The Impact of Information Technology on Mass Customization

Josephice M. Lim

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The Impact of Information Technology on Mass Customization—an evolving trend for companies that want to be successful in the e-business arena.

Josephine M. Lim

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The Impact of Information Technology on Mass Customization

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Abstract

Increasingly, companies are adopting mass customization as a business strategy to meet increasing customer demand for product variety to help compete in the global marketplace. This paper examines the effects and impacts of Information Technology (IT) on mass customization and how various IT tools are used as customizing mediums to enable mass customization and provide unique value to customers in the most efficient way possible. Examples are drawn from companies who leveraged IT technologies in their mass customization efforts. Recognizing the critical value of technology professionals, this paper further discusses IT professionals’ roles and how they are an integral part of the mass customization decision process. Additionally, some of the challenges that companies face when attempting to adopt Information Technology as an instrument to enable mass customization are examined. In this process, some possible solutions to these challenges are explored. Finally, some of the benefits and outcome of mass customization are discussed.
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1. Introduction

Traditional companies tend to keep products flowing in predetermined streams, allow no changes to their standard products, and ship from large inventories. Lean companies on the other hand, tend to adopt a different business model by organizing for mass customization. However a company chooses to mass customize its product or service, it still must use tools and other vehicles to enable mass customization. In recent times, it has become clear that more and more companies are using Information Technology (IT) as an enabler to help drive their mass customization initiatives. Many technologies exist to help companies move from mass production to mass customization. The Internet has many technological possibilities, particularly in the area of inter-company relationships, and in their relationships with suppliers, business partners, and customers. The Internet is also an ideal tool for mass customization because tangible products that need to be customized can be represented “digitally” and users can then submit customized representations as orders.

Some have realized that in order for mass customization to work, companies need a highly iterative, information-based, and technology-based business model. These companies are changing and developing IT infrastructures and systems, and using collaboration tools to achieve real-time value chain collaboration across the extended enterprise in order to meet their mass customization needs. For other companies, their existing systems and applications, such as ERP\(^a\) (Enterprise Resource Planning) systems may be enhanced or re-structured to meet mass customization needs. Cisco Systems is used as an example to demonstrate how it enhanced its applications to meet customers’ mass customization need.

\(^a\) ERP will be further discussed in the later part of this paper.
Still, other companies use Product Configurators with software modules to create, maintain, and use electronic product models to allow for all possible product options and combinations to meet customers’ need for uniquely defined products. The result is an accurate and valid order with a customized product configuration without validation from engineering personnel or the production floor.

Despite the hype of mass customization, using IT to meet individual customized needs can sometimes be a challenge. First, not all companies are willing to take this new step. For example, larger and more entrenched companies may be slower to adopt this strategy as it could mean changing their current way of doing business, changing their current processes, changing existing applications and systems, and possibly even changing their present way of thinking. Companies may also face high investment costs. While mass customization may increase customer satisfaction, often, the trade-off is high costs associated with customized IT applications and business processes. To this end, some possible solutions to these challenges are possible and are discussed in the following section.

2. Mass customization defined

Mass customization is about giving consumers a unique end product or service when, where, and how they want it – at an affordable price. Mass customization can take many forms. For example, companies may collaborate with customers to develop a product definition and then develop a customized product or service for the customer. Also, a company could offer one standard but customizable product or service that users (customers) can alter themselves. Another example would be for a company to offer a standard product or service but present it
differently to various customers. Or, a company could offer a custom product or service to the customer without letting them know that the product or service has been customized for them.

Mass customization is largely adopted by manufacturing industries\(^1\), although increasingly, service industries such as insurance, financial, and health organizations are mass customizing their services to meet customers' needs. These services are typically knowledge-intensive and will require knowledge-based systems\(^b\) to enable mass customization.

There are many reasons why organizations mass-customize their products and services. Organizations sometimes experience improved margins; a situation where products are customized and built only when needed to fulfill a specific order and mass production costs are avoided or reduced because there is no need to stock finished goods. These organizations also use IT applications that allow for optimization of processes across multiple sites resulting in further cost-savings and improved margins. For some organizations, they experience shorter order fulfillment cycle by adopting mass customization. With applications and processes that provide manufacturing visibility and control across the supply chain, response time is vastly improved. When the right applications and processes are applied, mass customization permits companies to make changes to products and services while at the same time, reduce cost of changes. In so doing, there is faster compliance, less waste, and less rework. Finally, companies that adopt mass customization often experience improved cash flows and reduced working capital. The flexible production lines minimize manufacturing asset requirements and allow for inventory reduction and therefore lower costs.

3. The Internet as a customizing medium

\(^b\) To be further discussed in the following section.
Mass production has traditionally been part of the American business. However, with the advent of the Internet, many new technologies exist to enable a break from this tradition and enable businesses to adopt flexible production and mass customization. For example, companies in a wide variety of industries are using the Product Configurators\(^6\) that are built on the Web to allow customers to configure products online and submit specifications directly to manufacturers or salespeople.

Today, there are many online companies that use the Internet to offer mass-customized products to their customers. Chipshot.com, a Sunnyvale, California, startup is one example. Chipshot.com lets its online customers configure their golf clubs from 500 million possible combinations of grips, shafts, heads, and detail work\(^2\). The orders feed directly into Chipshot.com’s manufacturing system, thus allowing the company to quickly custom-build its product according to the customers’ needs.

Chipshot.com built its configuration engine using a combination of custom code and freeware. A Dell NetServer runs the Linux operating system, Apache Web server, and MySQL database where product information and configuration questions are stored as objects. Custom Perl scripts then links the database to the Web server. When a customer adds a custom seven iron to the shopping cart, for example, the site seeks for information from the customer about his or her golf game, such as handicap, and typical score. Then it asks for details about the club, such as the shaft length and color. Based on the answers, the site generates a page showing the club’s specifications and price.

\(^{6}\) To be further discussed in the section “Product Configurator as mass customizing medium.”
The Internet is not limited to just tangible products such as Chipshot.com's golf clubs or custom-made Levis' jeans. Mass customization can also be extended to services and information. The Internet is an ideal tool for mass customization because anything that can be "digitized" can be also customized. Digitability is the extent to which functions that are relevant to customers' needs could be fulfilled by the use of information technology. News information is a good example. It can be easily digitized because customers do not need the sense of touch or smell to assimilate the information since it can easily be displayed and conveyed in different forms on the Web. Telecommunications, mass media, and software development are further examples. For example, mass customization in media software gives news broadcasters the ability to deliver local news as well as combining it with mass media news.

Frank T. Piller from the German Mass Customization Institute\textsuperscript{3} suggests that with the Internet, there are various mass customization strategies that are available for companies engaging in e-business. In particular, there are Internet technologies that can enable direct communication between customers and suppliers and these technologies can make mass customization work depending upon the degree of digitization on the Web and the interaction required from the customer. He further explains how this digitization versus interaction relationship can form some basic e-business strategies for companies.

One strategy that Piller has identified is the "add-on" group. This group has low degree of digitability and low degree of interaction, specifically if few components of the products can be customized, or if the customers have enough knowledge of the products so that they can find the sufficient configuration easily without much interaction with the producer. One example is the yahoo.com portal where news and information can be easily digitized and displayed on the
web and customers and users simply access the web sites to retrieve the information with low interaction with the producer. Some customization or “add-ons” may exist to allow customers to personalize their individual pages such as myYahoo.com and some customized online services may be added—such as birthday reminder, an address book, or personal stock portfolio.

Pillar identified another group where customers are characterized by the need for high interaction. With this group, an intensive interaction is also needed on the seller’s side to create confidence and to minimize the transaction risk—the more the sellers know about the customers, the more they can meet the customers’ needs. An example may be customized automobiles. While the customization itself is not highly digitizable, Internet technologies can help with the configuration process. For example, online instant messaging is available for buyers to chat online with the suppliers and software tools like recommendation engines can simplify the identification of preferences by recording, comparing, and aggregating former sales, pages view, or click rates. Product Configuration tools are also available to help customers configure the automobile according to their needs and the data is then transferred into the producer’s business application systems.

To make mass customization a success, companies must gather real-time information in order to better respond to customers’ needs. The Internet as a tool helps companies acquire this information by providing a platform to use for development of applications which capture customer information and allow the discovery of trend information about customers and products in real time compared to traditional methods of data collection and examination. This idea of using customer data to help segment the customers is termed CRM (customer relationship management) and will be discussed in the latter part of this paper.
Cultivating customer relationships and optimizing supply chains can no longer be considered unrelated. In the past, they were performed by non-integrated, standalone solutions. Today, integrated Internet-based solutions can enable mass customization and overcome the limitations of inflexible supply chains by integrating business communities into a common network. There are potentials still to be exploited using the Internet, particularly in the area of inter-company relationships, such as B2B (business-to-business) strategies and relationships between suppliers and sales partners.

The Internet has truly created new channel opportunities. Companies such as Dell.com and Amazon.com have created huge markets by selling their products directly to customers and bypassing traditional intermediaries. Dell.com allows customers to design their own computers on its Web site using tools that are tightly connected to the JIT (just-in-time) manufacturing operation that customizes the assembly of each order. The benefits for these companies include lower selling costs and lower communication costs since the companies can sell directly to the customers as well as creating a purchasing experience that perfectly meets the needs of the customer. Without layers of intermediaries, companies can get better and clearer signals regarding the customers’ preferences and demand levels, which in turn, leads to better inventory management and production planning. The type of initiative is being launched by many others, including Proctor and Gamble’s Reflect.com with the goal of giving customers a personal online beauty store where individuals can create their own make-up, skin care, and hair care products.

Mass customization is not limited to tangible products. Digital content providers can similarly provide customized products for their direct customers. And the contents can be custom-configured for each user’s requirements through the use of cookie file technology.
example, many portals enable each individual customer to customize the portal screen (such as myYahoo.com), thereby showing weather for that user’s hometown, user’s preferred news categories, favorite sports teams, and personal stock tickers to watch. Cisco Systems’ Manufacturing Web portal allows a user to customize a users’ personal Web page using myEMCO (electronic Manufacturing Connection Online). A user can customize the Web page by adding different prices of available information such as stocks, information from functional areas, news, training sites, and applications.

The above demonstrate the potential for businesses that are able to utilize Web-based technologies to create information flows and directly connect to customers to position themselves to gain long-term competitive advantages over their competitors. These businesses exploit the technological capabilities of the Internet network environment to create new market opportunities. By providing customized products and content, they improve the value proposition for their customers and suppliers, while improving their overall profitability.

4. Product Configurator as a customizing medium

The traditional one-to-many mass media such as radio, television, and print is a “passive” way of presenting content and information to the customers. However, with the Internet and the customization of the Web, companies are now able to have a personal relationship with their customers, resulting in a more proactive and interactive approach to selling. Increasingly, companies are using “Product Configurators” to help harness this relationship.

Product Configurators are “software modules with logic capabilities to create, maintain, and use electronic product models that allow complete definition of all possible product option and variation combinations, with a minimum of data entries and maintenance”6. Before Product
Configurators, companies assign part numbers and create a BOM (bill of materials) for every end-item, resulting in unmanageable product databases that require constant maintenance efforts. But with Product Configurators, these modules help resolve some of these problems by eliminating levels in the BOM. To be successful in mass customization, Product Configurators should be used throughout the product’s life cycle, including design and development, Sales Force Automation, and manufacturing.

The use of product configuration software to speed up the gathering of information as well as configuring product variations can meet customers’ individualized needs. Compared to the traditional practice of many lengthy inquiries back and forth with engineering, procurement, and manufacturing departments, configuration software offers various “what if” scenarios, prices, and availability quotes, often via a salesperson’s laptop or via a company web site.

In the BTO (build-to-order) environment, Configurators are essential to the success of mass customization by validating the BOM and by achieving rapid, accurate configurations of unique products before building them. Whenever a customer orders a particular configuration via the Configurator, the production department is immediately informed. Based on the requirements of the order, a work order is generated and transmitted to production along with a bill of materials and any special work instructions.

In today’s marketplace, companies are placing high emphasis on relationships with their customers, leading to the development of CRM processes and technologies. In many firms, the salespeople are the first point of contact with the customers and Sales Force Automation (SFA) tools are therefore often used to facilitate the customer-salesperson information exchange process. SFA tools may include real time access to product and competitive information,
Product Configurators, real time collaboration, and information sharing. SFA systems consist of many sub-systems, including Quotation and Proposal Preparation, Sales Analysis, and the Product Configurator module, an essential sub-system for mass customization. Product Configurators are used in SFA software to achieve more accurate configuring, quoting, and order entry. Once developed and deployed, the Product Configurator module allows the rapid definition of unique, often complex product configurations. The capabilities of a Product Configurator module enable the accurate order entry of a customized product configuration without constant, further validation editing by engineering personnel.

The Product Configurator can be used in the SFA process in various ways. Sales people can use mobile laptop computers right on the customer’s site for assisted buying. Or, customers can go directly to the company’s Web site for quoting, configuring, and order entry without assistance from an on-site sales representative. When products are complex, the mobile laptop computers method are more feasible compared to less complex products where buyers can self-educate themselves of the products via the Web. For instance, Blue Martini Solutions Configurator from Blue Martini Software allows sales representatives to use the application to produce quick, error-free proposals, a complete bill of materials from simple product recommendations to multi-level system configurations. In addition, it allows companies to automate sophisticated pricing policies for both internal users and channel partners, including setting “what-if” scenarios for specific mass customization requirements.

Whether SFA is used via a laptop or the self-assisted Web site, the outcome of the SFA process is typically an “order BOM.” The order BOM is fed into the ERP system for completion of the order by Manufacturing. The customized order also relies on PDM (Product
Data Management) systems to provide unique product and process information to the plant and the suppliers. For example, manufacturing and work instructions can be created using parametric drawings and animation graphics based on the customized product configuration at time of order entry. Product Configurators software are currently provided by most major PDM vendors, ERP vendors, some SFA and CRM vendors, and a few third party vendors, such as ILOG and Configuration Systems and Consulting.

Some vendors go even further by joining alliances to provide a wider offering of Configurator capabilities. For example, J.D. Edwards acquired Premisys Corporation, a company that provided sales engineering automation software called CustomWorks to manufacturers of complex, configured products, requiring custom engineering with spatial and dimensional design. One version of the Premisys product runs with AutoCAD to provide spatial layout capabilities. Integrated with J.D. Edwards OneWorld ERP, the combined products offer mass customization capabilities such as parametric and modular options/variations selection. For example, the front office SFA capability can generate technical documents needed for initial quotation activity and customer design review before order entry.

Another example is the strategic alliance of QAD and ACCESS Commerce, developers of Cameleon, a Product Configurator to address the specialized needs of the mass customization arena. The Cameleon product is embedded in QAD’s MFG/PRO software, providing seamless access, display, and use of products configuration information for users of the two systems.

Tay, Lim, Goh, and Viswanadham proposed a framework for the configuration process called the Icust (Internet customization design) system\textsuperscript{11}. Icust brings the customers into design and manufacturing by linking customers’ choices with the company using the Internet. The Icust
system first links product design, customer requirements, and Web tools together. The Web tools consist of 2-D imaging, 3-D imaging, rotation, video, and audio and are used during the process of virtual simulations of customizable products and services. The next step is to make the customizable product available on the Internet.

Information on the Internet requires a three-tier architecture, including the client interface (a Web browser), a Web server, and a database. All data exchange and storage between the client and the database goes through the Web server and is handled using Java servlets. The client interface is called the "virtual shop" and it allows the end-users to customize their products.

In the virtual shop, customers can customize their products using two different modes of selection. The first mode is assembly-to-order which allows the customer to select from various options that are already in stock and can easily be assembled into a final product. The second one is the make-to-order mode with that offers more customization and it gives customers the flexibility to have precisely what they want (the design, the configuration, and other desired functions) via a Product Configurator.

The virtual shop is linked up with the JSCMM (Java Supply Chain Management Module) so that customers can check prices and delivery times and authenticate the availability of customized products with stakeholders such as suppliers, manufacturers, designers etc. in the entire supply chain.

The final step of Icust is the concept of "spiral branding." It is an attempt to create and retain existing customers. Initially, traditional mass media like television, radio, or the print persuade customers to visit the Website. Once the customers have visited the Website,
companies use the Web to allow customers to customize Web content, products, and services. During the process, customers’ preferences and email preferences are stored in the company’s customer databank. The company then uses email to inform customers of updated information available via email, television, radio, or print, thereby creating a spiral effect.

Product Configurators often integrate with ERP systems as they need to interact with the item master, bill of materials, routing, cost, price, work order and sales order systems in order to accept a successful configured order. In order to configure the quote or sales order with the features, the Configurator needs to get information such as build time to make the product, how much it costs, delivery date, and availability.

5. Collaboration tools as customizing mediums

Today, companies need to have visibility into their suppliers’ capabilities while at the same time, give suppliers visibility into the companies’ actual demand and production schedules to quickly meet customers’ mass customization needs. The result is a network of diverse tools and applications that collaborate among customers, producers, and suppliers. As mentioned previously, the Internet enables real-time information flow between customers and suppliers. In this section, various collaboration tools that are responsible for the support of mass customization are explored. These tools and applications inter-operate with the Internet to provide a highly iterative and information-based business model.

One of the earliest collaboration tools is electronic data interchange (EDI). EDI is a standard format for companies to exchange data. An EDI message contains a string of data elements separated by delimiters. Each data element represents a price, a product model number, or a zip code, etc. EDI allows companies to communicate and process business transactions
electronically using a common interchange language, minimizing the need for users to re-
program their internal data processing systems. International Truck and Engine Corporation, one 
of the largest engine suppliers to Ford Motor Company has been successful with mass 
customization by building its supplier-collaboration system using electronic data interchange 
(EDI) and two proprietary Internet applications, effectively allowing International visibility into 
its suppliers' capabilities (such as inventory levels and lead times) and by giving suppliers 
visibility into the company's actual demand and production schedules\textsuperscript{12}.

Similarly, Dana Corporation, a tier-one supplier of chassis, engines and other automotive 
parts in Toledo, Ohio, is building a supply-chain management system that will provide real-time 
information to its lower-tier suppliers. Dana will use Covisint (an application exchange that is 
supported by Daimler-Chrysler, Ford, and General Motors) as its interface to automakers that are 
members of the exchange but will use its own system for others who are not members of 
Covisint. Dana connects 320 manufacturing plants worldwide for procurement of certain parts to 
meet unique customer requirements by using software vendors like i2 Technologies, Inc. and 
Ariba Inc. In addition, Dana uses supply-chain software from Supply Solutions Inc. to connect 
its own operations with those of its suppliers.

Camstar, a provider of manufacturing collaboration software, explains why building a 
"virtual factory,"\textsuperscript{13} collaboration model, can help meet a company's mass customization needs. 
This is important because a customized order cannot be fulfilled unless there are back-end 
applications and processes to ensure that the order is followed through. According to Camstar, a 
virtual factory uses real time live data to enable more effective planning, better information for 
responding to customized requests and less disruption when the product or process changes.
Camstar maintains that traditional applications such as MES (Manufacturing Execution Applications) systems produce real-time production data, such as production scheduling and tracking, material status and requirements, and product tracking, etc. But the use of these MES systems are not integrated with other ERP and CRM systems. Internet technologies and collaboration tools can enable a virtual factory where distributed but interrelated manufacturing sites are connected and meet those customized orders and requests in concert. A case in point is where a company has a unique opportunity to customize an order and deliver by a specific time. The company is able to quickly respond to this need only because it has visibility into each plant, their current status and backlog.

Several technical requirements must be met to make a virtual factory successful. A company needs a technology infrastructure to support data and information exchange and collaboration. The Internet, extranets, and intranets are natural choices that can support this as it has security and high reliability 24X7. Secondly, as mentioned previously, plant applications from MES systems provide two-way real time data to supply chain applications. Once the information reaches the supply chain applications, a collaboration component needs to exist to distribute and coordinate customer work orders across multiple sites and connect plant applications and the enterprise order planning and management systems. Therefore, application integration software is necessary to connect and talk to disparate applications such as ERP, PLM (Product Lifecycle Management), MES, and supply chain. Finally, real time data does not provide any value to the business if the data cannot be understood or utilized. For example, OLAP (data mining) tools can be used for reporting and analysis, raise notifications and alarms, and help the company make critical decisions.
The ability to collaborate with other members of the design team as well as with external suppliers and partners is crucial. Many manufacturers are tying collaboration to reduced design time. According to Information Week Research survey, 67% of manufacturers that share information electronically with suppliers also share product design and engineering information\textsuperscript{14}. For example, companies such as Engineering Animation Inc. (EAI, now part of EDS), Ames, Iowa, and CoCreate Software Inc., Fort Collins, Colorado have introduced software that enables design teams to collaborate in real time on designs over the Internet\textsuperscript{15}. CocCreate's OneSpace enables engineers and other users to share documents and 2-D and 3-D designs online, regardless of whether the designs were created with CoCreate's CAD (computer-aided design) systems or those of other companies. Users use this collaboration software to communicate, change, and view designs in real time. This flexible CAD solution is needed to enable companies to react quickly to customers' mass customization needs. EAI's VisConcept that was developed in close collaboration with GM also allows global teams to collaborate to produce virtual prototypes. It allows users to reduce the number of physical prototypes by at least 50% and view life-size prototypes within minutes – far faster than the 40 to 50 days it takes to build a physical prototype. The solution allows teams to evaluate product designs by including customers' mass customization requirements into the product innovations in various virtual environments.

The concept of Rapid Prototyping can also affect how companies can meet customers' mass customization needs in a faster and more fluid way, all the way from product conception to market. Rapid prototyping technology helps this process by automating the fabrication of a prototype part from a 3-D CAD drawing, thus presenting complete information about the product earlier in the development cycle. The turnaround time for a typical rapid prototype part can take
a few days compared to conventional prototyping that may take weeks or even months, depending on the method used. To meet mass customization requirements where production parts are becoming relatively small and quantities are typically fewer than 1,000, Rapid Prototyping help make mass customization a reality\textsuperscript{16}.

To support collaborative applications, companies also need available computing power. For example, Intel’s HPC (high performance computing) solutions support highly compute-intensive tasks. HPC provides top compute power for virtual prototyping and manufacturing, crash simulation in the auto industry, and the like. Its HPC clusters allow manufacturing to scale capability quickly in respond to mass customers’ needs\textsuperscript{17}.

In the previous section, technologies that leverage the Internet were discussed. A related concept is c-commerce\textsuperscript{18} (collaborative-commerce) which harnesses the power of the Internet and other information technologies. C-commerce is an idea that was conceived to improve information exchange through systems integration and communication through the Internet for all stakeholders, including employees, customers, and business partners. In the process of these exchanges, trust is built and information sharing is improved and business transactions are also vastly improved.

Companies adopt c-commerce to meet high customization demands. For example, they now use Internet applications that leverage an open and scalable architecture as well as common software and standards to support interoperability between companies in the entire chain. Members of the supply chain collaboratively design, build, market, and deploy their products and services. Suppliers like Taiwan Semiconductor Manufacturing Company, a contract manufacturer of integrated circuits, are benefiting from c-commerce by using the Internet to
share data and design information with their customers\(^{19}\). Before implementing its collaboration solution, Taiwan Semiconductor used slow and time-consuming tools such as fax, email, FTP, and standalone web sites. With the adoption of c-commerce solutions, Taiwan Semiconductor now automates a range of shared business processes with its customers, including engineering, forecasting, order management, work-in-progress updates, and shipment notifications.

C-commerce is important because many of today’s collaborative technologies are based on isolated architectures and do not integrate data and applications and they run into interoperability problems. A 1999 study conducted by the National Institute of Standards and Technology showed that interoperability problems due to data quality within the automotive supply chain alone cost as much as $1 billion a year\(^{20}\). Managing disparate CAD/CAM (computer-aided manufacturing) and complex interfaces between organizations were cited as major reasons why auto companies have not moved quickly to adopt C-commerce strategies.

Increasingly, manufacturers have as much as 80% of their materials from suppliers added to the final product rather than producing its own materials for the end product. For example, a Cisco Systems’ router may have a Chinese chassis, a Taiwanese memory card, majority of the components manufactured in Thailand, and proprietary IOS software, all assembled and built in Hong Kong. As such, collaboration in real time is important because manufacturers (such as Cisco Systems) need to have a good handle in their supplier base. Because United Technologies Corp’s products have about 80% of parts supplied from outside suppliers, it uses FreeMarkets Inc. for its e-procurement services to gain visibility to all its suppliers, including quality and performance metrics, and to gain visibility to how quickly suppliers can adapt, change, and customize to United Technologies’ mass customization needs.
In summary, customers have an increasing need for mass customized products and services to meet their specific tastes. Making these individualized products available require companies to adopt new processes and technologies, including the design process, interoperability, collaboration tools, etc. These tools exist to enable companies to produce personalized products through rapid manufacturing.

6. Web Services as a mass customizing medium

To meet mass customization needs, the entire value chain from order entry to product delivery needs fast and rapid information-sharing capabilities such as real-time connections. In the past, accessing data from an application required custom code to interact with application-specific interfaces. With Web services, similar data access requirements are met using modern protocols. SOAP (Simple object access protocol) is an open interface protocol that uses XML (Extensible markup language) to interact with and transfer data to and from the application.21

Norwich Union Insurance, a subsidiary of Aviva PLC uses Web services to meet its mass customization needs.22 Since insurance products are information-centered, production of custom policies can take place right at the point of customer contact by independent agent or by customers entering information into the company’s policy-creation processes by simply using Web services capability.

Insurance company, Cigna Corp. built a portal to provide customized information to subscribers to its health and financial plans. However, the giant applications that ran on separate systems were not scalable.23 The IT team then used IBM WebSphere and XML to break up the gigantic applications into Web Services that allows customers to pick and choose what they want to view in the portal.
Earlier, there was a discussion on EDI and its role in enabling mass customization. In recent times, there has been widespread speculation that in the future, XML and e-business infrastructures that are built on XML will most likely replace EDI\(^2\) (Note that EDI as a technology will not disappear but will become a limited technology). This is because XML-based EDI (XML/edi) is faster and cheaper than the traditional EDI. There are some key differences between EDI and XML that explain why XML is moving to replace EDI. First, EDI formats are externally defined while XML formats are self-described. Secondly, EDI standards are widely adopted while XML standards are still being perfected and adopted. And thirdly, XML files are generally huge compared to EDI files.

While these differences exist, there has been a movement from EDI to XML. Even though EDI has been around for a long time, only 2% of business utilizes EDI functionalities. With XML, the usability is forecasted at 70-89%. In addition, large retailers have only 20% of their suppliers using EDI\(^3\). A cost-related issue is the use of private networks versus the use of the Internet; compared to the latter, private networks are more expensive to use. A more compelling reason is interoperability. To compete in the E-business arena and meet mass customization needs, companies need to support data integration with their supply chain partners. With, XML, it provides a methodology to describe the structure in which the data resides, therefore providing context. It can also represent data in different formats.

The next step for companies as they transition from EDI infrastructures to XML/edi solutions is to learn from EDI and work towards the goal of standardization. Ultimately, through standardization, the user community will help determine the efficiency of electronic data exchange for either traditional EDI or XML-based systems.
7. Other IT tools and integrated solutions as customizing mediums

As companies become more outward focused, they realize the benefits of collecting customer data and preferences in order to better customize products to customer needs. They also realize the benefits of including customers and business partners in the value chain. This has created a need to integrate ERP systems with CRM and Supply Chain software solutions in the organization. For example, Osram Sylvania, manufacturer of lighting products, uses SAP as its main applications provider. Osram Sylvania built a portal called mySYLVANIA.com using CRM software functions from SAP. The portal also integrates with R/3, an ERP package from SAP. The result is the conversion of CRM information (like managing, acquiring, and retaining customers) into work orders and transmitting these work orders to the production floor. Most Product Configurators are a part of the CRM function. They capture customers' orders based on requirements and preferences. Based on predetermined rules, the Product Configurators convert the order requirements into feasible configurations. The configurations are then turned into work orders and are fed into production systems.

In their paper on how organizations can use information technology to advance the effectiveness of transnational organizations, Boudreau, Loch, Robey, and Straub underscore the importance of mass customization technologies. According to them, mass customization technologies allow businesses to modify products and services to suit specific customer needs while retaining some of the advantages of large-scale production of those products and services. According to the authors, the key to mass customization is the ability of information technologies to control the introduction of customized features into the production process. For

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\(d\) Organizations with extended activities around the world.
example, systems that allow firms to produce products on assembly lines to suit individual preferences are commonly exploited in the automobile industry. Made-to-order cars can be delivered to individuals within relatively short period because of the ability of computer systems to control the assembly of custom components at the precise moment needed in the factory process.

Companies sometimes partner with other companies to develop a solution to meet its own mass customization needs. For example, FitMe\textsuperscript{28}, a developer of mass customization solutions, and Hamamatsu, a manufacturer of advanced optical sensors, jointly introduced a software platform for the development of commercial applications using Hamamatsu's whole body scanners. Developed by FitMe, the platform will stimulate the use of whole body scanners for mass customization in industries such as apparel and fitness. With the availability of the powerful software development platform, Hamamatsu can generate various kinds of software applications for mass customization. The software will help speed mass customization in industries such as apparel, automobiles, and fitness. Essentially, the software facilitates development of web-enabled applications where an Application Programmers Interface (API) allows developers to focus on new applications and eliminates the need to understand database design to deal with hardware issues such as scanner upgrades. A simple automated application allows users to scan themselves at scanner kiosks.

In 1990, Bally Engineered Structures Inc., of Bally, Pennsylvania decided to increase its process modules to support its customers' mass customization needs. For example, it wanted to offer such features as welded construction and a much wider range of finishes and air and electrical control systems. As a result, different modules are now available to meet customized
order whether it is for a blast chiller, a clean room, or a freezer that can withstand steam cleaning. To do this, Bally developed a brand new dynamic network with a sophisticated information-management system called computer-driven intelligence network (CDIN). A sales person can custom-design each order in the customer’s office on a laptop computer that is connected to the CDIN via a modem. Once the design is completed, manufacturing software in the CDIN defines the exact combination of process modules required to make the product. The network also electronically connects everyone in the company, as well as independent sales reps, suppliers, and customers. The CDIN’s databases contain most of the information Bally uses, including leads, quotes, designs, purchase orders, and the skills and experiences of all Bally employees.

At SINTEF/NTNU, Alfnes and Strandhagen proposed a model, called The Control Model (CM) methodology that was developed for enterprises that want to adopt mass customization. This methodology is designed to help companies achieve high performance production and logistics. The methodology involves an approach to communicate and explain how businesses should be re-designed to achieve its mass customization needs. So far, this methodology has been successfully adopted in more than twenty manufacturing companies.

According to Alfnes and Strandhagen, many companies spend millions of dollars to upgrade Material Planning and Control Systems to ERP systems. They may also implement new programs to meet customers’ mass requirements. However, these ERP investments seldom

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The SINTEF Group carries out contract R&D for industry and public and private enterprises. It cooperates closely with the Norwegian University of Science and Technology in Trondheim, NTNU, in Trondheim, and the University of Oslo. This enables the institutions, whenever feasible, to share laboratories, equipment and specialist staff; a significant contribution to expertise.
provide the desired improvements because as customers and their needs grow increasingly diverse, these programs add unnecessary cost and complexity to operations. This is not to say that ERP systems do not play a major role in the CM methodology. On the contrary, cost efficiency, responsiveness, and flexibility are embedded in major manufacturing strategies like ERP-approach, lean production and socio-technical system design (such as semi-autonomous groups and participatory design\(^f\) where developers, business representatives and users have a voice in the design of a product). In addition, these manufacturing strategies form the backdrop of the CM methodology and they are principles and strategies that have inspired the CM methodology, both for enterprise design and for managing the design process.

In the CM methodology, the concept of lean production constitutes a platform for mass customization. Design by socio-technical principles enables enterprises to handle variation and uncertainty and provide solutions that improve work quality and performance. All these principles are combined with lean principles in order to design enterprises for mass customization.

For products that are intangible and knowledge-intensive, knowledge-based systems (KBSs) are critical enablers of mass customization. Since these products and services are typically knowledge-intensive, the “production processes” are usually based on personnel’s knowledge and experience. As a result, an infrastructure of seamless information flow between processing units such as people and software is required to meet mass customization needs.

For firms that offer knowledge-intensive services such as financial services, KB (knowledge-based) technology is an integral part of the whole infrastructure. Furthermore, in an

\(^f\) A method where users provide feedback to designers and engineering when prototypes are being developed. This leads to a product/service that better fit the users' needs.
effort to move toward a network infrastructure to meet mass customization needs, some organizations adapt their existing KBSs in ways that facilitate the reuse of these systems' knowledge\textsuperscript{31}. The ability to reuse the knowledge in these KBSs can play a critical role in facilitating the move towards mass customization for service industries.

Technologies are used widely to make Process Units\textsuperscript{6} (PUs) more functional and flexible. Because of cost issues and the degree that PUs can be cross-trained, most product-related knowledge and problem-solving responsibilities are assigned to KBSs and allow PUs to focus on other value-added activities. For example, at Cisco, the Selectica Configurator engine helps customers customize a product at order entry, thereby releasing salespeople of the burden of managing and remembering the various product configurations and allow them to focus on selling.

KBSs play a supporting role in knowledge-intensive process management activities such as creating, managing, and using a global memory. For example, a law firm may retrieve relevant past cases from a KB and adapt the past solutions to the current case. Another example of a KBS at work is the corporate financial risk management industry. KBSs in this area are used for designing option-based portfolios or task-specific KBS for reasoning about investment-related tax issues. As a result, mass customizing risk management portfolios can put together non-standard combinations of securities like options and swaps and take into consideration various firm-specific tax issues, credit issues, accounting issues, etc. Non-customized portfolios

\textsuperscript{6} Process Units are people, modules, software, applications that are necessary to get a task completed.
on the other hand, consider standard securities and assume that all firms face the same tax codes.

QAD Inc., a leading supplier of ERP and Extended Supply Chain software, suggests that a certain suite of IT tools is necessary to help achieve the objective of mass customization. These tools can be described in three groups – product definition, planning and control, and IT infrastructure. In the first group, a broad range of software tools are required to bring customizable products to the marketplace. One of the tools is Quality Function Deployment (QFD), a structured methodology to ensure that customers' mass customization needs are identified and met. It is a tool that is used frequently in companies that adopt modular design.

In planning and control, several IT-based applications are required for the delivery of mass customization. The most common application is Sales force automation (SFA), an advanced IT tool to automate the total sales cycle and is an essential element of mass customization. SFA systems may consist of many sub-systems including Quotation and Proposal preparation. However, of the many sub-systems, the essential one is the Product Configurator module.

ERP systems evolved from the early days of Materials Requirements Planning (MRP) in the 1960s as well as the Manufacturing Resource Planning (MRP II) in the 1980s to their current state. ERP systems are tools for the planning and control of the product form order entry through shipment. As MRP II systems expanded into ERP, more functionality was added, such as extensive accounting and financial capabilities. In addition, ERP systems differ from earlier MRP II systems in the use of more modern IT capabilities, such as Graphical User Interface

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This is an assumption.
(GUIs). ERP supports the process PLR (product line rationalization) where product lines are simplified via activity and volume information. ERP systems are limited in the sense that the serial processing of material needs and then capacity needs does not truly optimize plans.

A better alternative is Advanced Planning and scheduling (APS). APS systems take into account demand (such as dates and quantities) and resource constraint information (such as personnel, equipment, and material), and processes the data using intelligent analytical tools to prepare realistic and achievable plans. APS systems compensate for the slow response in ERP by using multiple “what-if” simulation scenarios for decision support and analysis. They can also develop plans and schedules simultaneously, in contrast to the serial approach of ERP systems. APS systems operate faster in minutes and hours instead of days and weeks, as is typical of ERP systems. This capability can better support mass customization by greatly reducing order fulfillment time with more accurate scheduling. Note that APS systems do not replace ERP systems. They do, however, need to be tightly integrated with ERP systems to leverage the capabilities of each system. In a survey conducted by Information Week earlier this year\textsuperscript{33}, IT managers agree that the most important projects for the coming year is enterprise applications such as ERP or financial applications. They further said that this would involve leveraging what their companies already have by adding new features or modules to existing systems.

The goal of flow manufacturing (FM) is consistent with the goals of mass customization: To produce a high quality product in the shortest order fulfillment time at the lowest cost. It is based on a “pull” strategy where the customer demand triggers the assembly and manufacturing
process as opposed to a push strategy that is based on a forecast and master schedule. FM method includes lot size reduction, elimination of work orders, flexible teams, and the like.

In addition to the above planning and control applications, an IT infrastructure with strong capabilities support product definition and planning and control systems is required to achieve the goals of mass customization.

Interoperability is the ability of varied systems to share applications software seamlessly. Middleware and enterprise application integration (EAI) software often provide the necessary capabilities to integrate numerous IT elements in a “best-of-breed” strategy. EAI software provides the necessary capabilities to link ERP and related applications.34

Closely related to interoperability is componentization. With componentization, application logic is contained in small software modules of information that can be easily manipulated. The modules can be reused, thus shortening new application development time resulting in application systems agility and flexibility. This allows a company to select the software that best fits its needs without the risk of “big bang” implementations when systems must be upgraded with new software releases.

Finally, as mentioned previously, the Internet is another IT capability that can connect the virtual enterprise of customers and partners, enabling rapid information flow globally. The three IT support capabilities (interoperability, componentization, and the Internet) support product definition and planning and control systems. They directly contribute to achieving the goals of mass customization. The many application elements of IT-based systems essential to mass customization must be unified into a seamless, cohesive framework.
Uniloy Milacron (Manchester, MI) is a mid-sized manufacturer of plastic blow molding equipment that are uniquely configured, manufactured, and sold to manufacturers of plastic bottles and containers. The company is an engineer-to-order (ETO) supplier that is fully capable of producing any desired configuration of its products. However, the company’s legacy systems were not adequate to cope with the ETO environment.

Initially, for each uniquely configured end-item, the company had a BOM that included 3,000 to 5,000 parts, resulting in days of order processing. However, with the implementation of Cameleon and MFG/PRO, Uniloy Milacron reduced order process times, minimized the costs of “one-off” methods of the ETO environment through the modular design approach of mass customization, and improved the downstream product documentation resulting from the initial configuration process.

The company also uses PLR software to better clarify product options, resulting in more accurate product configurations and pricing. Using Cameleon, engineering creates logic rules for the BOM during the design and development process. The resulting product model in the Cameleon-MFG/PRO system is then available whenever users throughout the product life cycle require configurator logic. This includes the script for configuring a unique product used in the visual selling process on laptop computers. For manufacturing, it can use it for uniquely configured routings with target costs. In the final step of the product life cycle, the as-built configuration is stored in MFG/PRO.

8. Case Study I: Dell Computer and Mass Customization
Probably the biggest and best-known success in mass customization is Dell Computer, one of the largest competitors in the PC industry. Dell pioneered custom-configured computers where each and every PC is custom-built and shipped directly to the customers, bypassing the retailers and channels. Today, despite its increased sales and volume, Dell is still able to configure each computer that it sells to meet the needs of individual buyer. At Dell.com Web site, one can get the exact computer by adding more RAM, processor speed, selecting a DVD versus a CD-ROM, or adding more extra disk space—all without Dell having to stock every conceivable version on the shelf.

Selling direct without a reseller or channel is not a new practice; mainframes and minicomputers were originally sold directly by companies but only to very big customers. This is because selling direct is expensive and requires complicated processes and a rather complex organizational structure. But for Dell, today, it is able to sell directly and has continued to sell direct to many of the Fortune 500 companies because it has created a sophisticated supply chain infrastructure that thrives on real time information so that the business can quickly react to changes and customers’ needs.

Many of Dell’s competitors build personal computers based on estimated demands and various contracts with distributors. These distributors turn around and sell the computers to individuals or businesses. Dell’s competitors decide how many computers to assemble based on these demand schedules, ship them to distributors, and hope they would be sold before the computers become obsolete. But for Dell, by eliminating markups charged by distributors and dealers and by selling direct, Dell is able to pass the savings on to the customers.
In the PC industry where technology changes quickly, Dell can deliver the latest and greatest technologies faster than its competitors by selling direct and by mass customizing to the customers’ needs. For instance, whenever there are new introductions of processor technologies, Dell can quickly adopt the new technologies by configuring machines to use these new chips without having to bleed off old inventories that are sitting on resellers’ shelves.

**History of mass customization relative to Dell**

In 1984, Michael Dell registers his business as Dell Computer Corporation with $1,000 in startup capital. The company becomes the first in the industry to sell custom-built computers directly to end customers, completely bypassing the retailers and distributors. After two years, Dell Corporation pioneered the first thirty-day money back guarantee and became the first company in the industry to offer onsite service program. In 1984, Michael Dell did not adopt a mass customization business strategy because he envisioned that it would eventually help build his computer company. Rather, he started to adopt mass customization way back during his college days where he could only afford to build products on demand since he did not have the working capital to accumulate finished goods.

By 1988, Dell raised $30 million in its initial public offering, with a market capitalization of $85 million compared to 4 years before. With the advent of the Internet, by 1998, Dell became an Internet leader by topping $12 million a day and offered its “Premier Pages” to its customers, as well as established web-based connections with its suppliers\(^{35}\). All these are made possible because Dell was able to leverage on the concept of mass customization.

**Partnering with other companies to exploit mass customization**
To make mass customization work, Dell realized that it could not do it alone without the help of other partners. In the Fall of 1999, Dell introduced the Dell Direct for SAP Program, where it partnered with SAP AG to allow customers to install SAP inter-enterprise business solutions on Dell PowerEdge servers. The program uses Dell’s mass customization technology to factory-install SAP R/3 solutions on Dell PowerEdge servers and PowerVault storage according to customers’ exact specifications with systems ready to plug and play after arriving at customers’ sites. Under the Dell Direct for SAP Program, customers access Dell’s Website directly to specify and order hardware and software configurations for SAP solutions on Dell PowerEdge 4300 or 6300 servers. A sizing and selection tools feature is available online for customizing the configuration to a customer’s exact needs and budget.

Another mass customization practice is Dell’s partnership with COM2001.com where the latter had selected Dell PowerEdge servers as the platform of choice for running InternetPBX communications software. The InternetPBX solution runs on industry-standard hardware and software and offers customers a complete package of telephony and network services including phone, email, fax, unified messaging, Voice over IP (VOIP), and Internet communications. Dell factory-installs InternetPBX through its DellPlus custom factory integration service. With DellPlus, Dell can mass customize customers’ systems and custom-built according to the customers’ specifications before they even receive the systems.

As an outsourcer, Dell permits partners and suppliers to do work that might otherwise be done by Dell’s employees. As part of its mass customization strategy, Dell questions if the work within each stage of the supply chain could be done externally outside the company. For example, Dell does not manufacture the semiconductor chips used in its computers and does not
install the chips to the computer motherboards. Rather, it was found to be more economical for Dell to buy computers motherboards from Dell’s long-term suppliers, including buying computer monitors from suppliers such as Sony. Dell contracts with Airborne Express, UPS, and other freight carriers to pick up computers at Dell’s plant in Austin, Texas, match the computers with monitors from the Sony plant in Texas, and ship both the components to the customer at the same time.

Further, Dell officials learned that through mass customization, the company can practice tight integration of product design with their supply chain partners. What all this means is that Dell’s customers and suppliers are treated as partners and collaborators, looking for ways to improve efficiency across the entire supply chain. Dell’s suppliers assign their engineers to Dell’s design team. The technology available today allows Dell to share design databases and methodologies with suppliers which increases time-to-market for Dell. However, Dell focuses on having as few partners as possible\textsuperscript{38} and instead, focuses on having long lasting relationships and them while supporting them to maintain their leadership in technology and quality. This resulted in closer and even more cost-efficient relationships with the suppliers, further lowering costs and delivering faster component shipments.

\textit{Mass customize by adopting manufacturing basics}

Dell’s approach to mass customization is to create an efficient order fulfillment and supply chain process that provides rapid delivery, competitive prices, and available computer options to the customers. The internal process starts with estimates of demand and long-term
contracts with component suppliers. Dell maintains electronic links to its suppliers that tell them exactly when the parts are needed. These electronic links ensure that Dell uses the most current parts and does not store large inventories. Dell tracks inventory turns and other related measures closely to reduce the risk of holding obsolete inventory. When its inventory balance is not ideal, Dell then directs its sales promotions to these inventories. The fulfillment process from order to delivery is managed electronically and has allowed Dell to build servers and computers efficiently and has allowed its customers to know where their order is in each step of the process. As a result of this efficiency, in 2001, Dell became the number one maker of file servers in the U.S.

The Dell order fulfillment process begins with customers placing orders via Dell’s web site or a customized page created for its business customers. Accordingly, over 50% of its customers place their orders via the Dell Web site which are then fed into the production queue where the required inventory and components are allocated in the production assembly area. Dell partners with suppliers to provide them information within the production pipeline, so they can have inventory readily available on the loading docks, thus allowing Dell to main only two hours of actual inventory on the factory floor.

The detailed specifications and listing of components are then printed on a “traveler” form that acts like a recipe that lists all the necessary “ingredients” to be added to make the build complete. Each component on the traveler is scanned as it is built to ensure that no one component is left off the list. As the assembler builds the server, he or she simultaneously performs testing on various servers. When a problem is detected during testing, a technician is alerted and may be further escalated to higher-level technicians. If the problem still cannot be
resolved, a new production order is placed and the broken unit is sent to a special laboratory for diagnosis.

Once the systems are completely assembled, they are sent to a “burn-in” area for testing. It is also during this time that any special customer software is installed and loaded. After testing, the server is then packed and shipped to the customer. With sophisticated data exchange, Dell’s computers are picked up in Austin by Airborne Express and its monitors are picked also by Airborne in Mexico, bundled together, and shipped to the end customers.

Most of Dell’s hardware and software modules are provided by OEM suppliers that assemble the modules in combinations that meet the precise needs of the customers. Dell is able to accomplish because its entire supply chain and distribution system is optimized to provide customers and suppliers direct access to information while reducing operating costs. This requires a complete rethinking of product design with attention on modularization and standardized interfaces. For example, Dell designs very few standard disk drives but can serve 90 percent of its market. This way, there is less variability in terms of demand.

Dell’s product design process also takes into account the concept of velocity. By designing the products around the supply chain and manufacturing process to squeeze out time in the process, Dell can manufacture products and ship them out faster than its competition. Dell build-to-order model and manufacturing process are dependent on what Dell calls “virtual integration,” the integration of information technologies throughout all operations, including order fulfillment, shipping, production, etc. According to Dell, what used to be vertical integration, does not work any more. In the old days, the supplier base was not well established and many companies had to manufacture product components themselves. But with virtual
integration, companies like Dell have come to realize that by leveraging the investments others have made and focus on Dell's own competitive advantage (which is delivering solutions and systems to customer), Dell is better off than trying to build every single component itself.

According to Michael Dell, its original direct model has evolved into the virtual model, allowing the company to leverage its relationship with both customers and suppliers and further allow the company to create a value chain. Dell has established direct relationships with its suppliers, customers, and manufacturers. Further, these virtual companies are tightly integrated with their suppliers and customers and they leverage the Internet to run their businesses.

Through virtual integration, Dell customers also enjoy some benefits that are not realized through conventional manufacturing. For example, through sophisticated applications, Dell is now able to load customer's software in the factory before boxes are sent to the customers. Eastman Chemical has a mix of software with some licensed from Microsoft and some written in-house. But with Dell's networked factory and manufacturing applications, it can download the precise software into the right Eastman server according to the orders.\(^4^2\)

Before the Internet, Dell was already a successful built-to-order manufacturer, designing products in a highly modular fashion quickly and cost-efficiently to meet a wide range of customer needs. Dell began this built-to-order model almost 20 years ago where Dell would offer customers a menu of choices and then assemble the individual computers according to customers' specifications. It is because of this successful practice that by 2000, Dell was number one in desktop sales, number one in notebook sales, and number in desktop sales, and had risen to number two in Wintel server sales.\(^4^3\)
In 1991, attempting to increase revenue growth, Dell decided to change strategy and entered the retail channel by selling a select set of predetermined product configurations through large retail stores such as CompUSA, Staples, and Sam’s Club. With this strategy, Dell could no longer maintain their price premium and experienced an increase in capital costs due to the 60-day finished goods inventory for the channel.

Dell quickly switched back to a built-to-order model and was able to turn inventory twice as fast as retailers because it no longer has to hold channel inventory. Although the mass customization strategy increased manufacturing costs by 5%, it allowed Dell to gain back its 12% price premium through add-ons and upgrades.

*Using customer information to leverage mass customization*

To make mass customization work, Dell discovered that it had to listen to the voice of the customer. Dell customers visited Dell’s portable business unit in Round Rock, Texas to voice their needs as well as learn what was coming. It was through these meetings that Dell learned that its corporate customers were more interested in reliability, consistency, and the ability to customize equipment with screen size and memory. In 1997, Dell responded to this needs with its new Latitude CP line\(^{44}\). This direct relationship with customers gives Dell a competitive edge over its competitors who typically have to go through resellers.

Because Dell sells direct, it has direct visibility to customers’ buying patterns and habits and is able to do market segmentation based on this information. In particular, Dell started to notice that customers who were coming to Dell were actually buying their second or third machines and these customers were willing to buy the most powerful machines and yet pay a
higher price. With this information, Dell then started a group to serve this market segment. Market segmentation further allows Dell to mass customize its programs to the customers’ needs. By understanding their needs and when they need the products, Dell has better forecasts. And with better forecasts, Dell can keep its costs down because Dell knows exactly what its customers want and how much and can adjust inventory accordingly. In contrast, some of Dell’s competitors do not have the right kind of information about their customers. With less information about the customer needs, these companies end up with huge inventories. Dell also relies on sales history and current orders to predict what kinds of notebooks its customers want and adjust its marketing programs accordingly.

Selling direct and having many system information links have also enabled Dell to provide better service to its customers. Selling direct allows Dell to keep track of customers’ purchase information, including software and hardware configurations. So, when a customer calls for service, the service person does not have to spend time determining the customer’s configuration. Everything is stored in an information database that is easily retrieved and analyzed.

**Using the Internet and information technologies to maximize mass customization**

In 1994, [www.dell.com](http://www.dell.com) was introduced together with Dell’s help-desk tools and other customer-accessible information. This web site contained technical support information and an e-mail link for customer support. In 1995, Dell introduced online configuration and it was during this time that Dell decided to extend its direct model to the Internet.
By leveraging the Internet, Dell has become one of the successful companies that not only sells computers to meet every individual’s needs but has also made mass customization a reality. The Web makes the process virtually seamless by allowing Dell to collect customized, digitized data that are ready for delivery to the people who need them. The Internet has the ability to transform relationships that are typically associated with traditional supply chain. With the Internet, Dell is able to share internal processes information with its customers and suppliers in real time and by integrating all other global operations.

Dell creates individual web pages called Premier Pages for its customers. These pages contain detailed account information unique to customers such as Ford Motor and Shell Oil. These pages reside securely within the customer’s firewalls and they provide purchasing and technical information about the configurations. By using these pages, customers like Ford and Shell can configure, price, and buy systems at the agreed-upon price. They can track orders and inventory through detailed account purchasing reports by group, geographic location, product, average unit price, and total dollar value. This also allows them to better manage their assets. They can also access contact information for Dell account, service, and support team members. They can check an order and find out if their system is sitting on the FedEx dock in Memphis, and how soon they can expect delivery. In fact, customers like Shell Oil are transitioning from paper purchase orders to electronic purchase orders.

Another thing that Dell does well is setting up employee purchase programs with many companies. Similarly, Dell builds web pages for its top 20 suppliers who provide about 90 percent of the components Dell purchases for its computers. Via these web pages, Dell’s suppliers can provide real time information on their build capacities, capabilities, inventory
levels, and current costs. Similarly, via these web pages (Dell created Web-based links for their suppliers, much the same way that they created for their customers\(^45\)), Dell can provide their suppliers with current forecasts, inventory data, quality data, and future demand schedules (including daily production requirements), technical requirements, and pricing requirements. Dell’s suppliers benefit from this setup because they can better control their inventory levels once they have better visibility to Dell’s forecasts and demand schedules, resulting in more consistent and demand levels and inventories. The process of forecasting and re-supplying inventories as needed is supported by the Internet infrastructure. Inventory are also better controlled because they can now measure inventory in hours or even minutes instead of days just by using the Internet.

In an industry where technology is the differentiation from one company to another, Dell has managed to differentiate itself by one other key element: price. Because Dell is able to use the Internet and other technologies to achieve the efficient asset management, they are able to pass the savings to the end customers\(^46\). Without the physical assets to manage, there are fewer things to manage and fewer things to go wrong, according to Michael Dell. Within Dell, inventory velocity is one of the performance measures and it helps Dell focuses on working with its suppliers to reduce inventory and increase inventory speed. In addition, coupled with asset management is people management. Dell does not have to deal with managing and interviewing an army of employees since all the other activities are managed by Dell’s suppliers and manufacturers.

The Internet gives Dell another benefit; Dell gets to have a deeper relationship with its customers by providing real-time information of customers’ demand and buying trends. The
other benefit offered by the Internet is lowered costs. On the Internet, there is almost no cost for transactional activities such as order status, configurations, and price. Ultimately, Dell can pass these savings on to its customers. However, before the Internet ever became popular, Dell initially had to launch an Internet campaign to its employees. Dell knew that to successfully leverage the Internet and make it a key part of its entire business, it had to start working on its own people and its partners. Therefore, it started to use the technology in all its information systems to connect with its customers and suppliers. Internally, Dell launched an internal campaign to persuade employees to use and familiarize themselves with the Internet. Management was asked to be early adopters by being buying books via the amazon.com Web site.

9. Case Study II: How Cisco Systems changed its applications to meet mass customization needs

Background

Cisco Systems Inc. is one of the worldwide leaders in networking for the Internet. A multi-national corporation, Cisco solutions provide networking foundations for service providers, small to medium business, and enterprise customers, including corporations, government agencies, utilities and educational institutions. Cisco Systems has 85 per cent of Internet traffic traveling across its systems and it uses the Internet to run its business online, from product orders and inventory management through to staff communications and travel expenses.

Cisco sells products to the United States government through a variety of channels: Through value-added systems integrators, direct value-added resellers, and distributors. When
Cisco sells to civilian government agencies, and through a General Services Administration (GSA) Federal Supply Schedule partner, it is subject to country of origin regulations which flow from the Trade Agreements Act (TAA) of 1979, 19 U.S.C. 2501-2582. The ability to offer its products on a GSA Schedule contract is becoming increasingly important in the Federal space because of a move by many agencies to base their purchases or contractual buying vehicles for IT equipment off an existing GSA Schedule contract. Further, the TAA requires that Cisco sell to the government “end products” that are “substantially transformed” in either the United States or from one of the 84 designated “qualifying” countries.

**Business need**

Cisco modified its order entry and order fulfillment systems to meet some mass customized needs based upon the TAA requirements. The systems and applications were changed to allow proper ordering and fulfillment of TAA compliant product for GSA while continuing to fulfill orders for other regular customers who do not have this mass customization requirement.

The need to modify the systems also stemmed from Cisco’s recent move toward a Direct Fulfillment (DF) model where most of its production is outsourced to contract manufacturers who are based in non-TAA compliant countries such as Taiwan, China, Thailand, and Malaysia. By modifying its system in Manufacturing, Cisco can uniquely direct a TAA order to a TAA-compliant production site.

**Gaps identified**

Before the systems were modified to meet the new mass customization need, some gaps were identified: 1) The ordering systems could allow Federal customers to mass customize and identify an order as TAA order; 2) Federal customers could place an order that could potentially
be built in both compliant and non-compliant countries, resulting in violating Federal regulations; 3) Manufacturing systems could not differentiate a regular order versus a mass-customized order such as a TAA order.

**IT solutions to bridge the gaps**

The front-end order entry systems and the back-end manufacturing systems were modified to bridge the gaps. In the Ordering Tool, the interface was changed such that a customer can now select an order and identify it as a TAA order. Ordering Tool will display a few TAA attributes/values in a specified field along with already existing values (figure 1).

Once the customer submits the order, it is imported to Cisco’s IC (Internet Commerce) Engine, an order tool that books and schedules an order before feeding it downstream to manufacturing. Since TAA-Customers are a subset of Federal Customers and Cisco’s distributors, a list of TAA customers is maintained in the IC engine. When a customer places a TAA order, an engine rule is added to the IC engine to perform a validation to confirm that the customer is in TAA-Customer list. If the customer is in the TAA-Customer list, the IC engine proceeds and processes the order. After processing the order, the IC engine then imports the order to Oracle and proceeds with booking using existing business rules. Once this is completed, the order is fed downstream to Manufacturing.

Once in Manufacturing, the Global Scheduling application (a customized application that is bolted onto ERP) looks at an attribute in the ordering tool interface. If the field has a valid TAA value, ERP will route this order to TAA-compliant locations for fulfillment.

The above demonstrates how Cisco Systems changed its systems from the front-end order entry applications to the back-end build systems to meet a mass customization need to improve customer satisfaction and secure federal revenue.
10. The role of IT professionals in customization success

Mass customization requires organizations to conduct business in new ways and will require some organizations to evaluate new technology capabilities. For some organizations to thrive, they must learn to integrate technology into new business models, rather than add technologies to old ones. The role of the technology professionals is to do just that: To help the enterprise determine what technologies are needed to meet organizational needs. There is a debate as to whether IT managers lead or whether they enable the business. Whichever it is, technology professionals are an integral part of the business team, where all members must participate in an ongoing and iterative planning, decision-making, and implementation process. Such collaboration must pervade the entire organization.

In the past, the head of operations and manufacturing makes sure that the production line operates successfully, and the CTO (Chief Technology Officer) typically makes sure that the information systems run smoothly. However, in recent times, there is a blurring of those lines. This recent event has something to do with the nature of the products and services offered; products and services need to be mass customized to meet customers’ needs. In the process, the organization becomes more information-centered. An information-centered organization requires all leaders from IT to operations, to manufacturing, to sales, and to marketing to share information and make decisions jointly during the decision-making process.

Another other reason why the line has blurred has to do with the delivery of the mass customized products and services. Companies rely on IT applications, tools, and infrastructure and make mass customization work. To do this, functional leaders have to collaborate and work together to ensure synergy and to ensure that all systems and processes within the entire supply
chain work. There is an unsafe tendency for IT professionals in an organization to deploy an application before thinking about business processes. This is why the boundary between IT professionals and other functional leaders have crossed. They need to collaborate and understand the current business landscape before deploying the right business solutions.

In his book, *Pathways to Agility*, John Oleson discuses how mass customization triggers a whole new set of activities, spanning from changing relationship with the customers to changing relationships within the extended supply chain, to outsourcing to improves economics and costs. In the midst of these activities, the practice of agility is a key element. According to Oleson, agility is the ability to respond quickly and effectively to unexpected events. Therefore, Industry leaders, particularly IT leaders and professionals need to anticipate the unexpected from the customer and have the capability to fill those needs whether by introducing new processes or by enabling IT capabilities to support these processes.

Further, to practice agility, IT leaders and professionals have to embrace change and they have to be the first to institute the change. Motorola instituted six-sigma quality ahead of most industrial firms. At the time this change was implemented, the company was having trouble competing and employees felt instituting six-sigma quality could not be done. The leadership insisted on it and six-sigma quality became a paradigm at Motorola.

In an agile or custom manufacturing world, IT leaders are no longer people who decide on how much storage an organization needs, they also need to have organizational skills to instill motivation and foster teamwork in people. In any business undertaking, it is the people who are key to the success and who make the difference. The actions of the leadership must promote cooperation to enhance a company’s cooperation. Cooperation is essential for operation of a
supply chain. It is also essential for the improvement of an operational supply chain as well as in implementing new processes, new products, and new markets.

11. Benefits of mass customization

One of the benefits of mass customization on the Web is cost savings. Cabletron Systems Inc., a $1.4 billion networking hardware manufacturer says that taking configured orders over the Web is saving the company more than $12 million a year on returned materials using its configuration engine. The configuration engine automatically adds cable, software, and extra parts that customers need but often neglect to order when using conventional ordering methods such as fax, phone, and EDI.

By using solution from Archetype Solutions Inc., well-known catalog and online retailer Lands' End began offering custom-fit chinos via the Web. At a price of $54, customers can select their style and fit preferences, enter details about their body shape and receive a pair of custom-made pants in their mailbox two to four weeks later. Consequently, Lands' End avoids stocking up to 2.8 billion different styles and sizes of garments. Lands' End is able to avoid the stocking costs because each custom order is individually fashioned by a contract manufacturer that ships directly to the consumer.

One of the major benefits of mass customization is profit. In one study by the American Apparel Manufacturers Association in Washington, it was estimated that if 10% of manufacturing output were devoted to mass customization, it would produce 30% of company profits. Gerber Scientific Inc. in South Windsor, Connecticut, has state-of-the-art systems that help its clients customize their apparel production lines. Its make-to-order process cuts inventory and brings extra value to the customer. Gerber has also invented systems that digitize sign-
making on a variety of materials, customize textiles and industrial fabrics such as pool liners, and computerize optical lens-making so eyeglasses could be turned out in less than an hour. According to Gerber, it predicts that mass customization will comprise 70% of Gerber's business by 2003, up from half\(^{52}\).

The most common example of mass customization is Dell Computer, which has a direct relationship with customers and builds only customized PCs. Dell passed IBM last quarter in 1998 to claim the No. 2 spot in PC market share (behind Compaq). While other computer manufacturers struggle for profits, Dell keeps reporting record numbers; in its most recent quarter the company's sales were up 54%, while earnings soared 62\(^{53}\).

12. Challenges and Solutions

In their article “Making Mass Customization Work,” Pine, Victor, and Boynton caution that it is important to realize that technology can also be potentially harmful. Mass customizers must periodically evaluate and overhaul the linkages that they have adopted because as the market changes, the nature of their businesses changes, the competitive landscape changes, and as technology advances, any linkage system will inevitably become obsolete.

As companies shift from a mass production model to a mass customization model of E-business, front-end applications and back-office systems have to integrate. This effort may even be extended to other key players outside the firewall—to the applications of suppliers, partners, and customers. The challenge then, to IT managers, is how to integrate these disparate applications. One way to overcome this problem is to use enterprise application integration (EAI) servers. EAI servers connect disparate systems to a single integration layer, using an adapter framework that shortens integration time, reduces integration costs, and eases the process
of introducing new systems into the environment. The advantage of EAI servers has been to eliminate the need to build and maintain custom point-to-point integrations among systems.

The other challenge has to do with technologies that are still in their infancy. In the previous section, Web services are discussed. These applications may be another solution to the application integration problem. However, while a great technology, Web services have scalability and performance issues that are inherent in XML-based approaches as well as security problems associated with Simple Object Access Protocol (SOAP). Also, its transaction capabilities are less robust than those of current EAI servers.

Another approach may be to use application servers for application services and integration. This approach is best for businesses that want to consolidate their back-end technologies and use fewer systems for a broader range of services. For businesses that want to leverage existing platforms for integration, the application-server approach makes sense mainly for basic integration of a small number of applications that do not have extremely high transaction volumes and have fairly uncomplicated transformation requirements. EAI servers are a better choice for high-volume, highly sophisticated integration needs that involve many disparate systems.

The other challenge of mass customization is the issue of trust. To make mass customization work, manufacturers and suppliers have to have real-time information exchange such as sharing their forecasts demand data and production schedules. Traditionally, manufacturers have not always trusted suppliers to use the information they collect. A key fear has been that suppliers might underestimate what needs to be built and a shortage of parts from the suppliers could halt a production line. Today, more and more manufacturers and suppliers
are building trust and collaborating as partners, although some industries are more ready to embrace trust than others. InformationWeek Research’s survey of information sharing and collaboration shows that only 12% of manufacturers share information electronically with their suppliers most often, ranking business partners and customers as their higher priorities. In contrast, 31% of retail and travel companies and 15% of health-care organizations put suppliers as their top priority for sharing information\textsuperscript{55}.

The auto industry is adopting this new attitude as automakers are beginning to trust suppliers. This new attitude comes in response to suppliers’ awareness that automakers want to reduce inventory while at the same time, are under pressure to custom-manufacture cars. By knowing manufacturers’ demand and production schedules, suppliers also do not end up with excess inventory and unnecessary costs. In the end, it becomes a win-win situation for both.

One other challenge of mass customization is the issue of trade-offs. Companies feel that they can only pursue one or the other strategy: A strategy of providing large volumes of standardized goods and services at a low cost, or it could decide to make customized or highly differentiated products in smaller volume at a higher cost. In other words, companies have to choose between being efficient mass producers and being high-cost mass-customized producers. This school of thought originated from the notion that the two strategies require very different ways of managing, and, therefore, two organizational forms. For example, in a mass production organization, the emphasis is on automating tasks and is characterized by highly compartmentalized jobs. On the other hand, in an organization that places emphasis on mass customization, the organization is more loosely structured and the workers are more skilled.\textsuperscript{56}
Pine, Victor, and Boynton argue that this need not be the case and companies can overcome the trade-offs. However, they caution that mass customization is not for all industries. For industries that have commodity products, mass customization may not be necessary. For instance, matches and lighters are commodity products and it is not necessary for the manufacturers to mass customize their products. Once a company has determined if mass customization works for their products, it needs a linkage system that is supported by four key attributes.

They refer to two attributes as “instantaneous” and “seamless” where processes are linked together quickly and where IT applications talk to each other and are well-integrated. For example, mass customizers like Dell Computer, Hewlett-Packard, AT&T, and LSI Logic use special software that records customer desires and translates them into a design of the needed components. Then the design is quickly translated into a set of processes, which are integrated rapidly to create the product or service.

According to Pine, Victor, and Boynton, to make mass customization work, it has to be costless—at least beyond the initial investment required to create this linkage system. Otherwise, organizations will start to experience the trade-off issue of high costs and expensive systems and applications. For example, many service businesses have databases that already have customer information and there is no need to regenerate customer information. Finally, Pine, Victor, and Boynton suggest that organizations have to be “frictionless.” When a mass customizer is frictionless, information and communications technologies play a very important role by finding the right people, defining and creating boundaries for their collective task, and by allowing them to work together in real-time in a virtual world. Technology must also automate
the links between modules and ensure that the people and the tools necessary to perform them are brought together instantly. For example, communication networks, shared databases that let everyone view the customer information simultaneously, computer-integrated manufacturing, workflow software, and tools like groupware (email applications) can automate the links so that a company can summon exactly the right resources to service a customer’s unique desires and needs.

Two other authors (Feitziner and Lee)\textsuperscript{58} offer a solution to the trade-off issue by drawing on the experience from Hewlett-Packard and suggest that companies can deliver customized products quickly and still experience low costs. According to the authors, the key to mass customizing effectively is by postponing the task of differentiating a product for a specific customer until the latest possible point in the supply network (for example, during the production and distribution cycle).

Accordingly, a product should be designed so it consists of independent modules that can be assembled into different forms of the product easily and inexpensively. Manufacturing processes should be designed so that they, too, consist of independent modules that can be moved or rearranged easily to support different distribution-network designs. The supply network where the positioning of inventory and the location, the number, and the structure of manufacturing and distribution facilities—all should be designed to provide two capabilities. First, it must be able to supply the basic product to the facilities performing the customization in a cost-effective manner. Second, it must have the flexibility and the responsiveness to take individual customers’ orders and deliver the finished, customized goods quickly\textsuperscript{59}. 


A common barrier to successful mass customization is resistance to change. According to Pillar\textsuperscript{60}, mass customization requires change. In 1990, Bally Engineered Structures Inc. of Pennsylvania adopted mass customization successfully by embracing change throughout all facets of its organization. At that time, Tom Pietrocini, President of the company was certain that to become a successful mass customizer, his organization would need radical changes in the organizational structure, systems, and culture.\textsuperscript{61} To change the culture, Pietrocini had to get employees to view the company in terms of its capabilities and values rather than focusing on it's business as a manufacturer of a set of products. For example, he emphasized that efficiency, flexibility, and quality, as well as customer demands (such as mass customization) would help the company determine what it would produce and drive the kind of products it would produce.

Next, Pietrocini, worked on Bally’s organizational structure. The organization’s structure was rigid with a long order fulfillment process and the manufacturing processes were organized in a sequential order with no room for modular design or modifications. To undo this rigid structure, Pietrocini worked to lower the number of customer options from 12,000 to 10,000 and the process modules were increased to meet more customized orders.

Finally, IT technologies were introduced so that a sales person can custom-design each order in the customer’s office on a laptop that is connected to a computer-driven intelligence network (CDIN). Once the design is completed, manufacturing software in the CDIN defines the precise combinations of process modules required to make the final products. The CDIN also connects all stakeholders such as sale people, suppliers, and customers and provides information access to everyone cross all functional boundaries.
Lack of customer knowledge can be a barrier to mass customization success. DigiChoice.com tries to overcome the obstacles of mass customization by establishing innovative business models to improve the mass customization transaction processes. Some of the obstacles include customer lacking the knowledge of what they want even though they want a customized product. From the customers' point of view, the implementation of a broker (or intermediary) can prove to be helpful since many of them do not have the necessary know-how to find a configuration that corresponds to their mass customization needs. For example, not all people know how to configure a PC online, knowing what kind of memory, hardware, software, etc. they would need. Therefore, an important task for brokers is their assistance in the configuration process and by establishing the required knowledge faster and more efficiently as they fulfill this process for several suppliers via economies of learning.

The other intermediaries for efficient configuration are software tools like recommendation engines. These engines simplify the identification of preferences by recording, comparing, and aggregating former sales, page views, or click rates. Recommendation engines enable the direct presentation of individualized content and offer a first suggestion of a configuration by comparing user profiles and indexes of contents – even when a user cannot explicitly express her preferences and wishes.

The other challenge is the issue of customer retention. Even with successful mass customization, customer loyalty is still an issue and companies have to find ways to retain customers. As mentioned previously, successful mass customizers use CRM programs that have knowledge that are based on the first configuration and purchase process of a particular customer. To further support the customer loyalty, the interaction process has to differentiate
between old and new customers. For new customers, a general profile of their desires and wishes has to be built up using the technologies mentioned previously. For existing customers the old configuration and additional information gathered during former transactions have to be used to make all following sales as easy as possible. For example, the last configuration may be presented and customers are asked just for variations. Amazon.com manages this process well by using a recommendation engine to make product recommendations to returning customers (see figure 2).

For some established consumer good manufacturers, one of the largest obstacles for mass customization programs is channel conflict. Large retail groups are often afraid of losing their profits when a manufacturer starts to interact directly with the consumers. Therefore, they often prevent any further action (for example, Nike has now limited its mass customization program to a limited number of personalized shoes per day). But with a broker involved, companies can avoid channel conflicts and the brokers end up being the visible market player.

As mentioned earlier, to be successful in mass in customization, companies have to consider using CRM applications. However, CRM is an added cost. With the help from brokers, mass customizers can outsource information processing to them. In particular, the collection and storage of customer data, system security and administration are basic activities connected to mass customization, which require very specific knowledge but are not companies’ core competencies. Brokers may even take over the software development of Configurators specific to the needs of the targeted customers. Additionally, online mass customization connected to electronic commerce can encounter problems such as contracting, payment, privacy policies that
can be subject to changes in regulations. These are not mass customizers’ core competencies and can therefore be better handled by brokers.

When considering the implementation of a mass-customization application, IT managers must ensure that the application is able to integrate effectively with legacy applications while still providing cutting-edge performance. Additionally, the application must allow for quick and easy product and price updates without extensive and costly programming. Both these requirements have proved significant hurdles for companies seeking to launch mass-customization applications on an Internet platform. To resolve this problem, some companies have selected scaled-back solutions that provide fewer options to customers and a limited number of configurable models and still have proven to be successful in helping customers get their customized choices.

Most manufacturers pursue mass customization do so at a huge cost in terms of time, money, and effort. For example, a large Japanese automaker offered 87 different varieties of steering wheels. But customers did not want many of them and disliked having to choose from so many options. As another example, a well known mainframe computer company attempted to deliver a custom-built mainframe in a week, stocked inventory for every possible order combination. The result was hundreds of millions of dollars in excess inventory. One approach to this problem of mass customization is solved by having the customer participate in the design and product definition process. “Design-to-order” as this approach is called is a dynamic design process in which the engineering designs required to build a product are dynamically generated when the order is received. The design-to-order approach involves the design requestors or customers much earlier in the product development process, during the
design phase where it is estimated that 70% or more of the product’s ultimate costs is determined. For example, at Motorola, a sales rep and a customer design together, on a rep’s laptop computer, the set of pagers (out of 29 million possible combinations) that exactly meets the customer’s needs. The design is then transmitted to the flexible manufacturing system to produce the pager. With collaborative product development and design-to-order, rapid product customization enables lower development costs and leverages the Internet for real-time and cross-enterprise collaboration.

Earlier, the use of Configurators was discussed. While Configurators do an excellent job in configuring orders and handling other customer-facing transactions, they still keep the customers out of the design process. As a result the only customization these manufacturers can offer is purely adaptive—customers can mix and match predefined components in a limited number of ways. Parametric Technology Corporation’s Windchill DynamicDesignLink allows customers to create their own variations of a virtual prototype by defining and modifying the product to fit their needs. Customers simply log into their personal product portal where an intelligent specification wizard guides them through a specification. They can define the specification in a team-oriented collaborative manner, save their specifications, and revisit them for further modifications. They can also request other product-associated deliverables, such as the CAD models, bills of materials, or quotes that can be saved by the product portal for future review and use.

13. Conclusion

To accommodate the growing demand for customized choices, companies must leverage available technologies and strengthen their information technology infrastructures. Back-end IT
systems and collaboration tools used to drive online ordering systems must be able to quickly and accurately accept orders from a large number of customers in a short period of time. If manufacturers can change designs quickly and inexpensively, they can win customers by targeting individual tastes and preferences.

Current technologies can reduce costs in information, distribution, and production. The Internet allows new technologies and processes to be exploited by allowing companies to provide all kinds of product information on their web pages and take orders from anywhere in the world. Computer-aided designs are replacing costly prototypes and by making it cheaper to personalize during production, technologies remove obstacles to providing goods and services for individual customers. Improvements in distribution reduce the fixed costs of getting products as the Internet spreads into more homes and businesses. In the end, average costs decline even without long production runs, permitting low prices along with meeting exactly what consumers want.

IT managers must consider some factors when implementing mass customization applications. Some of these challenges can be overcome by IT professionals and other functional leaders collaborating to change the organizational structure, company culture, and the systems and architecture.

In conclusion, market-dominated companies have attained a leadership position by aggressively deploying a number of integrated, cohesive strategies to gain the benefits of mass customization. Their experience demonstrates that the right blend of technologies can play a critical role in achieving the substantial benefits of mass customization.
14. Bibliography


9 Blue Martini Interactive Selling (2002). *Blue Martini* white paper.


### Current DPAS Fields

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#### Shipping

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- For Resale? [Yes/No]
- Ship Early? [Yes/No]
- Shipment Account

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#### Shipping

- Ship Partial? [Yes/No]
- For Resale? [Yes]
- Ship Early? [Yes]
- Shipment Account

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Figure 1.
Figure 2.
### Index of Acronyms.

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Definition</th>
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<tr>
<td>API</td>
<td>Applications Program Interface</td>
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<td>APS</td>
<td>Advanced planning and scheduling</td>
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<td>B2B</td>
<td>Business-to-business</td>
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<td>Bill of materials</td>
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<td>Build-to-order</td>
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<td>CAE</td>
<td>Computer-aided engineering</td>
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<td>Chief Technology Officer</td>
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<td>Computerized numerical controller</td>
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<td>Customer relationship management</td>
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<td>EAI</td>
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<td>KBS</td>
<td>Knowledge-based system</td>
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<td>Manufacturing Execution Applications</td>
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<tr>
<td>SOAP</td>
<td>Simple object access protocol</td>
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<td>TAA</td>
<td>Trade Agreement Act</td>
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<tr>
<td>XML</td>
<td>Extensible markup language</td>
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16. Curriculum Vita

Josephine M. Lim
308 Ribbonwood Avenue
San Jose, CA 95123
Retriever_usa@yahoo.com

PROFILE

- Global thinker with strong manufacturing, supply chain, and technology experience.
- Demonstrated success in project management and customer support.
- Definitive abilities in leadership, planning, organization, decision making, and team building.
- Skilled in visualizing resourceful and enterprising solutions to problems.
- Effective in communications with proven ability to gain the confidence of customers, team members, and senior management.
- Demonstrated talent for learning and utilizing new technologies, including client/server network systems, Enterprise Resource Planning, and the Internet.

PROFESSIONAL EXPERIENCE

PROGRAM MANAGER, Cisco Systems, San Jose, California (October 2000-Present)

Manufacturing Project Lead for Oracle 11i implementation project

- Manage a project team of six people for the Oracle 11i implementation. Responsible for successfully completing all phases of Conference Room Pilot. Worked with all business process owners and IT developers to capture requirements and design considerations.
- Duties include managing internal resources, maintaining the project schedule, resolving issues and project challenges, and interacting with project leadership on a daily basis.
- Worked with the configuration and design team to ensure compliance with Six Sigma standards, implementation methodology, and the global vision for future project phases.
- Coordinated with training group to implement training class for the core implementation team to assist grasping fundamental Oracle manufacturing module concepts.
- Worked with cross functional teams to identify scope, objectives, timing and communication approach.
Manufacturing Project Lead for Configuration Express and Tiramisu Programs

- Responsible for managing the Configuration Express Program for Manufacturing, an Internet commerce application that leverages Cisco’s flexible manufacturing capabilities to enable Service Providers to deploy customer premises equipment faster and at lower costs.
- Help to increase revenue opportunities by introducing and launching new products into the program. Evaluate business cases and customer requirements prior to launch.
- Work closely with functional teams to introduce new features and enhancements to the application. Responsible for gathering requirements, design test plan, set deliverables, conduct end-to-end process tests before launch.
- Fully engaged in all manufacturing activities related the beta test of Tiramisu, a revenue-generating application that supports a solution where modular or non-modular routers can be shipped from Manufacturing without slot specific information to enable Plug & Play hands-free deployment of Cisco IOS devices. Tiramisu addresses the customer requirement to extend Configuration Express to support modular platform with zero touch deployment at the time of manufacturing.

Manufacturing Project Lead for the Trade Agreement Act (TAA) Initiative

- Directed project evaluation and determined detailed mission requirements, including those from other functional teams.
- Developed and implemented process plans and creative solutions to unforeseen problems.
- Worked with all functional IT teams (Customs, Customer Service, and Manufacturing) to test solutions and team up with other functional groups to gain synergy and concurrence.
- Expected outcomes include improved customer satisfaction, a year-to-year increase in Federal sales of about 20%, reduced RMA, and a strong Cisco presence in the Federal market sector.

Managed the migration of a FAT Client/Server Architecture to a Centrally-managed and Web-based architecture for Manufacturing Labels

- Tracked progress of the project to ensure that timeliness and milestones were met. Monitored program status as well as identified and corrected technical and functional problems.
- Oversaw the design of Scalable Label web site, including developing requirements for enhancements to web-based interface used for database input, query, and report.
- Provided direct input to IT developers relating to enhancements of label formats and forms that significantly improved quality and customer satisfaction.
• Fully responsible for end-to-end testing for all major phases of project prior to project launch, including the test of codes, databases, processes, and systems.

*Helped to manage and meet the Two-Tier distributors conditions of satisfaction program*

• Worked with New Product Introduction managers and New Product Introduction Engineers to clean up all two-tier bill-of-materials.
• Worked with IT to provide enhancements to ERP transaction tools so that order fulfillment sites can package products accordingly.
• Worked with IT to develop a Production Report so that Production has visibility to all two-tier orders and proactively provide required materials for packing two-tier orders.


*Program Manager, Equipment Program Office*

• Helped to support timely launch of new products by working closely with the Product Development Team, Manufacturing Resource Team, and North American Solutions launch team. Support includes all aspects of Logistics and Distribution.
• Heavily focused on Level of Service by supporting and maintaining ongoing quality of products and customer satisfaction via the Office Digital Diagnostic Team. Ongoing supports include identifying problems, conducting root cause analysis, problem solving with team members, and providing monthly status to senior management.
• Worked with third-party vendor to ensure quality production of Carrier Documentation and Training.
• Member of the SITCO (Systems Integration To Customer Order) team to reduce inventory, increase cycle time, and improve quality.
• Acted as a product manager for new machines to fulfill year-end activities. Solely responsible for coordinating efforts to produce 500 machines from Mitcheldean; interfaced with Mitcheldean (Manufacturing), Welwyn Garden City (PDT), Quality control, Transportation, Demand & Supply, Warehouses, and others.
• Member of Software Solutions Team. Developing a new agile supply chain process and Distribution infrastructure to deliver software to our customers.

*Project Leader, Equipment Velocity Process Improvement*

• Analyzing and evaluating process segments of the supply chain for Equipment Order Fulfillment (EOF) with the successful introduction of recommendations, including new methods of analyzing process segments and Level Of Customer Service.
- Introduced *Velocity Network News*, a monthly communications vehicle to reduce delivery and install cycle time and to deliver increased customer satisfaction. Newsletter also helps to speed up the flow of information and decision-making between headquarters and the entities.
- Repositioning ESOF Operations Review by improving monthly presentation and communications. This is being achieved by collecting, analyzing, and assembling data and information from reports and printouts into meaningful charts and slides for senior management’s use.

- Implemented a $4-million marketing plan for a new product line by developing strategies to ensure profit and growth. Helped position the company as an integrated “one-stop” supplier of wire and cable that adds value to the customer.
- Secured new business markets and opportunities in the international arena, a previously untapped market for Rome Cable Corp.
- Conceived of and introduced *Sales Connection*, a sales newsletter that provided feedback and communication to 25 sales offices resulting in increased synergy between headquarters and the field.
- Responsible for developing and creating a Web site presence on the Internet, leading to increased company and product awareness.
- Supervised an administrative assistant. Trained employee to become an independent, creative, and high-quality producer; including acquiring computer skills in desktop publishing, spreadsheets, as well as better organization and improved communications skills.

- Managed the design and development of brochures, direct-mail solicitations, and collateral materials. This included working closely with external vendors and interfacing with all levels of management to identify and develop sales programs for library automation products.
- Coordinated trade show logistics that helped generate new sales leads as well as increase the overall success of trade show programs.
- Edited and contributed to *Network News*, a quarterly customer-focused newsletter that provided up-to-date information to user groups as well as enhanced customer satisfaction.

- Maintained advertising accounts by developing campaigns to increase profits and growth that resulted in sales growth of close to 90%.
- Designed and directed a comprehensive and effective award-winning advertising program that resulted in the award of three New York State Associated Press advertising honors: 1st Place, classified Advertising; 2nd Place, Special Holiday Edition; 3rd place, Overall Advertising Excellence.
- Wrote special business articles to target the business community, resulting in increased advertising.

EDUCATION

Rochester Institute of Technology, College of Science
Master of Science, Information Technology, graduating in 2003
Concentrations: E-commerce/E-business, Project Management

Syracuse University, School Of Management
Master of Business Administration, May 1997
Concentrations: Marketing Management and International Business
Graduate School Tuition Scholarship & Assistantship, Syracuse University, 1996-1997

University of Oregon
Bachelor of Science, June 1989 Major concentrations: Marketing and Management
Minor concentration: Psychology

AWARDS AND ACHIEVEMENTS

Cisco Systems
- Vice-President “Blinded By The Light” Performance Excellence Award for contributing to the Apollo project. 4th quarter, FY 2001.
- Vice-President “Blinded By The Light” Performance Excellence Award for successfully managed the migration of a FAT Client/Server Architecture to a centrally-managed and Web-based architecture for Manufacturing Labels. 2nd quarter, FY 2001.
- The Cisco Achievement Program (CAP) award for exceptional contribution for quick response to a customer issue related to manufacturing labels. Response included an ad hoc IT project to meet customer’s immediate needs and requirements. March 2001.
- The Cisco Achievement Program (CAP) award for exceptional contribution to the Apollo Team, a web-based project for a new configurator for validating bill-of-materials in front-end and back-end applications. April 2001.
- The Cisco Achievement Program (CAP) award for contributing to the test efforts for the CPR re-architecture project. September 2001.
- The Cisco Achievement Program (CAP) award for contributing to the go-live enhancements for the Two-tier Project to meet all two-tier conditions of satisfaction, a big win for Cisco and its major two-tier customers. December 2001.
- The Cisco Achievement Program (CAP) award for helping to FCS the Venus 2 pack bundle and for being able to coordinate everything on very short notice, shipping the first sales order the same day it was scheduled! This is a strategic launch for the business unit, and will be targeted for critical accounts such as Microsoft Network Hotmail. December 2001.
- The Cisco Achievement Program (CAP) award outstanding support and effort on the Keystone Project. August 2002.
- The Cisco Achievement Program (CAP) award outstanding support and effort on the TAA Project. September 2002.

Xerox Corporation
- Thank you award from ISC Human Resource Manager for support in planning and conducting the panel discussion with new college candidates on Blitz Day.
- Recognition award from ISV/VAR Engagement Manager for managing the shipment of a Document Centre shipped to a customer in record time. October 1999.
- Dinner award from Business Solutions Team for the support and expediting of 2060 equipment orders. August 2000
- Recognition award from Launch Manager, Production Color Systems, for support of June month-end activity, resulting in the install of 61 DC2000 units within one week. August 2000.
- Selected and recruited into the Xerox Early High Potential Program for 3 straight consecutive years. 1997-2000.