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# A New Approach to Product Configuration

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## Abstract.

This paper describes a new method for product configuration based upon constraint techniques. The method is implemented in the Beologic Product Configurator **salesPLUS**. It has very strong features for the end user; free order of choices, guaranteed fast response times and optimization functions. The method supports an easy maintenance process with a unique consistency check of configuration data. We compare the tool with previously proposed methods like expert systems to show the advantages of this approach. An example of car configuration is presented.

## Key-words.

Product-oriented information systems, AI, Design for Manufacturability/ Dependability, Testability, Product Configuration, Constraints.

Products generally become more complex with more variants and shorter life cycles. Wrongly configured products means increased expenses, unsatisfied customers and stressed sales people therefore the need for good sales tools to assist the configuration process is evident.

salesPLUS [2] exploits the recent development in constraint satisfaction algorithms to evolve a new methodology for interactive configuration.

## 2 Methodology .

### 2.1 Objects & Resources.

The most fundamental part of the configuration data is the object. All the items or parts that can go into a product must be represented as objects. Product features may also be represented as objects e.g., the screen resolution on a PC although it derives from the combination of Monitor and Videocard.

The objects have a number of attributes.

Object :: {Type, Id, Resources, Menu position, Description, Default-value,...}

A resource is a property or measure of some objects. Examples of a resource are "Price", "Memory", "Weight", etc. Objects can have positive or negative resource values. Hence it is possible to have a provider/consumer principle, e.g., devices use certain amounts of power whereas power-supply's provide more power.

### 2.2 Constraints.

The representation of a configuration problem is naturally done with constraints governing the objects. These constraints may stem from physical limits (as space limits) and from technical restrictions (as "supports only") and from marketing demands (only sell some combinations). This is the contents of the configuration problem. This product information can typically be found in a printed configuration guide and transformed on a one to one basis into constraints.

Two types of constraints are supported: boolean algebra and finite domain arithmetic. Examples from a UNIX workstation.

Storage  $\geq 300$

"The system should entail at least 300 Mb of storage (resource)."

RAM\_8Mb + RAM\_32Mb + RAM\_64Mb  $\leq 2$

"The model can only accommodate two optional memory options."

impossible( Model\_A, CDRROM )

"Model A does not support CDRROM."

The representation of UNIX workstations consists of only 30-40 constraints.

The constraints only state facts and there is no meta reasoning dealing with which rules to use. Since each rule represents a real world constraint they can mentally be checked individually.

salesPLUS has a consistency checker that can detect inconsistencies in individual constraints, bound objects and most important inconsistency in the overall configuration data.

Explanation and traces of conclusions can also be made for testing purposes.

## 4 Deduction methods of inference engine.

### 4.1 Constraints.

With traditional programming as with production rules systems the programmer has to master the general information flow. As a result, these systems are very intricate and they are hard to develop, test and maintain when either incomplete information or unordered information flow has to be dealt with. In contrast to constraint programming where you deal with problem contents only.

The basic step in the configuration process is the following: Given the partial configuration selected so far, the existence of a corresponding valid configuration has to be verified (consistency), and the elements that can still be selected have to be known (domain reduction). There is both unordered information flow and incomplete information available in a typical configuration problem.

The inference engine in salesPLUS is a State of the Art constraint solver [1]. It handles both boolean algebra and finite domain arithmetic constraints based upon interval calculus and the patented Beologic array inference technology.

Having a pure constraint representation allows the user to add additional constraints at runtime like "The computer should have more than 32 Megabytes of memory", and salesPLUS uses this information to reduce the set of possible machines.

Having asserted the additional constraints it is now possible to minimize the price resource with an optimization algorithm. The resulting computer will be the cheapest one that have more than 32 Mbyte of memory. This strong feature is impossible in traditional configuration systems.

### 4.2 Time Complexity.

The inference engine exhibits a nice and polite policy towards the user. It has guaranteed response time that can be user selected independent of the platform.

The inference engine's job is to check that no inconsistency occurs between the constraints and the assignments. Determining solvability to a set of objects that must satisfy a set of constraints is NP-complete i.e. the execution time grows exponentially with the size of the problem.

The inference engine may therefore use longer time than desired to establish all consequences. The engine will then give control to the user when the specified time (1-2 seconds) is used or sooner.

What the inference engine can deduce, increases with the number of assignments of objects. This is so because the search space only depends on the number of unbound objects.

For "large" products this means that an option may seem to be free, but when you select it the inference engine will find that it is not possible and assert this. In practise this is not a problem with the products that have been modelled.

The concept of the inference engine allows it to take advantage of future hardware improvements, and it will not be slow on weak computers.

## 5 Comparison with traditional configuration Systems.

### 5.1 Representation.

Configuration problems are by nature NP-complete. Traditional configuration systems deal with this problem in several ways.

\* For expert system rules that deals with the execution of the application are added to reduce the problem to a simple linear/polynomial problem. Adding these rules is very bad for maintainability because they are not founded in the problem contents but only in the context.

% salesPLUS does not have rules that deal with execution issues.

\* For decision trees the user is forced to make his choices in a predefined order. This reduces the problem by avoiding unordered information flow. This yields an application that is very constraining for the user. Imagine that a customer wants a red car. The system will prompt for model,engine,.. etc. And when it comes to the colour it might not be possible to select red at all.

% salesPLUS gives full freedom in the order of choices.

\* Batch mode validation does not allow for interactive configuration therefore the problem is reduced by avoiding incomplete information. Batch mode means that a user picks all the parts that he assumes appropriate. Then the validation algorithm produces a list of missing and conflicting parts. Here the user has to put up with an iterative process. Imagine that the customer specifically said that he wanted a part and the configurator then says that it is not possible. Then he has to start all over again.

% salesPLUS has an interactive mode where the status of resources are displayed dynamically such as price, storage and weight to give the user better overview.

### 5.2 Maintenance.

Maintenance of the product model is an extremely important feature of a configuration system where product changes may occur on a monthly basis or even more frequent.

Traditional configuration tools have difficulties with rapid changing product models. For expert systems it is known that rule bases with up to 10000 rules exists [5] which unfortunately makes it hard for even experienced engineers to change the rules.

Easy maintenance in salesPLUS is achieved by keeping the number of constraints small. A single constraint often replaces many production rules and a company's products should be split into several knowledge bases. It is therefore possible for even quite complicated products to be represented by less than 100 constraints.

Before release of any configuration system a test must be made to see if errors occur in the configuration data. With the product range decomposed it is only necessary to test the changed products. Whereas if you have one big knowledge base, you might have introduced side effects and the whole product range must be tested again.

Concurrent product configuration data maintenance is possible with salesPLUS.

## 6 Discussion.

The reason for the progress made in salesPLUS is the recent development in constraint

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