Product Configuration within R/3's System Enterprise Resource Planning

Introduction

Products brought to market today by enterprises in industries such as computer, peripheral and equipment manufacturing and distribution are often available as variant configurations, either as ranges of similar preconfigured products or as CTO (Configure to Order) products.

To support these environments, SAP's R/3 ERP system provides an integrated product configuration engine supporting a wide array of logistics applications including:

- Sales order entry
- Profitability analysis
- Production planning
- ATP (Available to Promise) checking
- Assembly order processing
- Engineering change management
- Field service management.

This document explores these and other configuration-related topics.

Configurable Product Modeling in R/3

In the first section, *Configurable Product Modeling in R/3,* we will examine the structure of the product configuration engine from both an external (sales) view and an internal (manufacturing) view. We will see how these two views are linked using R/3's integrated object classification system and object dependency knowledge, and how the ECM (Engineering Change Management) system is used to manage the product configuration knowledge base.

Configurator Engine Support of Sales Order Entry

The second section, *Configurator Engine Support of Sales Order Entry*, examines the process of entering a sales order for a configurable product within the R/3 ERP system. We will look generally at the sales configuration process, including multi-lingual and graphic configuration, and will see how R/3 supports preconfigured products. Other topics include configuration automation, pricing, ATP (Available to Promise) checking, and the alternate product configuration outputs generated by the R/3 configuration engine.

Configurable Product ERP

The third section, *Configurable Product ERP (Enterprise Resource Planning),* includes a discussion of production planning strategies supporting configurable product environments.

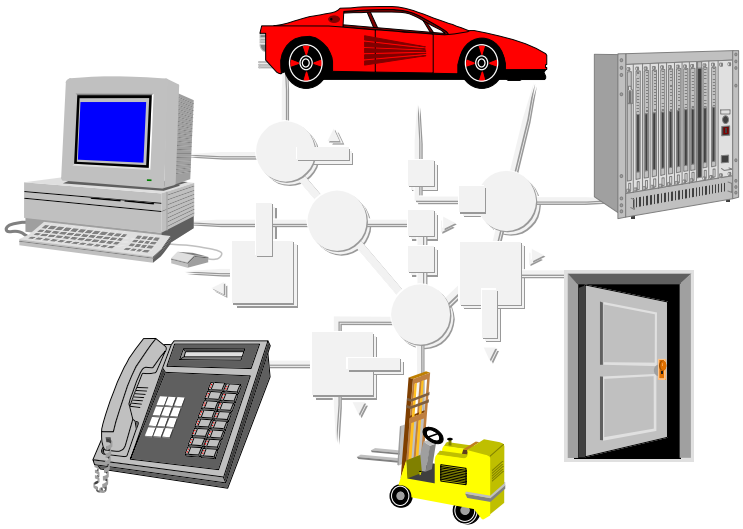

Figure 1: Configurable products

Service Management of Configurable Products

Section four, *Service Management of Configurable Products*, briefly discusses the relationship of product configuration to the service management function,

Integrated Product Configuration Compared to Stand-Alone Sales Configurators

Section five, *Integrated Product Configuration Compared to Stand-Alone Sales Configurators*, compares and contrasts these two systems approaches.

Note: Certain functions described in this document are still in development and may not be available in the 3.0b release of R/3.

Configurable Product Modeling in R/3

Sales View of Configurable Products via the Classification System

The representation of the configurable product presented to the buyer during the sales dialogue should be modeled in terms that are meaningful in the buyer's environment. In R/3, a *configurable product*, in addition to being the parent material of a *configurable BOM* (Bill of Materials), is also linked to one or more *classes* using R/3's object classification system. Classes are in turn linked to *characteristics*, and each characteristic is linked to a set of *values*, which can be expressed as numeric or as characters. The classification system allows configurable product options to be presented to the customer as freely-defined product characteristics and values. The product is configured via user selection of these product characteristics and values.

Configured Via User Selection

For example, the configurable product might be modeled so that R/3 SD sales order entry system presents the user with a set of product characteristics, like "color", with each characteristic in turn offering a set of values, like "red", "blue", or "green."

Customer-Oriented Terminology

While the characteristics and values can be modeled in manufacturing terms (using the names of BOM components or production processes), it is also possible to use customer-oriented terminology when modeling sales configuration options.

For example, instead of the user being presented with a list of CPU and memory components as listed in the BOM, the product representation can be modeled in different terms, such as ”system response time” or ”number of users” to be supported by the system being configured.

Object Dependencies

Through *object dependencies* (discussed below), the system maps the sales configuration terminology to the components required to support the user’s requirements.For example, specification of a certain system response time, with a specified number of users, could be modeled to result in the system creating an assembly order bill of materials containing the CPU and memory options needed to support the user’s requirements.

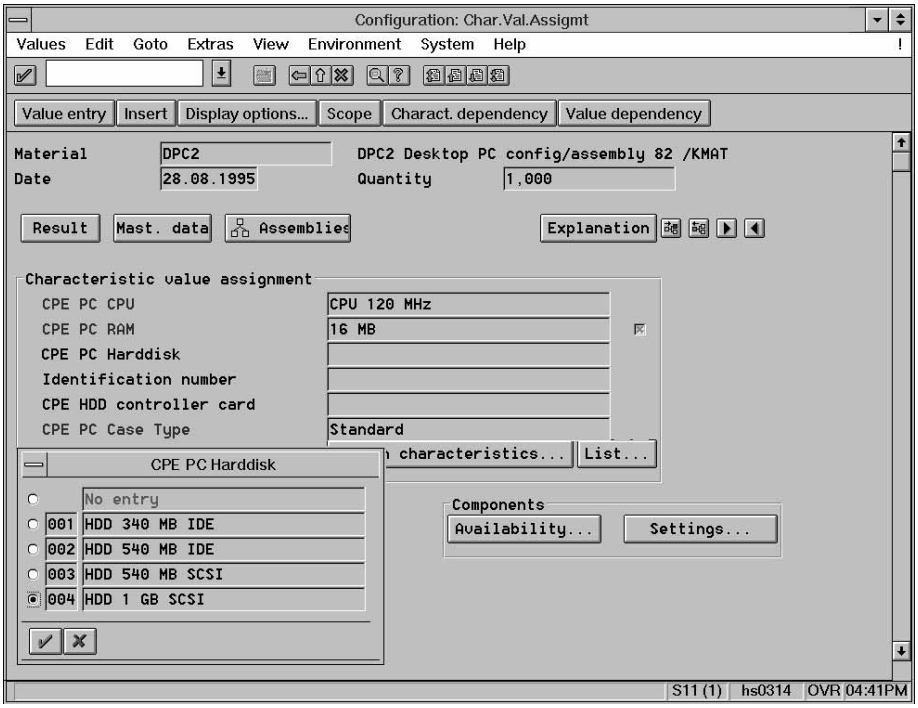

Figure 2: Sales configuration through selection of product characteristics

Eergonomic and Productive Sales Dialogues

R/3’s technique of linking configurable products to classes with associated characteristics and values in conjunction with configurable BOMs and configurable routings results in much more ergonomic and productive sales dialogues than systems that offer only direct selection of components from the BOM during the sales dialogue.

Manufacturing View via Configurable BOMs and Configurable Routings

Assembly Order BOM

After the sales configuration has been created in R/3 through selection of product characteristics and values, the system generates an assembly order BOM and routing by selectively copying certain components and operations from the configurable BOM and configurable routing.

Variant / Non Variant Components

The configurable BOM, used to generate the assembly order BOM, is a list of all possible components that could be built into any variation of the configurable product. There can be a one-to-one, one-to-many, or many-to-one relationship between characteristic values selected during order entry and

corresponding components in the BOM. The configurable BOM contains *variant* components (components which may or not be included in the order BOM, depending upon the customer's selection of characteristic values) and *non-variant* components (components which are always included). Characteristics and values need only be modeled for the variant components; the non-variant components are included in the order BOM automatically.

Single Configurable BOM

It is not unusual for companies to have thousands of variations of configurable products. Maintaining a separate BOM for each product variation, a traditional MRPII systems approach, requires intensive maintenance. With R/3, all assembly orders BOMs generated by the system to build products matching customers' requirements can be derived from a single configurable BOM. The assembly order BOMs are processed by MRP and are a source of product costing. They are also used for component issue or backflush during the assembly process.

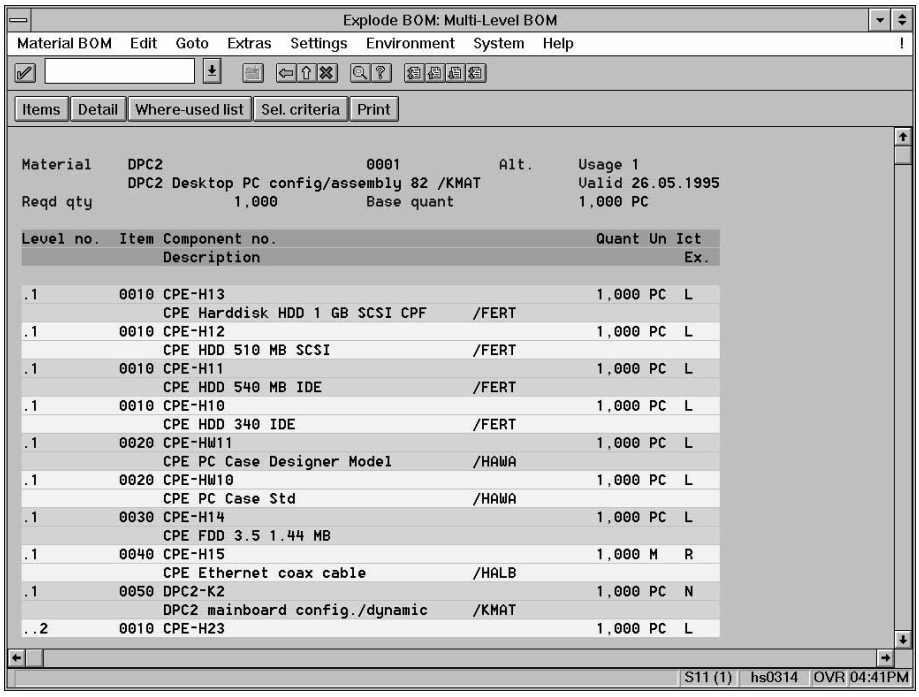

Figure 3: Configurable BOM containing all possilble product components

BOM Maintenance

BOM maintenance in R/3 can by be further minimized where common sets of components are used in several BOMs. These common components can be grouped under a class, and the class can then be entered as a single line item within bills of materials. Any changes made to the class reflect automatically in the BOMs containing the class. So if a class were included in ten configurable BOMs and a change were made (for example a component was deleted or added) then only the class would need to be maintained. Without this feature, the user would have to maintain ten BOMs.

Order-Specific Routings

Just as R/3's configuration engine can generate customer order-specific assembly order BOMs, so too can it generate order-specific routings to manufacture the product. The same technique is used to create the order routing

as to create the order BOM. A configurable routing, linked to the configurable product, contains a list of every possible operation that could be needed to create any variation of the product. The assembly order routing is derived from the configurable routing. Its uses include costing and capacity management, in addition to being a source of assembly and routing information.

Document and PRT

The assembly order routing can also contain documents and PRTs (Production Resources and Tools). Documents managed under R/3's DMS (Document Management System) can take any form: text documents, CAD drawings, digitized movies, process instructions, etc. This information can then be viewed online by the assembly worker.

More Flexibility

R/3's configurable BOM and configurable routing architecture is more flexible and requires less maintenance than systems that require maintenance of a separate BOM as master data for each possible variation of the product.

Object Dependencies

Product Configuration Engine

R/3's capability to configure during the sales dialogue is enabled by the integrated product configuration engine. The product configuration engine is fueled by a knowledge base. In addition to the object classification system and configurable BOMs and routings, the knowledge base includes a third element, object dependencies. Object dependencies help create the configuration and ensure that is consistent and complete.

Below are object dependency types available for use in R/3's product configuration engine along with brief descriptions of their use.

Preconditions

Preconditions are used to determine whether certain product characteristics or characteristic values are presented or can be selected during the configuration process. Preconditions are usually dependent upon other selections.

Selection Conditions

Selection conditions are used to determine whether variant materials, PRTs, documents and operations are included in the assembly order BOM and routing.

Actions

Actions are used to configure automatically. An action can trigger selection of a product characteristic based upon a separate characteristic. Another use of actions is to automatically calculate the quantity of a given component within an assembly order BOM based upon entry or selection of an numerical value during sales configuration. Actions can trigger formulas, useful in variant dimension product environments.

Constraints

Constraints are a higher-level dependency knowledge modeling tool which provide more powerful and efficient techniques for modeling dependencies and automating the product configuration process. Constraints can combine to form *constraint nets* through which multiple logical expressions can be linked to generate sets of parameterized valid option combinations.

R/3 provides the user with a choice of dependency modeling tools. While selection conditions attached to BOM items may be the most productive tool for simple configuration tasks, constraints may be more efficient for complex modeling tasks.

ECM (Engineering Change Management) of the Product Configuration Knowledge Base

Manage Change

As companies offer more products with ever-shortening life cycles, the task of managing product master data becomes more complex. With configurable products, it is necessary to manage change not only of traditional objects, like BOMs and routings, but also product configuration objects, like object dependencies. Engineering change of all objects within the product configuration knowledge base must be synchronized.

R/3's ECM (Engineering Change Management) system ensures that engineering change is synchronized over the following objects:

- Materials
- BOMs
- Routings
- Documents
- Object dependencies
- Classes
- Characteristics
- Values

Integrated Workflow Management

R/3 also provides integrated workflow management to coordinate the activities of personnel responsible for managing these configuration-related business objects.

Configurator Engine Support of Customer Order Entry

Classification System

Object Search Transactions

Sales configuration in R/3 is initiated by entry of the material identifier of the configurable product in a sales order line item. In environments where a large number of products are offered, the classification system can be used to retrieve the correct material identifier for sales order processing. Object search transactions can be triggered from within the sales order line item to find the right material number based upon user entry of material characteristics. This is similar to product configuration, but is used to find the product to be configured (or sold as is) rather than to configure the product.

After the material identifier of the configurable product has been entered or retrieved automatically, the system automatically takes the user to a configuration screen, where product characteristics and values are displayed for selection.

Multiple Configuration Options

The system offers multiple configuration options; for example, a characteristic can be set up to permit selection of either multiple values or a sole value for a characteristic, or to make selection of characteristic values mandatory or optional.

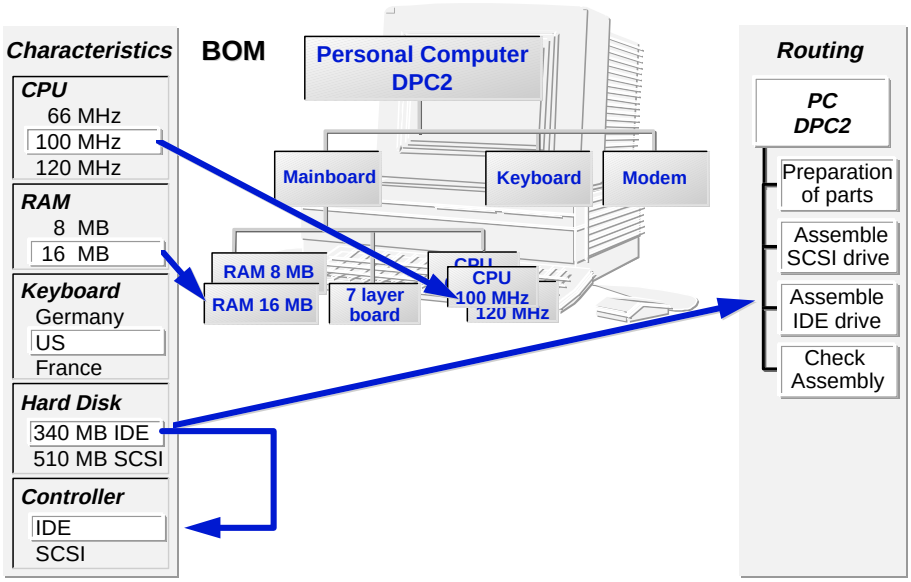

Figure 4: Product characteristics selection creates order BOM and routing

Configuration Automation Facilities
Multiple Levels

R/3 provides many configuration automation facilities, for example system display or suppression of characteristics and/or values based upon selection of other characteristic values. If the product is configurable at multiple levels, then selection of certain characteristics values at higher levels in the product structure can result in the selection of lower level configurable assemblies, which in turn are displayed with their associated characteristics and values.

Multi-Lingual Sales Configuration

The classification system supports external representation of configurable products in several languages. Language-independent keys form the class and characteristic master data. These language-independent keys are usually modeled quite concisely to facilitate the dependency modeling task.

Key Descriptions

However, it is the class and characteristic keys' *descriptions* that appear to the user during in the sales order. The description texts are usually longer and more meaningful than the language-independent keys, and can be maintained in multiple languages. Customer master data includes a language identifier so that product characteristics and values descriptions automatically appear in the customer's preferred language during sales configuration and on all related sales documentation.

Through this architecture, a single-language object dependency knowledge base can fuel a multi-language product configuration engine.

Graphic Representation of Configurable Products

API

Users can benefit from R/3's integrated configuration without being restricted to one GUI interface. R/3 provides APIs (Application Program Interfaces) enabling R/3 users to configure graphically. The API's map the graphic objects shown via the external GUI to the product characteristics and values which drive the configuration engine. This means that users can configure by selecting or manipulating graphical objects when entering R/3 sales orders. The graphic representation can be used not only to facilitate configuration but also to facilitate assembly or picking of product components.

Automated Customer- or Destination Specific Product Configuration

Customer, Country Dependency

Some elements of a product configuration, such as a product label or a power pack, depend on the customer or the country in which the product will be used.

These options can be modeled as product characteristics and values. In order to automate the product configuration process, R/3 can automatically configure using information in the header or line item sections of the customer order.

Automatic Selection

For example, entry of an order for a specific customer can result in automatic selection of a labeling option; internal system reference to a country code field can result in automated selection of a power pack option. This capability streamlines the order entry process and reduces customer-or destination-related configuration errors.

Dynamic Pricing with Profitability Analysis

Potential Profit

Narrower profit margins create the need in some environments to analyze potential profit during the sales process: quoting too high a price may lose the sale; quoting too low a price leads to loss rather than profit.

Automated Dynamic Pricing

R/3 provides automated dynamic pricing during sales configuration, based either upon costs or pricing conditions. Configurable products can be priced either by using a set of customer- and product-dependent pricing conditions or via cost-based pricing logic, with cost elements derived from R/3's assembly order BOMs and routings. These are generated dynamically during sales configuration. Configuration of products with variable quantity or dimensions is supported.

Component-Level ATP (Available to Promise) Checking

Many companies using ERP systems are evaluated by their ability to deliver products on time, within competitive lead times. Some industries, such as electronics and semiconductor, frequently experience constrained or unstable supply of critical components.

Automated ATP

Automated ATP (Available to Promise) checking during sales order entry improves customer service through ability to immediately provide the customer with accurate availability information which results in compliance of the actual delivery date to the quoted delivery date.

ATP Check at Component Level

Timely availability can be as important as cost or the features of the product itself. And with configurable products, the ATP check must extend to the component level as the end product is only assembled after the sales order is entered.

R/3's ATP (Available to Promise) checking during sales order entry is performed against the default ship-from site for the customer. A pop-up display lists other sites where automated ATP checks can be triggered.

Final Assembly Order

ATP checks can be performed at component level. During sales order entry in CTO/MTO (Configure-to-Order/Make-to-Order) environments, R/3 can generate the resulting FAS (Final Assembly Order), and can perform ATP check on components.

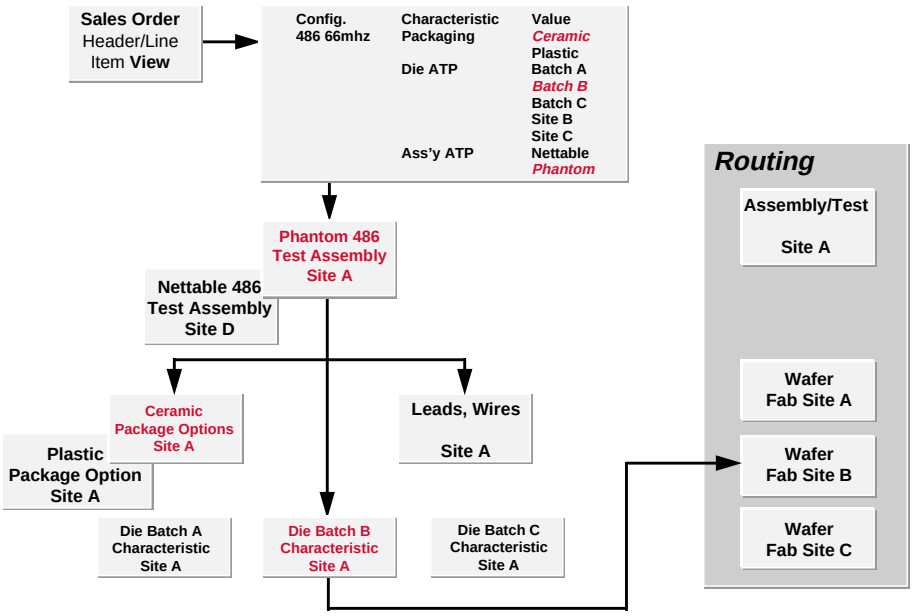

Figure 5: SOE with multi-level ATP (semiconductor product example)

User Selection / Deselection of Plants

In environments characterized by constrained supply of critical components, there may be a need to check component ATP in other plants. This requirement can be met in R/3 by creating characteristic values that correspond to other plants. With this technique, the system can automatically change the plant identifier at line-item level within the assembly order BOM with the result that the availability check occurs in the plant specified. User selection/deselection of plants can result in an iterative check of component availability over a range of plants.

There may also be a need for the availability check to extend to levels lower than a single level down. R/3 supports this requirement by providing visibility into component shortage situations resulting from demand exceeding supply within the component lead time.

Immediate ATP Reduction

The system reduces ATP immediately during sales order entry at the end item and at component level. Component level ATP reduction can extend multiple levels down in the product structure where the intermediate assemblies are phantoms.

Preconfigured Products

Build-to-Forecast Configurations

While some environments are strictly configure-to-order, it may in other environments enhance customer service to build some standard configurations to forecast, before receiving customer orders. These build-to-forecast configurations, known in R/3 as *stockable types*, are based upon the configurable product master data. They are created through specification of unique characteristics and values defining the stockable type. With R/3, only the stockable type characteristics and values need be stored. The system creates the assembly order BOMs and routings using the same configurable BOM and routing as the configurable product.

Stockable Types

Alerting the User to Existing Inventory of Preconfigured Products

Type Matching

Through a feature called *type matching*, R/3 provides the order entry person with an alert that products matching the configuration have already been produced or are planned for production. This eliminates the need to assemble a configuration specifically for the customer's order and in some cases allows the product to be shipped immediately to the customer.

With type matching, the system uses product characteristics entered to check whether similar configurations have already been defined and whether any available inventory exists. The system can be set up to search for a stockable type, perform an availability check, and in the event that the availability check is positive, automatically replace the material identifier of the configurable product with the material identifier of the stockable type in the sales order line item.

Product Configuration Representations Generated by the R/3 Configuration Engine

Configuration Profile

R/3 can generate a range of configuration results depending upon the *configuration profile* linked to the configurable product. Users can choose form three different profiles.

First Profile

When using the first profile, assembly orders are generated after entry of the sales order by running MRP, typically a daily or a periodic process. The MRP run generate either assembly orders or planned orders which are subsequently converted to assembly orders. The assembly orders contain the configured order BOMs and/or order routings used to assemble the product to customer's specification.

Second Profile

When using the second profile, the assembly order is generated directly during sales order entry. Costs are generated via the assembly order BOM and routing, and the system performs component-level ATP on select components.

Third Profile

Using the third profile results in generation of a product set or kit, represented as a set of items listed line-by-line in a sales order, rather than as components of an assembly order BOM. This third profile does not generate an assembly order, rather it generates a pick list directly from the sales order.

Configurable Product ERP

Production Planning Strategies

Production and distribution planning in configurable product enterprises requires a robust multi-site system to strike a balance between low inventory and high customer service levels. R/3's ERP (Enterprise Resource Planning) provides this support in configurable product environments through R/3's comprehensive suite of production planning strategies.

Forecast Consumption

The configurable product planning strategies have in common that they support forecasting at a product or product family level with dissagregation, using percentages, of the higher level forecast down to component level. R/3 offers forecast consumption at any level of the product structure and R/3's MRP processing drives demand seamlessly between sites through the global supply chain.

R/3 offers three planning strategies supporting configurable product environments, two of which are described below.

Preplanning Using Planning Objects (Planning Types)

Preplan Quantities of Representative Product Configurations

This planning strategy is used to preplan quantities of representative product configurations. Forecasts are made either at planning type level or at product group level. Product group level forecasts are disaggregated, using percentages, to forecasts at planning type level. After the forecast has been generated at planning type level, MRP drives the forecast down to component level, creating component- level ATP.

As sales orders are entered, the system uses type matching to identify and consume the forecast of the appropriate planning types; that is, the type matching the characteristics of the product being configured. Component ATP is also reduced during sales order entry. When the planning types are structured under a product group, the mix of the planning types can automatically adjust to match actual demand mix as the planning horizon extends into future periods.

Preplanning Using Product Characteristics Planning

Demand Probability Percentages

With this planning strategy, forecasting is done at configurable product level with demand probability percentages used to forecast distribution of demand over variant components. As sales orders are entered, forecasts are consumed at configurable product level and at product characteristics level. The system generates reports showing variance between forecast and actual component demand. ATP check is provided at configurable-product and component levels.

Service Management of Configurable Products

After-Sales Services

Configurable product suppliers often provide after-sales services. Just as automated product configuration is useful in the initial sales process, so too it useful when selling post-sales support services.

Serial Number Master

R/3's equipment BOM (the structure used to maintain details of the configured product at the customer's site) is created in the same way as the assembly order BOM. However, while the user must specify product characteristics and values during sales configuration, this is not necessary for creation of the equipment BOM. The user only has to enter the serial number assigned to the configured product in the serial number master of the equipment BOM. This number is internally linked to stored characteristics and values for the configured product, driving automated creation of the equipment BOM.

The equipment BOM stores the product configuration information necessary for service of products at the customer site.

Integrated Product Configuration Compared to Stand-Alone Sales Configurators

Many companies have made major investments in recent years in stand-alone sales configurators. In some cases, the decision to invest in stand-alone systems has been made because of business reasons (for example, the need to provide external distributor organizations with a quotation tool), in other cases the decision was made due to lack of availability of integrated product configuration within MRPII systems.

Robust Object Dependency Modeling Capabilities
Flexible Graphic Interface

With R/3's ERP system, two traditional advantages of stand-alone sales configurators, robust object dependency modeling capabilities and flexible graphic interfaces, have been neutralized - these are available with R/3's integrated configuration engine.

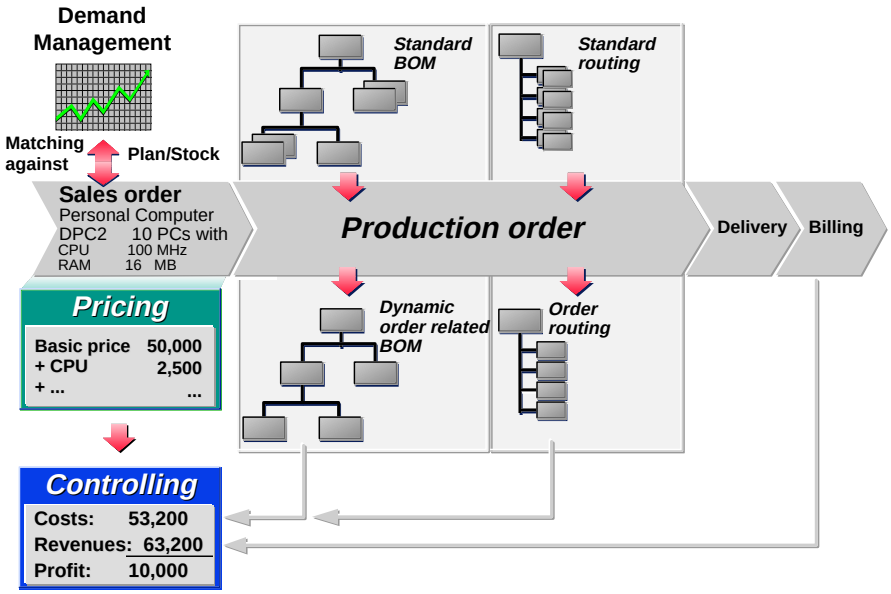

Figure 6: Integrated product configuration

A third differentiator, ability to operate independently from the ERP system, has its advantages and disadvantages.

The advantages of being able to operate stand-alone include:

- No need to dial into a host system
- Host system availability not a concern
- No impact upon host system performance
- Necessary for environments with high volume and large sales / distributor organizations

Disadvantages of Stand-Alone Sales Configurators

Disadvantages of stand-alone sales configurators include:

- Need to develop and maintain interfaces to the ERP system
- Need to maintain and synchronize two sets of configurable product master data
- Inability to apply the processing power of the ERP system to the sales configuration task
- Inability to perform real time ATP checking
- Inability to use customer-dependent pricing conditions

Interface to External Product Configurators

Which solution is best depends upon the environment, and there are clearly environments in which stand-alone sales configuration capability is required. To meet this requirement and to allow users to take advantage of investments made in legacy stand-alone sales configurators, R/3's APIs supporting interface to external product configurators continue to expand in terms of the data elements which can be exchanged between the two systems.

Summary

While the concept of integrated product configuration is inherently appealing to configurable product manufacturers and distributors, MRPII systems have typically not supported this requirement. SAP's R/3 ERP system now offers integrated product configuration. Below are listed the aspects of integrated product configuration that have been discussed in this document.

Configurable Product Modeling in R/3

- Sales view of configurable product via the classification system
- Manufacturing view via configurable BOMs and Routings
- Objects dependencies for automated configuration with consistency and completeness checking
- ECM (Engineering Change Management) of the product configuration knowledge base

Configurator Engine Support of Sales Order Entry

- Multi-lingual sales configuration
- Graphic representation of configurable products via APIs
- Automated customer- or destination-specific product configuration
- Dynamic pricing with profitablility analysis
- Component-level ATP checking
- Preconfigured products
- Alerts user to existing inventory of preconfigured products
- Multiple configuration representations
- Configurable projects

Configurable Product ERP

- Preplanning using planning objects (planning types)
- Preplanning using product characteristics

Service Management of Configurable Products

Integrated Product Configuration Compared to Stand Alone Sales Configuration

Integrated product configuration has many advantages over the approach of interfacing stand-alone sales configurators to the ERP system, yet stand-alone sales configurators are better suited to some environments.

The market is best served by ERP systems providing a combination of integrated product configuration along with the capability to interface to a stand alone sales configurator, allowing enterprises to select an approach or a combination of approaches best meeting the business requirements of the enterprise.