Product Configuration
Abstract

A product configurator enhances communications, increases control over production, reduces the chances of human error, and helps identify product modularity even for manufacturers with high design complexity.

Most importantly, it addresses the highly effective strategy of quick response manufacturing – shortening the order to ship time from days and weeks to hours.
# Table of Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table of Contents</td>
<td>i</td>
</tr>
<tr>
<td>The New Ground-Rules</td>
<td>1</td>
</tr>
<tr>
<td>CTO Overview</td>
<td>1</td>
</tr>
<tr>
<td>Business Objective</td>
<td>2</td>
</tr>
<tr>
<td>State-of-the-Art CTO Technology</td>
<td>2</td>
</tr>
<tr>
<td>A CTO Tutorial</td>
<td>4</td>
</tr>
<tr>
<td>Definition of a CTO Model Structure</td>
<td>4</td>
</tr>
<tr>
<td>CTO Option Definition</td>
<td>4</td>
</tr>
<tr>
<td>Wildcard Parts</td>
<td>4</td>
</tr>
<tr>
<td>Configuration Control Variables (CCVs)</td>
<td>4</td>
</tr>
<tr>
<td>Run Time CCVs</td>
<td>4</td>
</tr>
<tr>
<td>Calculation CCVs</td>
<td>4</td>
</tr>
<tr>
<td>Conditional Result CCVs</td>
<td>4</td>
</tr>
<tr>
<td>Table CCVs</td>
<td>5</td>
</tr>
<tr>
<td>Selection Rule CCVs</td>
<td>5</td>
</tr>
<tr>
<td>Subroutine Exit CCVs</td>
<td>5</td>
</tr>
<tr>
<td>Entering Configuration Data – Three Presentation Methods</td>
<td>5</td>
</tr>
<tr>
<td>The CTO Generation Process</td>
<td>5</td>
</tr>
<tr>
<td>CI Number Integration</td>
<td>6</td>
</tr>
<tr>
<td>The Latest CTO Advances</td>
<td>6</td>
</tr>
<tr>
<td>Smart Choices</td>
<td>6</td>
</tr>
<tr>
<td>Transparent Power</td>
<td>6</td>
</tr>
<tr>
<td>Summary</td>
<td>7</td>
</tr>
</tbody>
</table>
The New Ground-Rules

Changing customer requirements and increased competition have created an environment where the name of the game is to have the fastest fulfillment at the lowest cost and highest quality. These three qualities are not unrelated. In fact, to be the fastest requires eliminating non-value-added (NVA) activities, waste, rework, scrap and other factors that drive costs up and quality down.

Increasing agility and flexibility was the number one world-class business strategy according to the Fourth Annual Industry-Week Census of Manufacturers. And in the Grant Thornton 9th Annual Survey of American Manufacturers, time-based capabilities are the most important to their success. Specifically, they cite the following:

- Improve On-Time Delivery 87%
- Less than 1 year New Product Introduction 81%
- Shorter Product Lifecycles 76%
- Reduce Lead Times 74%
- Time-to-Market 70%

Given that 80% or more of the engineering process is NVA time and 60% of total lead time is accounted for by back-office processing (Stalk & Hout, Competing Against Time, 1990), process improvement is imperative. Product configuration, or configure-to-order (CTO), is a solution that covers the entire process from engineering to manufacturing to sales and delivery, and reduces lead times from days or weeks to a matter of hours.

Manufacturing’s ability to meet quality, cost and lead-time targets starts with, and is dependent on, how well engineers execute design engineering. High quality and design manufacturability eliminate mistakes in purchasing, rework in manufacturing, engineering redesign and unnecessary costs, as well as improving a company’s ability to market and sell its product.

The configure-to-order system accelerates the transfer of knowledge from engineering to sales and manufacturing by predefining models, options, conditional rules, Bill of Materials (BOM), routings and pricing. This coordinated transfer of knowledge eliminates the fumbles and delays associated with engineering each order. CTO promotes standardization, increases product variety and decreases production variability by reducing the number of custom-engineered orders. This decreases lead-times by getting orders into manufacturing faster with predefined bills, routings and fewer setups. Mobile CTO brings the manufacturer and customer even closer, and closer means faster.

CTO Overview

The configure-to-order solution provides a method of producing unique product configurations based on customer specifications and pre-engineered sets of options and rules. This not only provides a sales staff with an elegant and easy-to-use product configurator, but also provides a product engineer with a wealth of powerful and sophisticated tools to define the configuration process.

With current Web-based extensions, it not only allows for easy selection of features and options, it can perform calculations and present specific choices based on parameters entered by the user, such as dimensions of a door opening. The configurator verifies the selections against the rules, and may present additional options based on its calculations against engineering specifications. It rolls up costs and pricing and generates bills and routings.
Thus, when certain options are selected, additional or alternate options may be presented based on the engineering-defined rules and previously entered data. For example, selecting an ultra-slim computer case may prevent accommodation of more than two expansion slots. As soon as the user selects the ultra-slim case, the configurator calculates that only certain options are available with that case. The user, then, is presented with only those options, such as the choice of one or two expansion slots. This rigorous rules enforcement assures the customer, as well as the production line, that the product ordered is one that can be built as configured.

Any manufacturing company that assembles or builds a standard product to customer specifications (such as size, color, optional features, etc.) is a good candidate for CTO. CTO is designed to accommodate the needs of assemble-to-order, make-to-order, repetitive and even some engineer-to-order manufacturers.

Each configuration produces its own unique item, BOM, and routing. Most of the information related to this unique configured item may itself be ‘configured’ to customer specifications. CTO is also very useful as an estimating tool, since it provides the ability to ‘configure’ cycle times, setup times, production sequences, and product cost. Manufacturers demand powerful and flexible rules-based product configuration tools. Configure-to-order software satisfies these demands.

Business Objective

A manufacturing company that assembles products to customer specifications is presented with the daunting task of managing the production and inventory of these unique products. Defining each possible combination as a permanent inventoried item is not feasible due to the exponential number of possible combinations. Setting up a new item, bill, and routing manually per customer order is also not feasible due to the large volume of customer orders.

Since a standard product is usually offered to the customer with a pre-defined list of sizes, options, colors, etc., a tool which allows the definition of these options is useful when used as the reference point for configuring the product. An order entry operator can now be prompted for specific options, etc., which have been pre-defined by an engineer. As a result of the entry process, the configurator automatically produces a temporary item, bill, and routing to customer specifications.

Because engineering has control over the selection process used by the order entry operator, only ‘buildable’ products can be ordered. A wide variety of selection options and rules give an engineer this control.

This approach satisfies the basic difficulties manufacturers are likely to encounter when managing the production and inventory of unique, configured products.

State-of-the-Art CTO Technology

The software industry has an opportunity to provide powerful tools to manufacturing companies who need the ability to configure new products quickly according to basic product models. These basic models are defined with all possible combinations of options that apply to a specific product line. The user is prompted to select the applicable options, which in turn create a unique product complete with a BOM and routing.

CTO has been installed successfully in many environments and its powerful logic has enabled users to achieve very short lead times for products with millions of combinations. CTO is an advanced ‘rules-based’ software application for manufacturers that make or assemble unique
products to customer specifications. With it, complex make-to-order or assemble-to-order products such as industrial pumps, residential windows, office furniture, playground equipment, archery bows, or gauge dials are configured easily.

CTO allows a manufacturer to translate product engineering knowledge into rules that define relationships among product options, materials, and manufacturing processes. The collections of rules that relate to a specific product constitute a product Model. Once these Models are defined, less experienced users can configure complex products. Configurations can be generated through the engineering function, quoting function, or directly in sales order entry complete with costs and pricing. The system offers four different entry methods, Customized Entry screen(s), Configuration Code, or Sequential presentation of options to create a BOM, routing to build unique finished products that meet each customer’s specific requirements and the internet. During the configuration process, pre-defined rules called Configuration Control Variables (CCVs) are used to govern and guide the entry process and to prevent invalid combinations of options.

Overall features and capabilities include:

- Configured products are defined using a consolidated, integrated configuration management tool.
- The configurator can ‘configure’ specific quantities of specific components, assembly sequences, prices, costs, descriptions, run standards, and much more.
- A friendly and elegant product configurator guides the operator through pre-defined option and quantity selections.
- A shorthand configuration entry code is supported that allows the experienced operator to enter a configuration in a fraction of the normal time.
- User-defined front-end screens may be used to prompt for large amounts of sophisticated configuration information.
- The configuration process creates a unique, temporary item, bill, and routing that may be planned, manufactured, stocked, and sold just like any regular item.
- A set of unique costs and catalog prices is created for each configuration. Descriptive information is also produced.
- Configuration Control Variables provide the engineer with very powerful and flexible rules-based decision tools to help tailor the configuration process. These include:
  - Calculations
  - Single and Double-Axis Table Lookups
  - Conditional/Results Tables
  - Selection Rules
- Nested referencing of CCV’s is supported, providing an extraordinary amount of flexibility and complexity.
- The configurator can provide access to inventoried items directly, without using product structure linkages. This can significantly reduce product definition time.
- Rules may be defined that prevent the operator from making incompatible option and quantity selections. Definition of these rules and resulting exception messages is completely under an engineer’s control.
- The quote-only feature allows configurations to be entered as quotes. Quotes may later be turned into active sales orders.
- When the configurator and configuration definition process is fully integrated with the rest of the system, it provides a seamless link between sales, planning, production, and all other areas of the organization.

In the next section of this paper, Models, Options, Wildcards, and CCVs are described. Following that are the different methods of entering configuration data, the generation
A CTO Tutorial

Definition of a CTO Model Structure

A CTO model is at the top level of configuration bills. Structured to it is any number of parts, options, sub-models and/or wildcards. For each model in the structure, the configurator creates a Configured Item. Duplicate configuration checks can be used to prevent multiple generations of the same end item. Once a CI number is created, it can be retained for use as a standard product or it can be purged from the system at a later date. Note that models can be structured beneath other models and also beneath option parts giving the user full flexibility to include other models based on customer requirements.

CTO Option Definition

Options are utilized to collect information from the user at run time, to select existing sub-assemblies for inclusion into the CI number's bill, to build a configured routing, and to generate new items without lower level components.

Wildcard Parts
Wildcards allow the user to add one or more real parts onto the CI bill with user specified quantity per assembly.

Configuration Control Variables (CCVs)
CCVs are used in many ways to control the configuration process. They verify selections and quantities, include or exclude items from the CI bill and routing, retain data for later references, accumulate data, store calculations, plus much more. Six different types of CCVs govern the entire configuration process: Run Time (RT), Calculation (C), Conditional Result (CR), Table (T), Selection Rule (SR), and Subroutine Exit (SE). Each type of CCV can reference or be referenced by other CCVs except for Run Time CCVs, which store data input by the user. The following descriptions of their abilities demonstrate the flexibility they add to the CTO module.

Run Time CCVs
Run Time CCVs is used to store data input from Configuration Codes, Customized Entry screen(s), Option Results, and Quantity Results. The other CCV types guide the configuration process and build meaningful information that is stored in the CI bill and routing reference information stored in these CCVs.

Calculation CCVs
Calculations can be defined to compute anything desired for use in the configuration process. They can reference numeric constants, literals, and/or other CCVs and have extensive mathematical functionality. Two types of results are possible, numeric or literal. The numeric result is a number whose value is substituted upon completion of the configuration process.

Conditional Result CCVs
Powerful in their ability to return true or false conditions, these CCVs use input from all other types of CCVs to include or exclude options based on other CCVs and input data.
Table CCVs
Single or double access tables may be defined to return values based on intersections of X and Y-axis values. The intersection value may be a literal, number, or another CCV. A resulting CCV may be another table type CCV, which gives n-dimensional table capabilities.

Selection Rule CCVs
Two types of Selection Rules are supported:
1. Front-End Selection Rules are used to select options automatically in the Model bill based on references to other CCVs, mainly Run Time CCVs.
2. Back-End Selection Rules verify all selections from the Model bill to insure the validity of the options and quantities chosen during the configuration process.

Subroutine Exit CCVs
This type creates a template subroutine, which is stored in the user’s custom code basic program library. This template subroutine is then modified by the user or custom code department to reference other CCVs to determine a result which is then returned to the configuration process.

Entering Configuration Data – Three Presentation Methods
Once a CTO Model bill is defined, three different methods of gathering user input are available. Customized Entry screen(s), Configuration Code, and Sequential entry.

Customized Entry screen(s) allow multiple screens and prompts per screen to be defined to guide the user through the configuration process. A typical application is complex Models, which require that all configuration data be entered prior to beginning the generation process.

Configuration Codes are user specified combinations of alpha-numeric segments which are interpreted by the CTO module to select the desired options to create the Configured Item Bill, quickly and efficiently.

For example, 486-66-V1-SC-17 could be a simple Configuration Code for a PC Model, where 486 selects the processor type, 66 represents the megahertz speed, V1 selects the correct video card, SC includes a sound card, and 17 defines the display width of the monitor.
Numerous edits are available when defining the Configuration Code segments on the CTO Model to prevent invalid inputs.

In the Sequential Entry Process the user is prompted to select an Option from a list of Options. The list of selected Options will become the BOM for the CI number when the configuration process is complete. During the CTO Model setup process for the sequential method, users can define options to be pre-selected, state whether an item can be de-selected, allow changes to quantity, define minimum and maximum number of Options which may or must be selected, etc.

The CTO Generation Process
Relatively simple, the generation process takes all of the input from the user and creates the CI bill and routing complete with costs, prices, and meaningful descriptive data. However, once an item has been configured, the generation process may perform some other duties such as duplication checking and regeneration of existing items based on CTO Model changes. Three duplication checks are available to prevent multiple CI bills that have been configured with the same options: Configuration Code, Format Direct Code, or CI number. If a duplicate configuration has been found, another check is made automatically to determine if the model has been changed since the duplicate found was created. An example of this is when CI number 100 was created on March 4th and its model had a new sub-assembly added on April 7th. The system will prompt the user to determine if they would like to regenerate the existing...
CI number 100 as its Model bill has changed, or to use the CI number 100 as it currently exists.

CI Number Integration

Integrated into all other areas of the system, the CI number is treated the same as other items in the database. Planned Orders may be entered, Forecasts may be defined, Sales Orders submitted, and Product Schedules may be set up so that the next MRP run makes the necessary recommendations to meet the appropriate requirements. Even the Serial Number Tracking module allows CI number integration.

The Latest CTO Advances

The Internet makes shopping around easy – sometimes too easy. When online customers or prospective customers can’t find the exact product with all the options they require at one site, they all too quickly turn to a competitor’s site. Web-based configure-to-order puts the power of the configurator in the hands of the online user. Customers can order products over the Web configured to their exact and unique requirements. The Web-based configurator extends the Web-based Sales Order Processing module by allowing customers or distributors to configure products on-the-fly and/or select from product catalogs. The Web-based version of the CTO module is an extended version of the powerful rules-based configurator.

Smart Choices

Web-based configure-to-order can present choices based on parameters the Web user enters. A window manufacturer can allow builders to order windows by entering the dimensions of the desired opening. Likewise, the configurator can calculate requirements and return choices of pipes based on flow rates, choices of gauges based on pounds of pressure, etc.

Transparent Power

Some Internet-based configurators are cumbersome and slow because each time a selection is made, it must be validated against the rules which reside on the host. Having to call the host and retrieve data after every entry is inefficient, and can result in a frustrating buying experience for the customer. The validation rules for Web-based configure-to-order may reside on the Web client, rendering quick responses and moving the customer rapidly through the selection process. With the rules resident on the Web client, the validation and configuration processes are efficient and transparent to the user.
Summary

Success stories from new and existing users of CTO are numerous. A leading Archery Bow manufacturer was posed with the daunting task of defining 15,000 separate BOMs to support varying combinations of components. Research was done to discover that only 5 CTO Models were required to allow them to define each new bow combination as their customers placed orders. So far, 3158 new combinations have been configured, with none being duplicates.

Another example in a different and somewhat more complex industry is of a manufacturer of electronic gaming machines (i.e., slot machines). CTO was of interest because every order was customized and engineered to specify monetary denominations, lights, payout tables, glass, plating, handles, electronic components and other options. What took them hours of engineering time is now done in a matter of seconds and includes generating the BOM, routing, costing, pricing, and an accurate description.

New challenges continue to arise for manufacturers. Most recently, according to the Fourth Annual Industry-Week Census of Manufacturers, the top 2 reasons manufacturers are adopting the internet is to improve customer service and attract new customers. Technology, especially information technology and ERP will continue to be extended and capabilities will be added to CTO as it matures to meet the increasing needs of the manufacturing community.
About Epicor

For 20 years, Epicor has been a recognized leader dedicated to providing leading edge enterprise software solutions to midmarket companies around the world. With over 15,000 customers, Epicor delivers end-to-end, industry-specific solutions that enable companies to immediately improve business operations and build competitive advantage in today’s real-time global economy. Epicor’s comprehensive suite of integrated software solutions for Customer Relationship Management, Financials, Manufacturing, Supply Chain Management, and Services Execution and Control provide the scalability and flexibility to support long-term growth. Epicor’s solutions are complemented by a full range of services, providing a single point of accountability to promote rapid return on investment and low total cost of ownership.

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