Applying Mass Customization Techniques into Mass Production Apparel Business

Michael Yee, Wendy W.K. Wai, Mavis S. T. Ng, Rosita W.Y. Au, Mitchell M. Tseng

Michael Yee
Executive Director
Esquel Enterprises Limited
12/F, Harbour Centre, 25 Harbour Road, Wanchai, Hong Kong
YeeMi@esquel.com

Wendy Wai
Department of Industrial Engineering and Engineering Management
Hong Kong University of Science and Technology
Clear Water Bay, Kowloon, Hong Kong
wendywai@ust.hk

Mavis Ng
Department of Industrial Engineering and Engineering Management
Hong Kong University of Science and Technology
Clear Water Bay, Kowloon, Hong Kong
mavis@ust.hk

Rosita Au
Department of Industrial Engineering and Engineering Management
Hong Kong University of Science and Technology
Clear Water Bay, Kowloon, Hong Kong
rositaau@ust.hk

Mitchell M. Tseng, Ph.D., Professor
Department of Industrial Engineering and Engineering Management
Hong Kong University of Science and Technology
Clear Water Bay, Kowloon, Hong Kong
tseng@ust.hk

Acknowledgements:
The authors would like to sincerely thank the Hong Kong Technology and Information Commission for their Innovation and Technology Fund (ITF) to support the work throughout this project and Esquel Enterprises Group for providing us with the opportunity to get a better understanding of apparel business.

Abstract: In apparel business, contract manufacturing has become a common practice to leverage on global capabilities. In the mean time, the supply chain of the apparel industry has become very volatile with smaller batch size, higher variety, and faster response without substantial increases in cost. Facing huge diversity in different brand requirements, businesses revamp their models to survive in this dynamic global marketplace. In particular, this paper examines the conventional practice at Esquel Enterprises Group. Currently, samples have been used as vehicles for both the buyers and contract manufacturers to convey their agreement on the specification of products. As the delays and errors in making samples are very costly in marketing the products, mass customization technologies is needed to apply to mass production apparel business, namely Esquel.

This paper reports a framework for an apparel business to improve the development of specification between brand owners and contract manufacturers. The framework is based upon the fundamentals of the Product Family Architecture (PFA) and the buyer’s profile, to facilitate the specification of garment cater to the individual brand requirements and avoid iterative modifications and delays. This collaborative approach is implemented as an IT system prototype with E-commerce solution.
1.0 Introduction

Businesses are revamping their models more frequently than in the past. In the 20th century, mass production is widely practiced to make low cost products with controlled standardized processes. However, as customers are demanding more and more, businesses must react by producing customized and personalized products to survive in the competitive market. Namely, businesses are adopting mass customization and personalization (MCPC) techniques to produce great variety of volume production in an economical way.

In particular, the apparel industry is highly demanding. As the fashion changes more frequent than other industries, its production demand is shifting towards smaller batch size, higher variety, and shorter time-to-market. Although customers are satisfying, the supply chain of the apparel industry is becoming volatile. Many businesses react by subcontracting their production processes to maximize production capability, distribution channels and parties’ contributions to their full capacity. Yet, often this creates problem in the information process chain between parties, which is currently a problem in Esquel.

The decoupling production process creates errors and delays in the information process chain. While samples are always produced in small volume with fast response, they have been used as vehicles for buyers and contract manufacturers to convey their agreements upon specification of products. Often, the changes in making a perfect sample are very costly. Therefore, applying mass customization technology to meet the needs of brand name customers effectively and efficiently will significantly improve the production process.

For this reason, the goal of this paper is to apply MC technique in Esquel to consolidate information flow in between the process chains. This technique focuses on developing a framework that can generate a precise and systematic order process. The approach is to integrate the concepts in PFA and a buyer’s profile to develop an IT system prototype.

In terms of product design, in order to handle product variety, designing product as a family has been recognized as an effective method instead of designing product individually. The purpose of PFA is to rationalize product development for mass customization by synchronizing manufacturers’ varieties across product families. It can identify the commonality between product variants and model the design process of a class of products based on individual customization requirements within coherent framework (Tseng and Jiao, 1996). Later, a PFA of a men’s woven shirt is presented to illustrate the effective implementation of mass customization.

For better understanding of each brand’s preferences, an analysis on a buyer’s profile is reported. It is imperative to incorporate each buyer’s preference into product specifications to enhance product definition for customization and personalization. This approach is based on the results from data analysis through evaluating buyer orders used in a garment manufacturer. Based upon the high and frequent requests from the buyers, the related PFA preferences are studied to generate a data summary implemented into the IT system prototype.

Based on the available technology, this prototype is designed in such a way that integration into existing enterprise information technology environments is enabled. It aims at providing users with visualization and systematic text-based features to
improve user-friendly interface with consulting service. As stated, the prototype will be based on the fundamentals of PFA and the buyer's profile.

Collaboratively, this leads to production efficiency by shortening time to market with high product variety in small batch size.

2.0 Literature Review

2.1 Product Family Architecture (PFA)
To accommodate product diversity, a product family architecture (PFA) is necessary to characterize customer needs, thereby fulfilling these needs by configuring and modifying well-structured modules and components (Jiao, 1998). This dictates that a PFA involves two characteristics of design: (1) the modularity of a product structure, and (2) the commonality among individual product variants. As such, a PFA acts as a context-coherent framework under which the reusability of modules and components is maximized.

According to Jiao, a PFA consists of three perspectives, namely the functional, behavior and structural views which deal with specific aspects of product information. These views involve functionality (underlying topology of customer requirements), technological feasibility (application of a technology to a product design) and manufacturability (physical realization of a product design) respectively. They are then described by functional features (FFs), technical parameters (TPs), and components/assemblies (CAs). In the case study where the OEM garment manufacturer has to satisfy customer orders with precision, there is an overlap between functional and structural views in such a way that functional features are directly embodied by components and assemblies. Subsequently, this paper focuses on the structural view of a PFA, which is materialized by adopting a methodology called 'Generic Bill of Material' (GBOM).

2.2 Bill-of-Material (BOM) and Generic-Bill-of-Material (GBOM)
In more details, a product structure is the way in which a product is built up from purchased parts and/or semi-finished products. (Van Veen and Wortmann, 1992) Usually, it is built by using Bill-of-Material (BOM), which is a list of all the subassemblies, intermediate parts, and purchased parts that go into a parent assembly showing each quantity required to make an assembly. (Cox et al., 1992) Therefore, one product structure only represents one product.

In today’s industry environment, particularly in garment industry, in order to have better customer satisfaction, many manufacturing companies have been forced to drastically increase their product variety. Yet, studies have shown that BOM structuring is not sufficient to rationalize large amount of product data. To illustrate better implementation, the product data including BOM data must be defined explicitly by its part number to categorize each product variant distinctively, (Van Veen and Wortmann, 1992) The maintenance problem is implied by the requirements to identify each product variant explicitly by a part number for which product data including BOM data must be defined explicitly. (Van Veen and Wortmann, 1992) The more recent concepts of representing BOMs of large number of product variants are based on similar functionalities, components, and subassemblies. Although their primary focus is not on the final product variants, these recent concepts take a broader view towards representing any range of product variants at any level in the product structure.
One way to develop a product family structure is to use Generic Bill-Of-Material (GBOM), which represents a set of product with similar BOM structure. The key concepts in GBOM are product variants, parameter values, and items. A product variant represents a particular kind of product. It is identified by a set of parameter values, which represents the product characteristics of that particular product variant. Such a set of parameter values is called a specification. An item is a set of one, or more different product variants, which belongs to the same product family. (Van Veen and Wortmann, 1992) It can exist in the GBOM structure in different levels. Therefore, it is possible to describe each product variant within an item by means of parameters. This means that an item is associated as a list of parameters, and for each parameter there exists a list of parameter values. Each combination of parameter values represents a product variant within an item.

To handle interdependence in the parameters, constraints and relationships are necessary to present the GBOM structure completely.

3.0 Framework
As stated, the current trends in today's marketplace force manufacturers to shift to OEM businesses. The benefit of this business model is the decoupling of the production capability and distribution channels, so that every party contributes its capability and strives for a common objective in better serving the end users. Yet, this decoupling often weakens the information process chain in parties.

The purpose of this framework is to improve the information process chain between manufacturers, OEM businesses, and its clients. The following sections discuss the structure and feasibility of the framework in the garment industry.

3.1 Structure of Framework
As stated, the backbone of this system is based upon the foundation of PFA and customer profile. These two concepts are integrated and implemented in an IT system prototype that focuses on the interface between manufacturers and clients.

3.1.1 Product Family Architecture
The garment industry is facing intense pressure in global competition. In order to cope with the dynamic market, PFA is an effective method of rationalizing product variety.
The three construction phrases include a structural diagram, variety parameters and values, and a relationship development.

### 3.1.1.1 Constructing a Structural Diagram

To better illustrate this method, this paper focuses on the physical development of PFA with men’s woven dress shirt (Figure 2).

![Figure 2: PFA of men’s woven dress shirt.](image)

This architecture is represented as a GBOM structure by using the concept of object-oriented programming language to model the classification of components and attributes. In this case, Men’s Woven Shirt is a generic item that belongs to the men’s woven shirt product family.

The key concepts of the shirt structure are as follows:

- the *square shape* represents the four types of items, namely, product, intermediate part, subassembly, and component
- the *number*, followed by *x*, represents quantity relationship between child and parent objects
  - depending on the particular shirt, *y* can be zero, but always a whole number, to specify whether the shirt consists of that particular items
    - for instance, the cuff can be button or button-less
- the *diamond shape arrow* represents the ‘part-of’ relationship
  - for instance, sleeve is an intermediate item, which is ‘part-of’ the men’s woven shirt
- the *triangular arrow* represents ‘is a’ relationship to show XOR relationship
for instance, the collar and band piece item and single piece item in collar will never exist simultaneously

3.1.1.2 Identifying Variety Parameters and Values
Following this structural development, the next step is to develop variety parameters and values to represent variants occur in each item. These parameters are identified from buyers’ perspective that is to say parameters are the features, which buyers care; hence, they are captured into the following Table 1.

<table>
<thead>
<tr>
<th>Components</th>
<th>Variety parameters</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men woven shirt</td>
<td>Fabric</td>
<td>(Code)</td>
</tr>
<tr>
<td></td>
<td>Fabric match</td>
<td>Total match, Bias Cut, Symmetric, Alignment, Upper &amp; Lower cuff match, No matching required</td>
</tr>
<tr>
<td></td>
<td>Stitch</td>
<td>13-21</td>
</tr>
<tr>
<td></td>
<td>Stitch Method</td>
<td>Chain, Single</td>
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<tr>
<td></td>
<td></td>
<td>Double</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Triple</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lock Stitch, Single</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Double</td>
</tr>
<tr>
<td></td>
<td>Washing method</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Quantity</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Buyer name</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reference Pattern</td>
<td>(Code)</td>
</tr>
<tr>
<td></td>
<td>Sample Type</td>
<td>Prototype, Fitting</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Prototype, Sales Sample</td>
</tr>
</tbody>
</table>

Table 1: Portion of the Variety Parameters and Values

3.1.1.3 Identifying Relationships within the Structure
Inherently, items in the BOM structure are interdependent. For instance, some items share the same parameters in a GBOM structure, some items share the same parameters for any genuine product variants, and some items have no parameters. Hence, additional concepts are needed to handle the interdependency.

Briefly, the three relationship concepts that best describe the parameters are (Hegge and Wortmann, 1991):
- inheritance: the choice of a parameter value is passed on through the structure from the lowest-level of common subassembly
  - For example, the fabric style of a whole shirt is inherited for every component of the shirt. (Figure 3)
3.1.2 Buyer’s Profile
A GBOM deals with decomposing products into components and assemblies, and rationalizing varieties across product families. Products are subsequently built upon a common building block created with the premise of the GBOM. While in the case study,
an individual buyer may demand not only a differentiating 'style' on its garment, but also subtle differences across its sub-brands catering to a realm of end-customers. What's more, Esquel is faced with a challenge commonly found in the garment industry that some of the requirements from the buyers may change from season to season. These induce a necessity to recognize such an aspect of personalization of buyer requirements coupled with the seasonality concern, without which could debilitate a manufacturer's ability to best satisfy its clients.

In order to decipher and exploit this type of abstract, yet valuable information which is often shown in the form of 'experience', a dynamic buyer's profile is constructed as a knowledge repository incorporated in the IT system prototype with configuration rules governing the combination of variety parameters and/or parameter values. These rules are established through data mining for the purposes of (1) discovering the high frequency occurrence of the combination of variety parameters and/or parameter values for each buyer; (2) disentangling the intertwined relationship among variety parameters and/or parameter values for each buyer; (3) the combination of purpose (1) and (2) with regard to different sub-brands under each brand customer over time. The resulting findings will be stored as the default on the IT system prototype every time the buyer's name and its sub-brand's name are entered.

3.1.3. Integration of FPA and Buyer's Profile: IT System Prototype
This system is based upon the commonality of product variety captured by the PFA and the high frequency preference by the buyer's profile.

While focusing on the interface between sectors, the major requirements for the system include:
- personalization features: customized buyer's profile
- enhanced product presentation by means of visualization
- intelligent system for error detection
- intuitive and user-friendly layout with guidelines
- consulting service of technical terms

Nevertheless, in this changing marketplace, especially in the garment industry, the need to consistently change its product requirements is essential. This dynamic system is aimed at providing users with an easy-to-implement technique such that qualified personnel can consistently update the database.

Nevertheless, in this changing marketplace, especially in the garment industry, it is essential to be responsive to the changes in product requirements. This dynamic system is aimed at providing users with an easy-to-implement technique such that qualified personnel can consistently update the database.

3.1.3.1 Feasibility in the Apparel Businesses
With this system, the result generated will be in a form of precise and systematic order summary passes through the production process. This will enhance the informational process chain between sectors. As customer requirements are listed in details on the sheet, this will eliminate the repetitive interactions with ambiguous product verifications between sectors. This orderly manner shortens the production process and hence, reduces time to market. This factor is crucial in today's marketplace where customers are demanding products exactly as they want it, at the right place, right time, and right price.
4.0 Conclusion
This paper presents a unique mass customization technique of constructing a framework based on the implementing and integration of the PFA and buyer’s profile into an IT system prototype. This technique enhances the information process chain in the apparel businesses by facilitating the information flow between buyers and contract manufacturers in a precise and systematic manner. In addition, this framework demonstrates an easy-to-perform order taking process, which leads to production efficiency by shortening time to market with high product variety in small batch size to meet today’s global competition in the garment industry.

5.0 References