Model-Driven ERP Implementation

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Abstract. Enterprise Resource Planning (ERP) implementations are very complex. To obtain a fair level of understanding of the system, it is then necessary to model the supported business processes. However, the problem is the accuracy of the mapping between this model and the actual technical implementation. A solution is to make use of the OMG's Model-Driven Architecture (MDA) framework. In fact, this framework lets the developer model his system at a high abstraction level and allows the MDA tool to generate the implementation details. This paper presents our results in applying the MDA framework to ERP implementation based on a high level model of the business processes. Then, we show how our prototype is structured and implemented in the IBM/Rational® XDE® environment

1 Introduction

Due to the increasing pressure on IT cost and standardization, a growing number of companies have turned to Enterprise Resource Planning (ERP) systems to build their core IT system. Formerly limited to big companies, the phenomenon also reached the Small and Medium Industries (SMI) [21]. It is now widely accepted that ERP systems provide a viable alternative to custom application development for the standard information management needs and that it is often superior in terms of quality of the implemented business process [8]. If ERP systems have become a true alternative to custom-made IT systems, managers are concerned about the excessive dependency it may leads to the ERP vendor. Seen from the outside, an ERP implementation is overwhelmingly complex. Also, it is seldom the case that the IT team of a customer company masters all the details of its ERP system. In fact, when some large modification must be made to the system, it often requires the help from the ERP vendor's consultants. This may lead the company management to feel that it is "loosing control" over its IT system. A solution is to provide the management with a model of the system which would fit its level of understanding and expertise. In fact, the right modeling level rests at the business process level and should be expressed in some graphical way. However the modeling tool and graphical language should not bring yet another level of dependency. This is why our tool and approach use UML and its extension mechanism to design the standard business modeling elements and semantics. In fact, an UML extension has already been proposed by Eriksson & Penker [6] that closely matches one of the widely used business modeling standard [4]. It complements the

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UML Business Modeling Profile published by IBM [13]. We then used the Eriksson-Penker profile and implemented it in a widely available and extensible modeling tool, XDE® from IBM/Rational®. However, for this approach to be successful, one must make sure that the model is aligned with what's implemented. A very promising way to do it would be to generate the parameterization elements from the model itself. Starting from this idea we then investigated the use of the OMG's MDA framework [15,5] to build a semi-automatic ERP customization tool. Starting from a business process model, the tool then gradually refines the model into increasing level of detail down to the database elements necessary to implement the processes on the target system.

2 Related Work

Acknowledging the fact that the mismatch between the enterprises needs and the system customization is one of the reasons for ERP implementation failure [22] and that the proprietary customization language is often hard to manage, some attempts have been made to replace it by some standard graphical language. On the other hand, the need to develop business process models for ERP implementation projects is well known [7]. The Use-Case and Object Oriented (OO) approach to model business processes has been advocated by Jacobson since the mid nineties [12]. Later, the use of UML as a business process modeling language has been widely documented by IBM/Rational consultants [16,3,10]. But the application of the OO concepts to ERP implementation has not been proposed until recently. For example Arinze and Anandarajan [2] proposed an OO framework to ease the customization of an ERP system. However, their approach does not really improve the level of modeling. It mainly replaces the proprietary customization language by some OO representation. But the business processes themselves are not the target of their modeling tool. The modeling of the business processes in a ERP-independent format has been proposed by Sheer [18] who developed the commercial product ARIS [11]. However this approach yet reintroduces a level of dependency, not to the ERP system but to the tool vendor. The use of the OMG's MDA framework to model the enterprise and its processes has been deeply investigated by Wegman [23]. But his model has not been applied to the development or customization of IT systems. Linvald and Østerbye recently proposed the use of UML to implement an ERP system [14]. However, it concentrates on the visual aspects of UML and does not propose any methodology nor does it use the MDA framework. On the other hand, Rolland and Prakash proposed to use UML to model the functional requirement of an enterprise IT system and to compare it to some target ERP system [17]. But this work stays at the specification level and does not deal with the customization problems. Finally, it is worth noting that the advantage of using one unique modeling language, namely UML, for business as well as system modeling has been advocated by Heberling et al. [9]. But their work does not mention the use of UML for ERP implementation.

3 MDA and ERP Implementation

One of the motivations behind the design of the OMG's MDA framework is to promote platform independence when designing IT applications. In fact, the developer will concentrate on the platform-independent features of his application and will let the programming environment generate the details and programming elements according to the chosen target platform. The highest conceptual model, the CIM (Computation Independent Model), is targeted at domain practitioners [15]. It is sometimes called the domain model and includes the main concepts and entities of the domain. Then, by adding the knowledge of the common business processes implemented in any ERP system one gets the Platform Independent Model (PIM). Although the target ERP platform should not be considered at this early stage of the modeling process, one nevertheless knows that the target is an ERP system and not a custom-developed application. This is consistent with the observation of Almeida et al. [1] that the design of the PIM should know the "general capabilities of the potential target platform". In this sense, the MDA framework resembles the best practices in ERP implementation: first design the business process to be implemented then proceed with parameterization [19]. All our models are based on UML and its lightweight extension mechanism: the UML Profile. As UML is becoming standard knowledge for IT engineers, using our technique will save them the burden to learn some proprietary ERP implementation language. Moreover, our approach can be implemented in any commercially available tool which supports the MDA framework, such as IBM/Rational® XDE®.

MDA was initially intended to generate custom made applications. In this case the last step of the process, the transformation from the PIM to the Platform Specific Model (PSM), represents the code generation for the target platform. In the case of an ERP, the system is already implemented. It must only be configured according to the target business processes. This amounts usually to the generation of the parameters in the ERP's tables. Grossly speaking, an ERP system is like a toolbox of components (visual and non visual) to enable/disable and tune according to the process to be implemented. This is why the customization of an ERP differs from code generation: we do not generate or remove components; we only enable/disable components and generate constraints information for the ERP parameterization engine to configure the system. Of course, many ERP customizations include the programming of some specific function using the ERP's integrated programming environment. This could to a large extent be modeled as Object Constraint Language (OCL) expressions. But this very capability is not covered in the present paper as we only target the generation of the ERP parameters.

4 Steps of the Implementation Method

To extend the UML language to include the business process modeling we designed a UML profile that includes some new stereotypes and tagged values [20]. Tagged values are used to propagate the customization information among the MDA models by the MDA transformations. For example, some of the tagged value will tell the system if a given entity will be enabled or disabled on the target system leading to its presence / absence on the screens.

4.1 CIM and PIM Model Elements

In the case of an ERP, the CIM and PIM models are pre-built and represent the entities of the domain model. In fact, the PIM is not *generated* from the CIM but it is *tuned* according to the target process to implement. The elements of theses models are business entities represented by the *Resource* stereotype, which is an extension of the “Class” metaclass in the UML meta model. According to [6] a resource is an entity which is either consumed or transformed by a process. Moreover, a Boolean tagged value is associated to each of these entities to represent the state of the entity: ‘used’ or ‘unused’. Examples of such resources are: item, order, currency, invoice or loan. Figure 1 shows a subpart of the CIM model built in our prototype system.

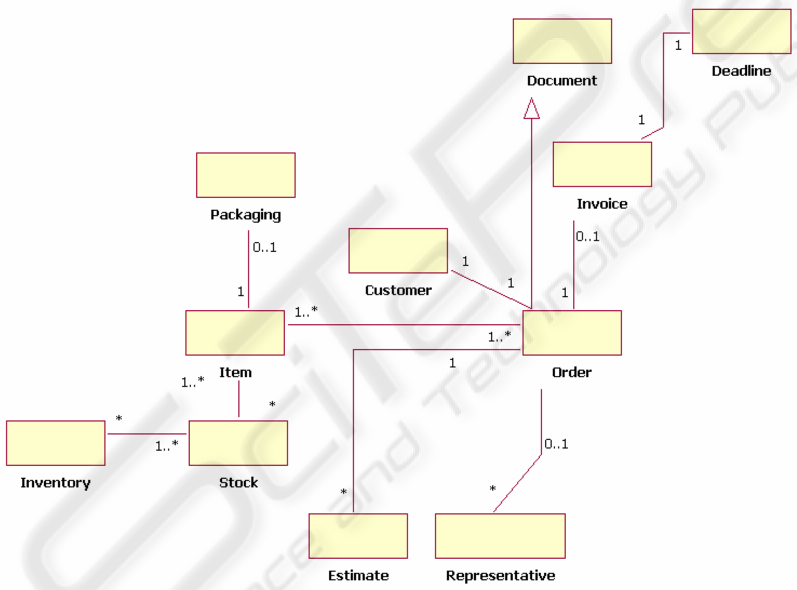


Fig. 1. The CIM model.

4.2 PSM Model Elements

The elements of the PSM are specific to each target ERP system. They are implemented as table rows, code units, forms, screens and reports (whose parameters are usually represented as values in table rows). In our prototype, we targeted Adonix®, one of the leader ERP system in the SMI business segment. Then, the PSM takes the form of value of rows in the Adonix tables.

5 Transforming the CIM to the PIM

On of the key feature of our approach is that the transformation rules from CIM to PIM and from PIM to PSM are themselves represented as models. In fact, our goal with this approach was to make it as easy as possible for the ERP customers to use our tool to configure their system. Then, the CIM to PIM transformation is represented by the high level model of the generic business process to be implemented in the ERP. This model is used to propagate tagged values from the CIM to the PIM depending on the state of each of the business process' tasks. When an engineer must configure a transformation, he will simply select the generic process to be implemented from a library, then select the tasks that must be enabled (used) or disabled (unused) in this process. For example, if a process is disabled, then the linked resources will also be disabled. This will then further propagate to all the processes that use or manipulate these resources. Next, if a resource represents the output of a disabled process, then it is also disabled and all processes that use this resource as input will also be disabled. At the end of this propagation step, any OCL constraints that represent specific limitations, initial values, message or time constraints in the CIM must be copied to the PIM. Figure 2 shows a business process model that represents the CIM to PIM transformation rule in our prototype system, with its associated resources, people, information and goals.

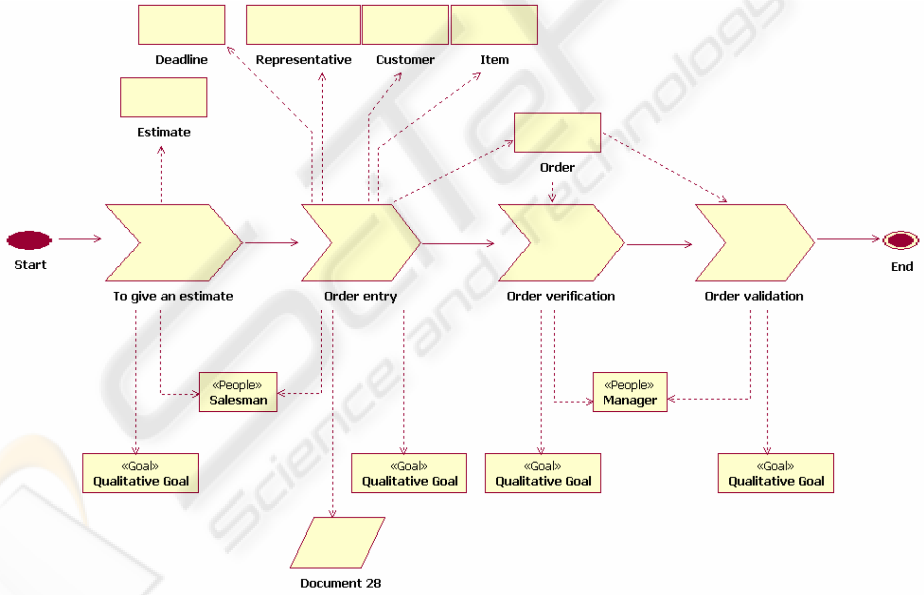


Fig. 2. Transformation rule: a process model.

The business model that represents the transformation rule from CIM to PIM is built from the following elements.

Business process (stereotype): represents a set of activities to be performed by people. It may be structured as a hierarchy of sub processes where the lowest level is the *activity*. The business process is therefore an extension of the “Activity” metaclass (fig 3). However, the activities associated to a given process are platform dependent. Therefore they will be defined when dealing with the PIM to PSM transformation. When building a process model, the resources must be linked to the business process which manipulates them.

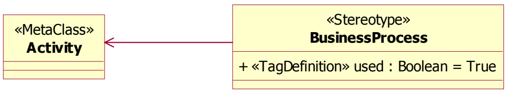


Fig. 3. The Business Process metaclass.

People (stereotype): represents a “human resource” that is associated to a process. It is an extension of the “Class” metaclass (fig 4). This element is used to define authorizations profiles over the system (access rights to the ERP functions). *Goal* and *information* (stereotypes): represent the business goal of a process and the information required to perform a process. These elements must be linked to their business process. For the moment, these two elements are used for documentation purpose only. They both are extensions of the “Class” metaclass (fig 4).

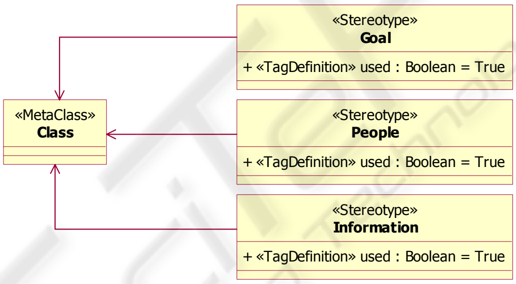

«Stereotype»
Goal
+ «TagDefinition» used : Boolean = True
«MetaClass»
Class
«Stereotype»
People
+ «TagDefinition» used : Boolean = True
«Stereotype»
Information
+ «TagDefinition» used : Boolean = True

Fig. 4. The metaclasses for resources.

6 Transforming the PIM to the PSM

The PIM to PSM transformation is also represented by a model. In this case it is the model of the actual implementation, in the target ERP system, of the generic business process used as the CIM to PIM transformation. This implementation is represented as a set of *Business Activity* diagrams, each diagram corresponding to one of the tasks of the business process. These models are used to configure the PSM model elements according to the tagged values of the PIM model elements and the status of each of the activities of the activity diagrams of the tasks. In fact, when an engineer must configure a PIM to PSM transformation, he will simply select the status of the activities in the activity diagram that represents the business task to configure. The value of the status of an activity is dependent on the target ERP system. For example, one may have : unused, optional, obligatory, shown,… In figure 5 we represent a business activity diagram that shows the entity linked to each of the activities. The figure also shows a pop up menu that let the configuration engineer choose the status of one of the activities.

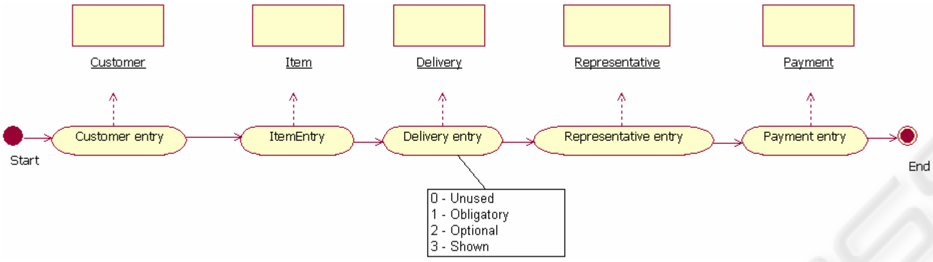


Fig. 5. Business activity diagram for a business process.

The transformation process will propagate the values of the activities' status to all the attributes of the linked business entities, unless the latter were already disabled by the first transformation. For example, if the status of the "Payment entry" activity is set to "Obligatory" then all the attributes of the linked business entity "Payment" entity will be set to "mandatory" through the addition of a new property. From the final status of these entities, the system will generate the parameters for the target platform. Finally any OCL constraints will be processed to generate the constraint in the appropriate target format. For example if, as in Adonix, the target of the customization process is a set of tables, a set of generic SQL scripts will be executed to populate these tables using a mapping file that holds the mapping from the entities and their attributes to the tables' records.

The activity diagram that represents the transformation rule from the PIM to the PSM is built from the *BusinessActivity* stereotype which is an extension of the "Activity" metaclass (fig 6). A business activity may be of type data entry, data validation or data selection. It is linked to the resources it manipulates. A tagged value "status" is associated to each business activity to represent the user-selected status of the activity (see figure 5).

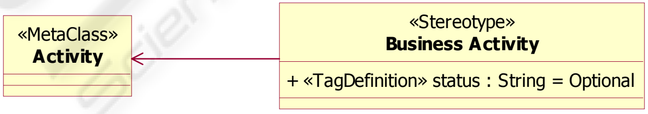


Fig. 6. Business Activity metaclass.

The business activity diagram associated to each business task is ERP dependent. Then, it must be created for each new target ERP platform. Moreover, if the target of the customization process is a set of tables, one must also create the mapping file from the business entities to the tables of the target platform. In figure 7, we summarize the steps of the transformation from CIM to PIM to PSM using the technique we described.

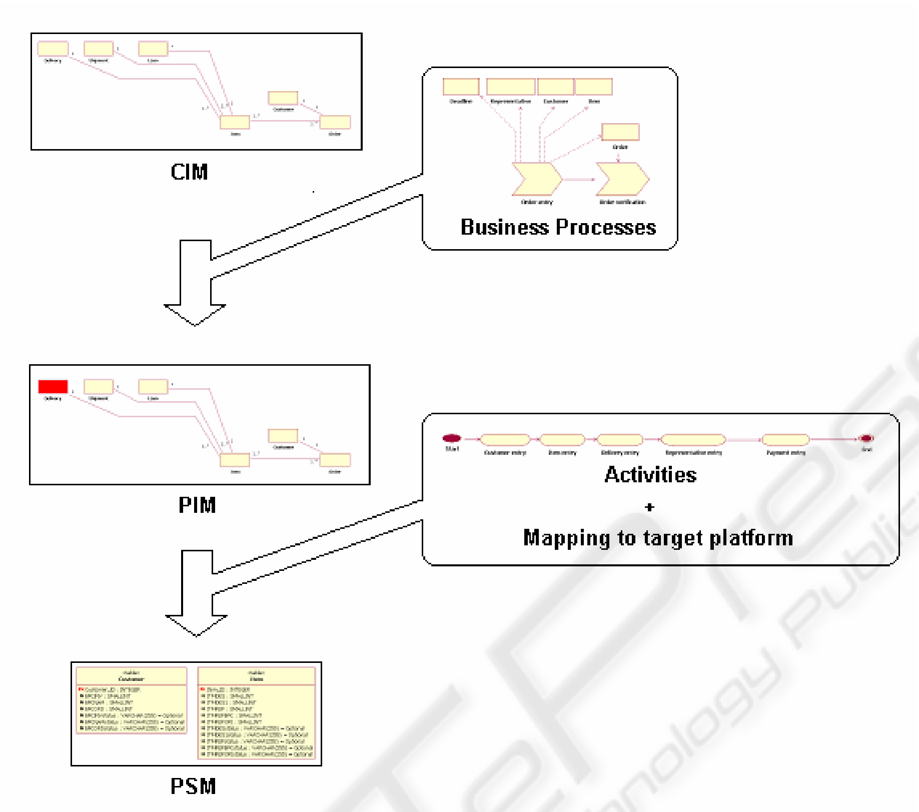


Fig. 7. Summary of the model-based MDA transformations.

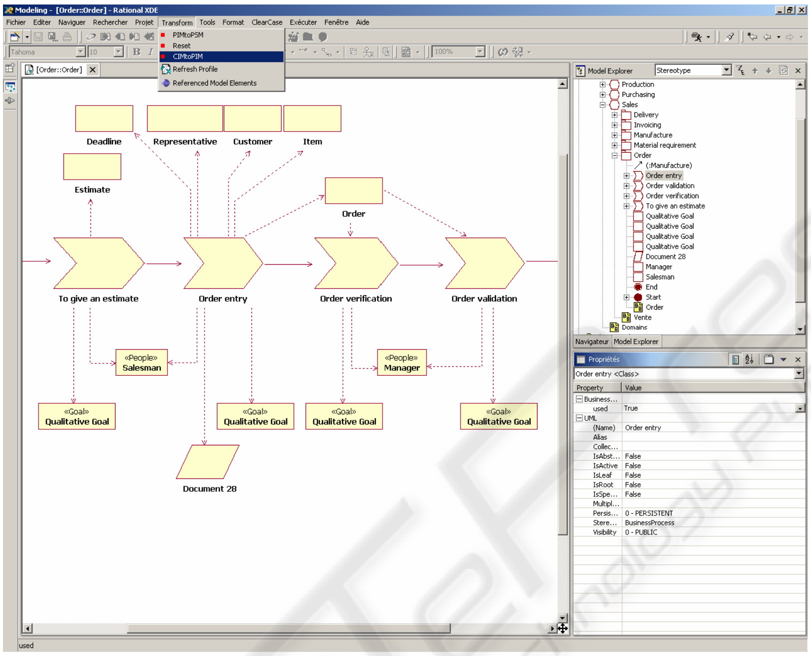
7 Implementation of the Prototype

The prototype of our system has been implemented in the IBM's XDE environment augmented with the MDA toolkit (fig 8). Our own extension is built as an eclipse plugin written in Java. When a task of a generic business process is disabled by the configuration engineer or if an entity gets disabled by status propagation, it is turned to another color (red) in the diagram. Then it is easy for the configuration engineer to see the current status of the customization (fig. 9).

8 Conclusion and Future Work

The goal of this project was to validate the applicability of the MDA framework to the customization of an ERP. The use of an ERP system as the target platform of the MDA approach brings some unique constraints. First, the final application is not generated because it already exists. Rather, it must be configured or customized.

Second, the process that could be implemented are dependent on what is available on the target platform. In other words, the spectrum of the possible business process to implement is limited. Third, although the customization language is specific to each ERP, the business process to be implemented can be represented by some standard graphical notation.



Order entry <Class>

Property	Value
Business...	
used	True
UML	
(Name)	Order entry
Alias	
Collec...	
IsAbst...	False
IsActive	False
IsLeaf	False
IsRoot	False
IsSpe...	False
Multipl...	
Persis...	0 - PERSISTENT
Stere...	BusinessProcess
Visibility	0 - PUBLIC

Fig. 8. Prototype in the IBM's XDE environment.

Then we investigated the possibility to use this graphical notation to generate the customization constraints. This lead us to define the MDA transformations themselves as models (business process and business activity diagrams) using a standard notation (BPML, which has been implemented as a UML Profile). This has the unique advantage to free the user from knowing the peculiarities of some specific customization language or system. Using this technique, the customization is self documenting. The impact of any subsequent change could then be easily analyzed at a conceptual (business) level. Although our first prototype only covers a small subset of the business processes of Adonix, we have been able to generate the parameters down to the Adonix tables successfully, only using our graphical notation. These parameters triggered the correct behavior on the system. The next step in this research will be to extend the prototype to the other processes and to further validate the approach by targeting other ERP platforms (Microsoft's Navision®). A new topic of research would be to go the other way around: to generate the high level (business) view from a given ERP implementation. Although one could already foresee the many difficulties of this endeavor, the present research has shown some path toward this goal.

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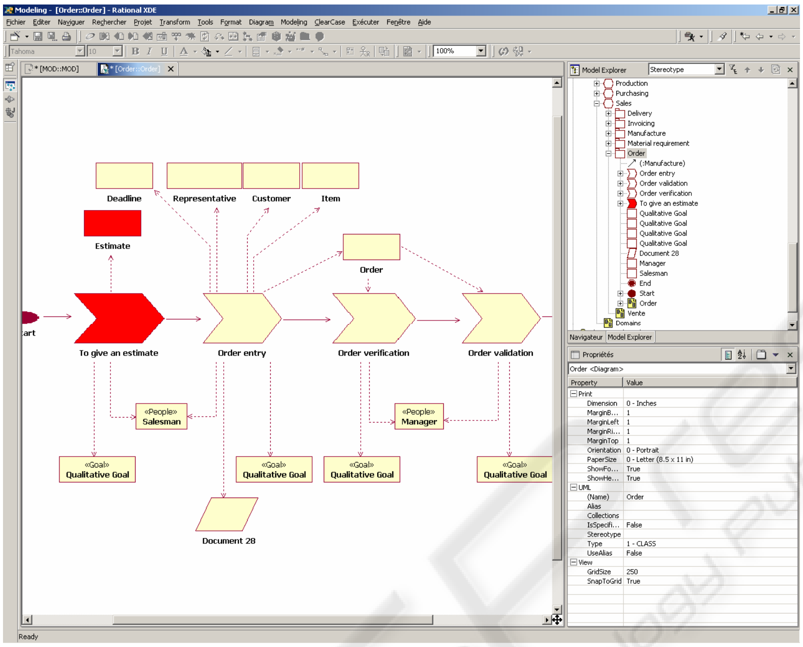

Order <Diagram>

Property	Value
Print	
Dimension	0 - Inches
MarginB...	1
MarginLeft	1
MarginRi...	1
MarginTop	1
Orientation	0 - Portrait
PaperSize	0 - Letter (8.5 x 11 in)
ShowFo...	True
ShowHe...	True
UML	
(Name)	Order
Alias	
Collections	
IsSpecifi...	False
Stereotype	
Type	1 - CLASS
UseAlias	False
View	
GridSize	250
SnapToGrid	True

Fig. 9. Business process with disabled elements.

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