The Business Challenge of Configuration

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Abstract

The real business challenge of configuration is the consolidation of the configuration domains that occur in various business processes. Typically, different configuration domains require different tools and technologies. Today's research and commercial applications are strongly focussed on tools and technologies that address the specific problems of these specific configuration domains. For a growing number of businesses, that is not were the added value lies of configuration. This paper explores the problems to be addressed and provides some directions for future applications.

Position statement

A quick glance over the agenda of any conference or workshop about configuration tells you that configuration is an intrinsically difficult subject, both from a scientific viewpoint and an applications viewpoint. Subjects that receive everlasting scientific interest include among others reasoning methods, knowledge acquisition and representation, validation, and man-machine interaction. Application subjects typically include maintenance, reconfiguration, and integration with the latest and hottest applications such as nowadays e-commerce.

The fact that the configuration domain is so highly knowledge intensive has an important drawback in its commercial application: configuration products typically focus on specific, confined domains. Most configurators focus for example on sales configuration. Others (but much fewer) focus on domains such as engineering configuration or service contract configuration.

The position taken in this paper is that this focussed approach to configuration applications can be very beneficial for some businesses, but is extremely sub-optimal in many other businesses. Baan Company is currently developing a configuration framework that addresses these issues.

Analysis

It will take little to convince the configuration community of the complexity of the domain. Statements as the following are common: "From a user or nontechnical-management perspective, a configurator appears to be just another piece of software supporting the business process. However, the development and introduction of configurators are demanding tasks, for various technical and organizational reasons: • the tasks' complexity requires the knowledge of technical experts. (…) " (Fleischanderl 1998)

The focus of configuration products on specific domains is also obvious. The survey of Sabin and Weigel is evident (Sabin and Weigel 1998). In their list of eight product and sales configuration tools, only one is arguably not a sales configurator. In their list of 7 business systems, only the ERP vendors offer configuration products that cover more than sales configuration. Notice that both BAAN and SAP make a distinction between a sales configurator and a back-office configurator, where the latter is also used for specific sales configuration situations. Albert Haag of SAP calls this high-level versus low level configuration: "Sales configuration is typically a high-level configuration (…) Low-level configuration, in contrast, is manufacturing-oriented — a non-interactive, procedural process (…)." Important is his statement that "Low-level configuration is possible only in the integrated R/3 environment." (Haag 1998).

This last conclusion is result of the fact that different configuration applications domains use different configuration technologies. Combining sales configuration and back-office configuration in one configurator is extremely difficult and certainly not yet commercially available. Companies often buy different commercial applications for sales configuration and back-office configuration. Each of these products focuses on solving their specific domains. Integration is for many companies a real nightmare due to differences in configuration paradigms and inability to match these paradigms.

This does not only apply to the most obvious domain of sales and back-office configuration. The trend towards more customer-driven activities increases the need for configuration technologies in an increasingly number of domains. The problem of consistency and integration will therefore appear more often.

In this paper, I will describe the specific configuration requirements in an assemble-to-order (ATO) situation where most of the assembly is driven by a customer order. We will see four different configuration domains in this example. The challenge of this type business is not to solve each of these domains individually. The challenge is to come up with one single integrated system that supports

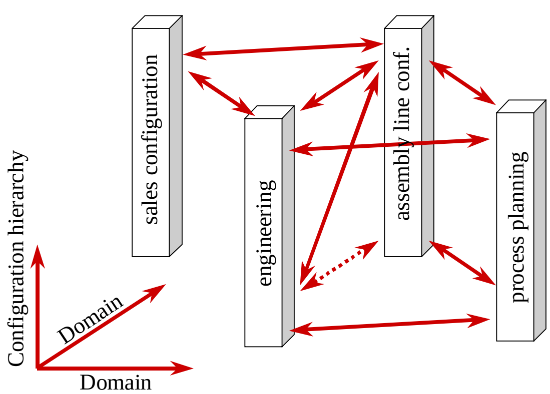
the business process. Notice that this situation is only one of many possible examples and many more domains are identified as well. Other situations include Make-to-Order and Engineer-to-Order situations. Examples of domains not mentioned in the example include Shop Floor Control, Service, and Software Configuration.
The paper concludes with a paragraph explaining the key features of a configuration framework that addresses this business need. Baan Company is currently implementing this framework.

Configuration Characteristics

In this chapter we explore the characteristics of four different configuration domains based on a real-world example of an assemble-to-order (ATO) case. Businesses that are of this nature include high volume, line assembly businesses such as for example the car industry, truck industry, aircraft industry, industrial air-conditioning system industry and high volume machine tools industry.
The figure below illustrates the four configuration domains that are used in this case description:

- Sales configuration
- Engineering configuration
- Assembly line configuration
- Process Planning

The vertical bars in the figure represent configuration hierarchies. For example, the top of the engineering bar refers to a small catalog of products that engineering offers to sales while the bottom of the engineering bar refers to the complete catalog of thousands of parts that are specified by engineering to actual manufacture and assemble the product.



The arrows between the bars indicate relationships between configuration domains. For example, a sales configuration will have to be based on an engineering configuration and has to include a reference to the assembly line the product will be assembled.
Following paragraphs will explore each domain in more detail and will address the specific configuration challenges including the relationships between configuration domains.

Sales configuration

Functionality in relation to integrations

- Product configuration
- Available-to-Promise checks (ATP); available-to-promise is the function to check if the configured product can actually be delivered to the customer in the specified configuration and delivery time. Two different types of ATP are used in the assemble-to-order (ATO) business: option based ATP and assembly part ATP. Option based ATP is a check on the selected options (we still can produce 6 trucks with the option heavy-duty), while assembly part ATP requires a bill-of-material explosion to determine if the critical parts in the selected configuration are in stock or ordered.
- Order completion: the sales office has to add information to the order for processing purposes. In an international, multi-site case, this includes assigning the order to an assembly/manufacturing facility. Sales offices are often uniquely assigned to specific facilities, but this is not common.
- Forecasting; production and assembly forecasts are often based on both a top-down global market analysis and a bottom-up sales forecast. The challenge is how to define forecasts on configurable products, and how to aggregate these into global forecasts. And what are the consequences for the assembly facilities? For example: the global forecast includes 30% left-hand drive vehicles versus 70% right-hand and 20% heavy-duty versus 80% light-duty. Assembly facilities provide capacity for 5% heavy-duty left-hand vehicles. Is this sufficient? The challenge is therefore to use the critical option combinations for manufacturing and assembly in the sales forecast, taking into account that these will change over time and that the combinations may not even make sense for a sales department.

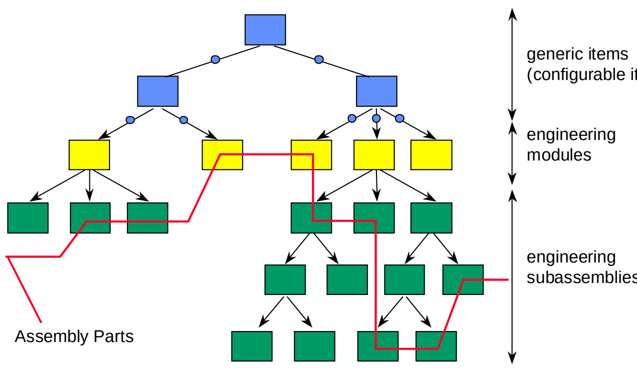
Configuration technologies required. Configuration technologies required are 'classic': interaction between the sales person and the configurator (the system), constraints/ rule based reasoning, constraints management, explanation of constraints, optimization, consistency and completeness of a configuration, complete deduction, graceful degradation, reconfiguration, et cetera (Skovgaard 1995) (Yu, Skovgaard 98).

Integration challenges. Some of the integration challenges are easy to deduct from the above paragraph on functionality: how to provide ATP and forecasting information to "the back-office".
A bigger challenge is how to map the product models that are defined by engineering to the product models that are used in a sales situation. This can be trivial if the modules defined by engineering are the same as used in the perception of the customer. For example, when configuring a kitchen, engineering develops stoves, cabinets, sinks, et cetera. A customer configures stoves, cabinets, sinks, et cetera.
In many cases however, engineering models differ drastically from the sales models of a product. For

example, a truck in engineering consists of 6000 assembly parts that aggregate into a chassis, powertrain, body, et cetera. The customer however is interested in freight capacity, cost efficiency, and usability. This mapping is not trivial. Moreover, do you want to include all engineering parts in the sales configurator? How to deal with constraints defined in the engineering model?

Engineering configuration

Functionality. Key functionality in engineering is the modeling of a product in *engineering* structures. These engineering structures include the specification of configurable and standard items, their relationships and constraints.



The engineering structure in the assembly industry is often composed of configurable items and 'standard' Bill-of-Materials. While the top level in the engineering structure consists of configurable items, at the lower levels one will find standard bills-of-material: engineering modules. Examples of engineering modules in the truck industry are braking systems, electrical systems, and powertrains. Note that these modules often do not appear in the sales configurator.
The need for these specific engineering structures is to simplify both engineering and production planning. Imagine the calculations needed for the parts requirements planning of 10,000 cars each consisting of 6000 parts if the bill-of-material of each car has to be exploded into its parts. Typically, there is simply not sufficient computer power available to process this in the available time. Much easier is to define standard engineering modules, calculate the number needed of each module and explode each module only once.

Configuration technologies required and Integration challenges. Configuration technologies needed are often much different from sales configuration: constraints management, consistency and completeness of a model, version control, change order control, effectivity and expiry control, multi-user modeling.
Integration challenges in engineering often relate to integrations with Product and Engineering Data Management systems, CAD systems, et cetera. This is outside the context of this example case. Integration challenges with sales and process planning is discussed in separate paragraphs and considered —right or not —as challenges for sales and process planning rather than challenges for engineering.

Assembly line configuration

Functionality. The complexity of modern assembly lines lies in the fact that they have to support the assembly of a huge variety of products. Fine-tuning a line is no longer a one-off activity, but a continuous activity, based on the actual load (combination of products being assembled) of the assembly line. Furthermore, the assembly line configuration is used for planning purposes. This includes long term forecasts as well as short term available-to-promise logic based on combinations of line configuration, line offset times, and work loads.
The fact that production planning and process planning use different line configurations increases complexity. One configuration is used to define what parts are needed at what time; the other is used to define what resources (machines, tools, people) are needed when. Often multiple assembly lines are scheduled simultaneously.

Configuration and Integration challenges. The key challenge is to build a model of the assembly line that can be used by all planning processes. Technologies needed for this include constraints management, version control, change order control, effectivity and expiry control.

Process Planning

Functionality. The process planner defines what components in the engineering structure are the assembly parts that will be supplied to the line. This can be different per line! 600 different suppliers is not unusual for one assembly line in the automotive industry.
Process planning is the process of defining tasks and operations that specify the relationships between assembly parts, configurable engineering items, assembly lines, tools, machines and people. These relationships can be constraints and time dependent. A process planning model of a product (i.e. the assembly model) differs from the engineering model: the engineering model specifies how a product looks like from a form-fit-function point of view. The assembly model specifies how the product can be assembled. For example, the electrical system and break system of a truck can be two different engineering modules. In assembly, the dashboard will be a module, which includes both electrical and break 'components'.
Business processes that are directly related to process planning include the 'solve process' or 'final assembly planning'. The purpose of the solve process is to calculate time-phased assembly part requirements for pseudo orders and sales orders. Long-term parts requirements are often calculated based on the engineering structures. Short-term parts requirements have to take process-planning configurations and line configurations into consideration.
ATP requests that originate in the sales configuration are often executed by process planning.

Configuration and Integration challenges. The key challenge is to maintain a model that links the configurable engineering items to assembly parts, assembly lines, tools, machines and people. This model will be used by complex planning algorithms. Change management and efficiency are therefore key properties of the configuration system.

Example relationships between these configuration domains

Providing each of the above configuration domains with appropriate configuration tools and technologies is a big challenge. Even a bigger challenge however is to keep the models between these domains consistent. Just to mention a few touch points:

1. Configurable sales items are derived from engineering items —including constraints.
2. Configurable engineering items are related to lines; e.g., for assigning orders to lines.
3. Assembly parts are related to lines or line segments for parts requirements planning and assembly order generation.
4. Assembly parts are for assembly order generation indirectly (via process planning) related to line stations.
5. Process planning items are related to assembly line segments.
6. Assembly operations are allocated to line stations.
7. Process planning items are related to configurable engineering items.
8. Assembly operations are related to assembly parts.

Configuration Framework

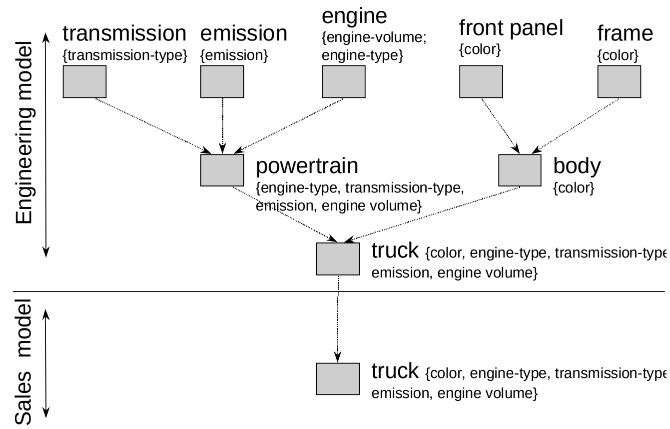
The goal of this paper is to address the need for a configuration framework that covers the business need of an integrated configuration solution across the business process. Such framework is not available today. It is not the intention of this paper to specify in any detail how such configuration framework would look like. Based on the case described in this paper, we can however identify some key characteristics.

- One common modeling language supporting different models
- One constraints solver logic embedded in all configuration solutions
- Various modeling tools for various application domains
- Various user interfaces for various application domains

I conclude this paper with a short exposé about the need for supporting models in the modeling language.

Different functions different models. For different domains, such as engineering, manufacturing, assembly, marketing, it is often more practical to specify different configuration models than to specify views.

Each function has its own configuration model and components. The configuration components of different functions can be related through inheritance and dependency relationships. These relationships guarantee the passing of information between models. The product specification can be passed from one model to the other through dependency relationships and the properties of the components. The inheritance and dependency relationships between components in different models have to be specified such as to guarantee the transfer of a complete configuration.



The sales model in this example consists of one configuration component ‘truck’ which has an inheritance relationship with the engineering component ‘truck’. Notice that the component truck in the engineering model can be different from the component car in the sales model, even though the name and the properties are the same; the properties of the engineering component truck are inherited by the sales component truck.

An example is the passing of product variants (instances) from a sales model to an engineering model. This process is referred to as 'sales solve'. A sales solve can be implemented by specifying a 'sales relationship' between the truck in the sales model and the truck in the engineering model. A general purpose solve method will translate a product variant of the sales truck to a product variant of engineering truck using the user-defined 'sales relationship', taking into account constraints from both sales and engineering.

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