

WHITE PAPER

Knowledge-based engineering applications in retail and consumer packaged goods industries



Abstract

Retail and consumer packaged goods (CPG) industries' most pressing need is to introduce highly customizable, high-performance, high-quality, and visually appealing products quickly to the market. Two major challenges they face are pricing pressure and vulnerability to obsolescence. It is these forces that demand a continuous reuse of existing designs to produce new and improved designs. Besides, many retail and CPG products are only available as customized ones, making it unrealistic to design each product from scratch. Knowledge-based engineering (KBE) can play an important role in meeting the current and future challenges of these two industries. In this paper, we discuss some applications of KBE in the retail and CPG industries.

Introduction

The retail industry deals with the lifecycle of merchandise mostly in a physical store and occasionally, online. The consumer packaged goods (CPG) industry, on the other hand, deals with products that are sold quickly and at relatively low cost. A common thread across both these industries is a need to constantly introduce high-quality, high-performance products quickly to the market. These industries are also characterized by pricing pressure, vulnerability to obsolescence, and pressure to introduce visually appealing products with a high level of customization. In fact, many retail products, such as furniture and interior design articles, are often available only as customized products.

Knowledge-based engineering (KBE) is a set of engineering product or process development methodologies and tools where the intelligence (engineering rules and knowledge) of a product or process is captured, stored, and embedded in a software system (known as the KBE system). KBE systems help design products with options and variants by managing their underlying rules. These systems can be used to design and configure similar, yet different products.

This paper discusses the applications of KBE in the retail and CPG industries. It discusses the landscape and the challenges faced by the two industries. In addition, it offers a perspective on how KBE solutions can help in meeting the challenges presented to these industries.



Retail and CPG industries overview

The retail market consists of largely the following types of outlets:

- Malls: A range of retail shops in a single location
- Supermarkets / hypermarkets: Sell a variety of goods at low margin
- Discount stores: Sell goods at very low price
- Mom-and-pop stores: Family-run small shops, mostly catering to the local community
- Specialty stores: Sell goods of special category, such as shoes, medicines, etc.
- E-tailers: Sell products online
- Vending machines: Automated equipment where money can be dropped and products selected or dispensed

The CPG industry in general, sells products that are replaced or fully used-up once in a few days or months. This industry is characterized by frequent purchases, low price, high volumes, and extensive distribution networks. Consumer sentiment, aesthetic appeal, ease of selection of the products, and brand loyalty often play an important role in this industry.

The global retail industry generated a total revenue of about US\$10 trillion in 2009. The top-200 retailers of the world contribute to about 30% of the total revenue in this sector.

The segmentation of the retail market⁽⁷⁾ in terms of revenue, in billions of USD, is shown in Fig. 1.

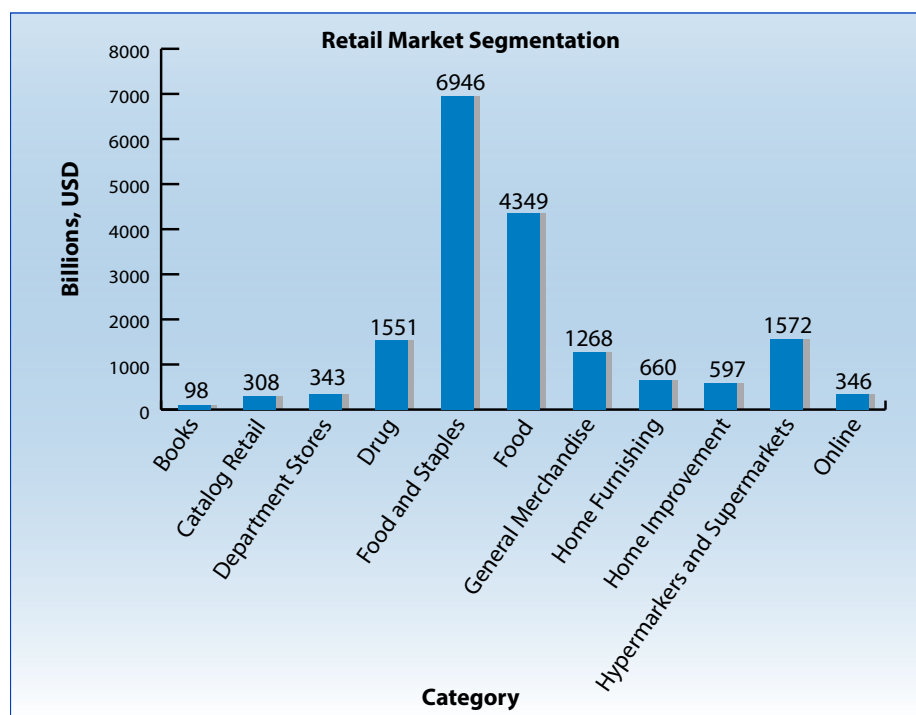


Fig. 1 Retail Market Segmentation

The segmentation of the CPG market⁽¹²⁾ in terms of market capitalization, in billions of USD, is shown in Fig. 2.

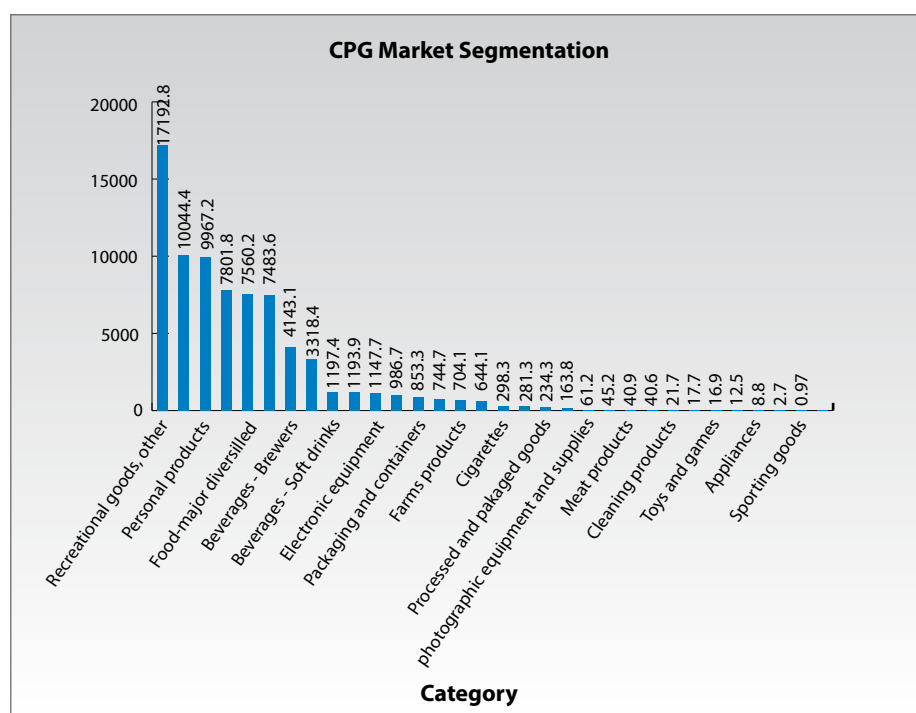


Fig. 2 CPG Market Segmentation

Major challenges

The retail and CPG industries face many product development challenges, some of which are:

Product introduction

The industries are constantly confronted with a need to introduce high-performance, high-quality products quickly, in the market. The visual appeal of the product, as well as the functional characteristics, such as weight and cost, play an important role in the successful deployment of the product in the market.

Product customization

The industries pay a very high premium on customer preferences. This means that most products are highly customizable. Some products, such as interior design, are available only as customized products. Managing product options and variants from a canonical and parameterized design is a huge challenge.

Design reuse

There is a need to introduce new product variants faster to the market. As it is not

possible to design a product afresh, every time a new variant is introduced to the market, heavy reuse of existing designs is necessary. In some cases, certain basic components of a product run through generations and their designs are not available – only an old physical design is available as a reference. In such cases, generating an accurate and reusable digital model of the design is a challenge.

Managing manufacturing data

In many customized product design scenarios, it is important to carry forward the product information from the early design stages, all the way to manufacturing. It is important to capture all relevant manufacturing data and functional design information from the design stage to manufacturing.

Product standardization

From a designer's standpoint, when numerous product options and variants are possible, it is important to have the ability to standardize product components so that design and manufacturing costs

are reduced. This is a scenario where the customer has a large number of product options and variants to choose from, whereas the design and manufacturing departments of the enterprise need to work only with a handful of component variants. It is important to identify and differentiate the "generics" and "specifics" of the design.

Order management

Integrating design, prototyping, manufacturing, and ordering data is a challenge. A customer may like to see a digital product, get a look-and-feel, play with product options and variants, and review the cost before actually placing an order. It is important to develop a framework where the customer workflow can be supported and the customer's experience around product review and purchasing can be enhanced.



Knowledge-based engineering (KBE)

Central to KBE is the capture and reuse of both product and process knowledge. KBE offers several benefits, including:

- Reduced cost and rework through digital prototyping
- Reduced cycle time, faster time-to-market
- Ability to define, measure, and manage product performance and quality through metrics
- Ability to capture, reuse, and retain product and engineering knowledge

The digital prototyping approach can reduce the cost of manufacturing the actual physical model and minimize rework. In this approach, the customer can see the digital product, perform a walk through, and get an idea of the cost and other parameters. If satisfied with the model, they can get the physical product manufactured, else iterations can be performed on the digital design and an optimal solution arrived at. This approach also saves a significant amount of time.

KBE can help in defining and measuring the product performance parameters. These could be efficiency, weight, cost, etc. Metrics can be arrived at and the performance of various design options measured against these metrics. This would help in optimizing the designs. In addition, KBE can help capture the underlying functional product knowledge. It can help retain and store such knowledge for future use and designs. This reduces dependency on a particular individual or group in the enterprise as it facilitates sharing and reuse of the engineering knowledge underlying a product.

Our KBE solutions for the retail and CPG industries:

1. Configurators

a. Sales configurators:

Sales configurators are lightweight applications that are widely used in pre-sales environments. These are simple-to-use applications that accept functional requirements as input and generate a lightweight digital representation of the final product.

The target audience for this application could be top-level executives of the enterprise's customers. These applications often place emphasis on visually appealing, yet technically correct output that can help win multi-million dollar deals for our client enterprises.

Sales configurators can be either internal (for example, used by sales in a company to generate a quick model and quote) or external (for example, used by a customer to log in to the company website and create a product or generate a quote). They generate quick models that resemble the final product. They can help drastically reduce the lead time to generate a design, often in the order of 90%.

b. Product configurators

Product configurators are applications that are used for both design and manufacturing. These applications accept functional requirements as the input and generate detailed digital prototypes, such as 3D assemblies and 2D drawings. These are similar to sales configurators, but produce richer and

more detailed outputs required for design and manufacturing.

Product configurators can be of various types: assemble-to-order (ATO), configure-to-order (CTO), or engineer-to-order (ETO).

An ATO configurator can be used to assemble a product from standard components configured to a customer's specifications. Examples include computers, kitchen, etc.

A CTO configurator resembles an ATO configurator, except that it takes more detailed information from the customer on how exactly to assemble a product and is driven by a rules engine. An example would be a tool that selects cloth, embroidery, and color of shoes.

An ETO configurator requires both complex rules from a rules engine as well as customer specifications. This type of configurator must be able to handle complex and non-standard instructions, such as price, BOM, scheduling, etc. A company that manufactures furniture might use this type of configurator.

Product configurators can be used to control the options and variants of a product in the design and manufacturing stages of a company's business process. They can minimize rework and wastage, reduce human errors, drastically reduce the cost of design and manufacturing, as well as reduce the time-to-market that would alleviate the risk of a design becoming obsolete by the time it hits the market.

c. Knowledge configurators

A knowledge configurator captures information in a structured manner and displays the resulting information to the user^[8]. The knowledge paths can be complex and are dependent on the choices made by the user. Advanced knowledge configurators can be integrated with CAD software to provide productivity solutions.

d. Enterprise configurators

These are complex enterprise-level solutions that interface with multiple enterprise-wide systems^[9]. They can facilitate quote-to-production order systems, and enable sales and engineering process automation (such as quotations, invoicing, BOMs, legal documentation, routing and scheduling, etc.).

2. Reverse engineering

Many designs used today stem from designs created several years ago.

Several new designs are created by designers replicating an existing physical part through visual inspection and measurements. One potential KBE offering in this area is an application that scans an existing design using a 3D scanner, converts the scanned data to a digital editable product in a CAD / PLM software, and then modifies / enhances the design to produce newer designs.

3. Complete solutions, from concept to design and manufacturing

KBE can offer a full coverage of the design and business process, right from conceptualization to design, manufacturing, and generation of outputs, such as BOM and custom reports. Parts of this process can be standardized and a library of parameterized parts created. Moreover, knowledge items that are generic to the design can be separated from specific ones. An example of a user workflow here could be: a customer logs into a website, specifies functional parameters, and creates a digital

prototype on the spot. This prototype can be evaluated against various metrics such as strength, weight, cost, etc. The customer can modify the functional parameters to generate a more optimal design that satisfies their acceptance criteria. Once it is generated, the customer can place an order online or send the design for manufacturing.

4. Interior design / configuration

Companies that specialize in interior design almost always need to produce a custom design for a specific space available in a house or an office. KBE applications can help these enterprises specify the functional design parameters and constraints, and generate various options for interior space configuration that could include free space, furniture layout, etc. Additionally, it helps generate a detailed design- and manufacturing-friendly output of components like furniture.



KBE technology landscape in the retail and CPG industries

1. Configurators

Configurators are the most exploited area in the retail and CPG industries. Here are some commercial tools that currently address the configuration space.

Tool	Company	Solution	Market segment
3DVIA Virtools ^[14-15]	Dassault Systemes	Ability to develop custom software	Mid-range
Solid Works ^[14-16]	Dassault Systemes	Ability to develop custom software	Mid-range
CATIA ^[14-16]	Dassault Systemes	Ability to develop custom software	High end
Autodesk Inventor ^[17-18]	Autodesk	Ability to develop custom software	Mid-range
AutoCAD ^[17-18]	Autodesk	Ability to develop custom software	Mid-range
Autodesk Intent ^[18]	Autodesk	Rule-based solution for the ETO space	Mid-range
Unigraphics ^[20]	Siemens PLM	Ability to develop custom software	High end
KnowledgeFusion ^[20]	Siemens PLM	Rule-based solution	High end
ConfigureOne ^[10]	ConfigureOne	Web-based configurator	Mid-range
Vizualise ^[8]	Vizualise	Company that makes custom configurators	Mid-range
Fluid Configure ^[9]	Fluid	Product customization solutions	Retail market

Custom softwares, driven by a rule-based engine, are often developed for interior design and office space layout using AutoCAD. They are usually developed using softwares like Autodesk Inventor or Solid Works, for segments like furniture designers and manufacturers. The aircraft and automotive industries use CATIA and Unigraphics to develop custom software to configure airplane and car interiors.

2. Reverse engineering

Reverse engineering process involves creating point cloud data from an existing model using 3D scanners and creating surfaces and solids out of the data. The scanned data often requires manual refinement.

AutoCAD Shape Extraction tool, currently available in select countries, offers the potential to convert scanned data to solids.

ScanTo3D functionality, currently available in Solid Works Premium Edition, helps in importing scanned data and generating meshes out of it.

One interesting and sophisticated product in this space is Rapidform⁽¹⁹⁾. Rapidform XOS can convert raw scans to NURBS surfaces and meshes. Rapidform XOR can create CAD models from 3D scan data. The solids created in Rapidform can be exported to standard commercial softwares, such as Solid Works, Autodesk Inventor, CATIA, Unigraphics, and Pro Engineer. In some cases, it is even possible to form the history of model creation. Rapidform XOY helps in product inspection. Rapidform can handle millions of points in the point cloud data and it also provides API support.

3. Complete solutions, from concept to design and manufacturing

This space is largely addressed by custom softwares developed for specific scenarios. ETO and enterprise configurators often need to support complex customer workflows that may involve generation of quotations, invoices, BOMs, and legal documentation.

KBE in the retail and CPG industries - The way forward

The variety of challenges encountered in the retail and CPG industries and the solutions required, offer tremendous potential to develop custom software solutions using KBE. There is a demand for developing web- and desktop-based configurators – sales, product, knowledge, and enterprise – across various segments of the industries. The trend is to have the customers configure and customize products on their own and place an order. Behind the scenes, there is a requirement to develop softwares to manage orders, generate quotes, create BOMs, schedule workflows, and manage inventory.

Various sections of the retail and CPG industries, such as apparels, shoes, and toys, demand introduction of newer

variants of products rapidly, which translates to tremendous potential for reverse engineering-based solutions. A typical solution workflow would be to scan an existing design using a 3D scanner to generate point cloud data, convert the point cloud data to surfaces or solids, and modify the resulting geometry to create newer designs. This process saves time and helps create new designs based on older designs for which an electronic model may not be available. Moreover, in the case of art products, experienced and skilled designers can create an intricate design using clay, and the prototype can be scanned and modified to create an electronic model for manufacturing using mass production.

As part of software development, KBE can offer evolution and definition of product quality and performance metrics that can be linked to financial metrics of the enterprise. For instance, one can imagine how the weight of a certain beverage bottle can impact cost savings for the enterprise. Cost of each component in a design can be captured using KBE techniques and the final cost of manufacturing a product can be ascertained. KBE tools can be used to capture product knowledge, develop analytics, and optimize designs to achieve stronger enterprise results. KBE can also help in standardizing components, thereby maximizing customer product variants while minimizing design and manufacturing effort and costs.

Conclusion

The retail and CPG industries face several challenges in introducing high quality, high performance, and visually appealing products at an optimal cost, and with the ability to efficiently reuse designs. Product options and variants play a major role in the product lines since a majority of the products are highly customizable and configurable.

This paper presents a few KBE solutions and applications that can bring value to the retail and CPG industries. These KBE solutions can help reduce cost and rework, enhance time-to-market, enable knowledge management, and measure product performance metrics.

Infosys is actively involved in developing various KBE frameworks, processes, holistic solutions, and methodologies to address the needs of the retail and CPG industries. Over the years, we have developed several proofs of concept (POCs) to study and address the needs of these industries; an ample testimony to our commitment and expertise in conceptualizing KBE solutions to address specific needs of these industries.





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