they have different *what* and *who*. This is the case of using same name for different meanings.

To address the situation of dimensional process equivalence, we will use the same principle of dimensional activity equivalence.

For that we will use the concept of transitive closure (T), which means, consider a directed graph $G=(V,E)$, where V is the set of vertices and E is the set of edges. The transitive closure of G is a graph $G+ = (V,E+)$ such that for all v,w in V there is an edge (v,w) in $E+$ if and only if there is a non-null path from v to w in G.

$P \equiv P'$: A process (P) is dimensional equivalent to another (P') when P transitive closure (T) is equal to P' transitive closure:

$$T(P) = T(P')$$

This means that P and P' have the same when, what, where, who, and why for all of its children, if the dimension is used.

Using the following example, *Cooking a Chocolate Cake* and *Cooking an Apple Cake* are two processes. Let us imagine that the process of Cooking a Cake can be decomposed in: sift, stir, sprinkle and cook. Probably we could decompose some of them a little more, but let assume like this. For cooking a cake we need ingredients, one or more people to do it, a specific location, time, and a motivation. By common sense, if we follow the same recipe for cooking the cake, we probably will have the same result. Imagine now that we are going to cook a chocolate cake and an apple cake. We will have the same activities, but we need to change ingredients to have different cakes. Can one say that *Cooking a Chocolate Cake* and *Cooking an Apple Cake* are dimensional equivalents?

Yes, they are equivalent if we use the how, where, who and when, because to cook the cake we have the same activities, done by the same person, in the same place at same time, however if we consider the what dimension the ingredients are different and for that we can not say that they are equivalents.

Resuming, dimensional process equivalence is translated in the relationship that a process has with other dimensions. As we referred, dimensional equivalence is a weak type of equivalence since we only consider the structural aspect of the process. To accomplish full equivalence we should also consider the behavioural aspect of the process, i.e. the flow among activities. This characteristic will be address in future work.

5 CASE STUDY

We conduct an experimenting case to validate the applicability of this business process modelling approach. We create two different teams, Team A and Team B responsible for design activities for the same organization. Each member of team A had a mission describing those activities recurring to all the dimensions of the Zachman Framework. The members of team B should describe activities aggregated for dimensions, which means, they only should be considered as different activities those whose the dimension answers were not the same. The purpose was to produce, as many as possible, activity schemas and compare them at the end.

Examples of those blueprints are the following figures that show a real example, for a Governmental Travel Agency with two processes for booking trips. The first type of booking is open for everybody (figure 6); the second one is exclusive for senior people, which implies specific documentation to prove that they are in conditions of use the special price rates (figure 7). We have different blueprints to represent two processes with activities that have the same name but we can conclude that they are equivalent.

During this phase of experimentation and blueprint's analysis we develop a tool for controlling the level of detail in which each dimension will be used for equivalence evaluation. This Level of Detail Controller (Figure 8) enables us to set up the level for each dimension and therefore define the criteria to apply in the process equivalence analysis.

In the blueprints of figure 6 and 7 the controller was set up as we present on figure 9 and in these conditions the activities *Book Reservation* are not equivalents based on what we present previously in this paper, because they take place in different locations, one is executed in *Reception Desk* and the other in *Booking Desk*. However, if we reset up the controller as we show in figure 11 we could say that those activities are equivalent, because they refer the same location (*where*), use the same input data (*what*), produce the same output data (*what*), produce the same output data (*what*) and are performed by the same people (*who*).

During this experimenting case we have realized that for applying the principles of equivalence through the Zachman Framework dimensions leads to decompose concepts in several levels of detail. This implies a large number of instances and without a tool is not very practical for human manipulation and analysis.

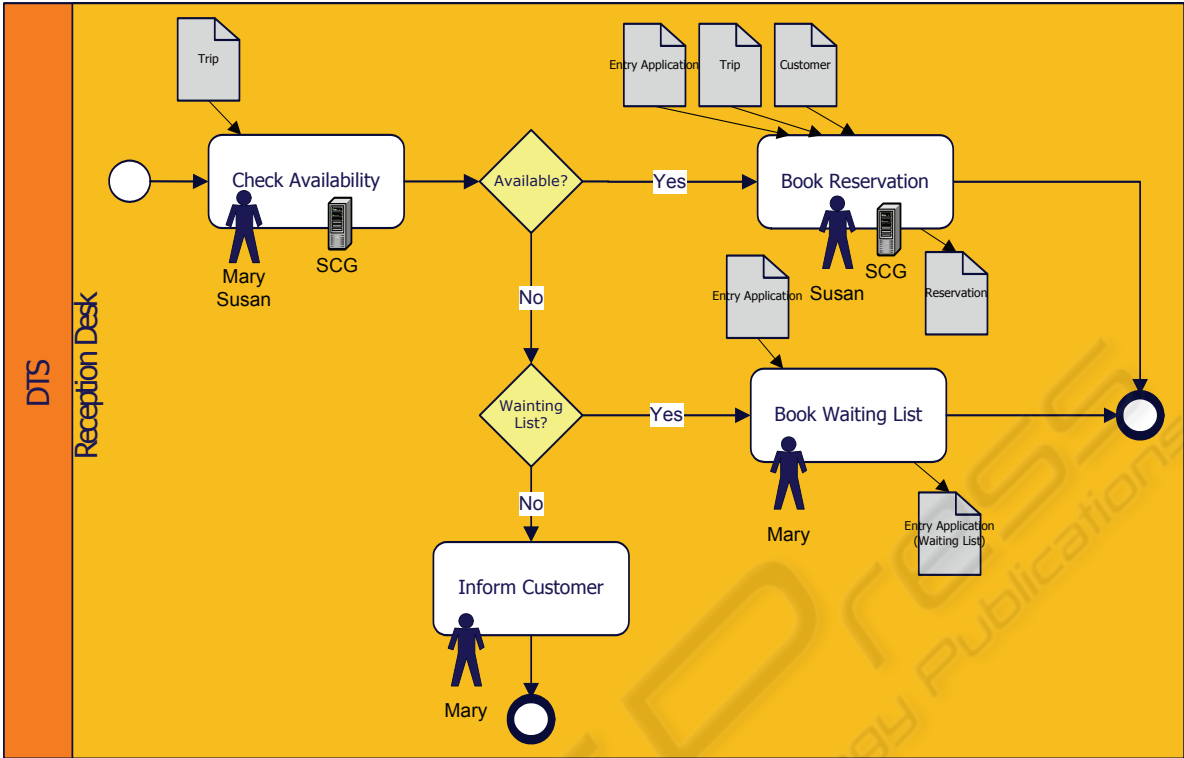


Figure 6: Booking Trip Blueprint.

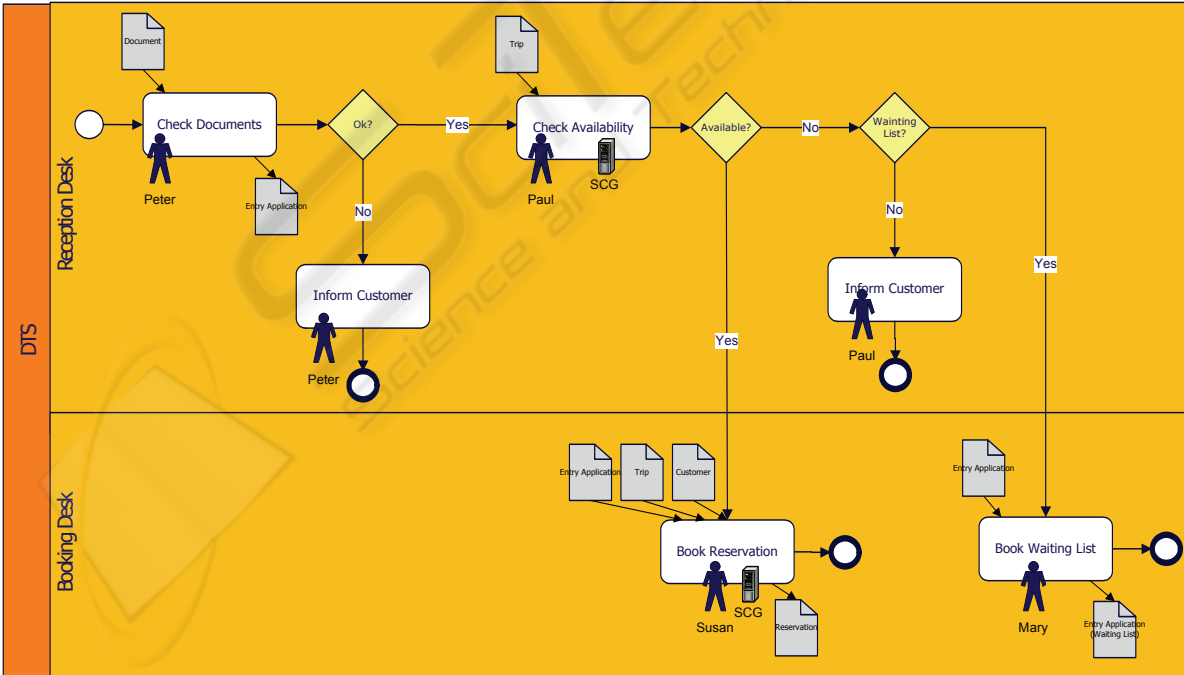


Figure 7: Booking Trip Senior Blueprint.

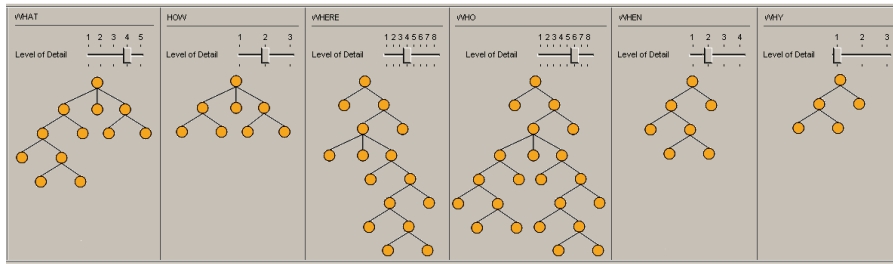


Figure 8: Level of Detail Controller.

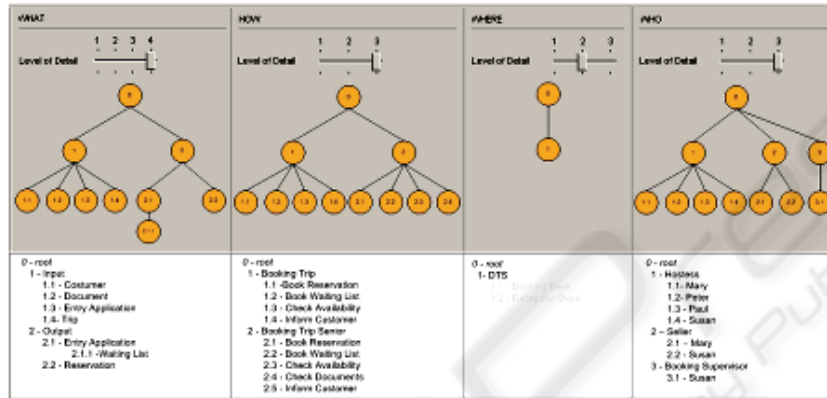


Figure 9: Controller Criteria I.

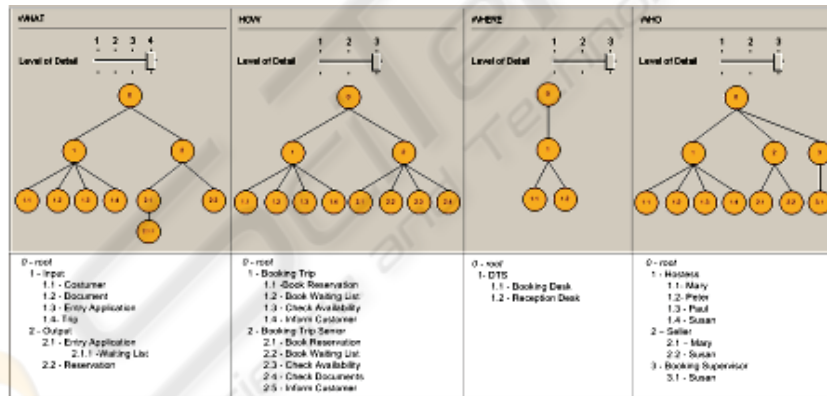


Figure 10: Controller Criteria II.

We used the enterprise architecture tool, System Architect, to manage all process instances and their relationships.

The implementation of the proposal approach for business process modelling holds the necessary information to achieve two major results:

- (1) There is more independency and objectivity for teams doing the process analysis; this means that after they populate the tool with business processes blueprints, this can evaluate them through the principles of equivalence that we proposed.
- (2) It allows us to building specific views to specific process stakeholders. A view is a set of dimensions criteria that are different in processes or activities. For example, a view including only different *why*'s would lead to the common value producing view of processes.

A view including only *where*, *what* and *when*, would be suited for a logistics view of the processes. A view based on *who*, would be adequate for the human resources analysis. A view based on *what* and *how*, would be suited for and information systems analysis, and so on.

6 CONCLUSIONS AND FUTURE WORK

In this paper we discussed the difficulty in modelling business process which consequently produces different business blueprints. We propose a business process modelling approach based on the Zachman Framework Dimensions. We can conclude that using these criteria for analyzing and designing business processes and activities we reduce the number of different blueprints. We also believe that such an engineering approach for processes would lead to a solid basis for addressing other domains, such as Enterprise Architecture, IT Alignment, Organization Reasoning, etc.

We introduce the concept of dimensional process equivalence and we are optimistic relatively to its pertinence and applicability in business processes blueprints.

Our ongoing and further work also includes understanding the relationships between the Zachman Framework's rows and columns as well as the joint criteria that can be obtained from them. It is also important to analyse the correct sequencing of the criteria in order to define a business process modelling method within a given context. It is our intention extends these principles of equivalence to any concept of an organization.

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