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RFID, an Emerging Wireless Technology for Sustainable Customer Centric Operations

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1. Introduction

The main applications in the first wave of RFID have been in the supply chain mainly for improving the distribution of physical assets in the systems (Hardgrave and Miller, 2008; Sarma, 2008). The burgeoning use of RFID technology extends its applications to both upstream (supplier management) and downstream (retail and service) of manufacturing supply chains. RFID tags, also called "smart labels", together with other pervasive computing technologies realizes lean thinking in real-life and creates a smarter operating environment through adding *value* not only to customers with user-friendly shopping experience but also to merchants with agile and responsive store operations. Harrison and Hoek (2008), define *value* as relative advantage in general which is specified as *perceived benefit* obtained from the products or services in terms of the final customer, while as *economic profitability* in terms of the management, and the concept can be extended to other supply chain stakeholders as *value stream* which represents the *value-adding processes* beginning as raw materials from suppliers that are progressively converted into finished product bought by end-customers, such as aluminum is converted into one of the constituents of a can of coke. Being one of the management best practices, lean thinking preaches simplification and elimination of wasteful tasks, which is applicable to overly complex and nonintegrated processes that are inefficient and provide little added value. The firms following these practices have seen such dramatic improvement in performance that lean has spread across entire supply chains leading users to map their business processes to drive out *wastes* in operations, and becoming a lean enterprise has the potential to improve operations, reduce costs and deliver services with shorter lead times (King, 2009).

Ohno (1988) identified seven kinds of manufacturing *waste* that need to be eliminated: *overproduction*; *transportation*; *inventory*; *motion*; *defects*; *over-processing*; and *waiting*. These seven wastes represent the most commonly wasted resources and associated wasteful manufacturing activities which do not add value or are unproductive, in which the concept can be applied in non-manufacturing. Womack and Jones (2003) defined the eighth waste, i.e. delivering goods or services *not meeting customer need*, which represents a key attribute of a customer-centric lean enterprise. Lean thinking is proved to be an effective management system for manufacturing to improve overall efficiency and to enhance the work environment, in which the "getting more with less" concept can be applied in any type of business upon value creation (Aikens, 2011; Russell and Taylor, 2009). By offering the benefits of reducing complexity, improving efficiency, speeding delivery, and

understanding customer needs, lean thinking has gained the wide acceptance in non-manufacturing (Heizer and Render, 2007; Russell and Taylor, 2009). Successful cases of adopting lean thinking in services have been applied in some instances to insurance (Swank, 2003), healthcare (Miller, 2005), government (Gupta, 2004), library (So and Liu, 2007), and retailing (Heizer and Render, 2007; Russell and Taylor, 2009; So and Sun, 2010).

To adopt lean services effectively in operations, firms need to made changes on three aspects: (i) *standardization of tasks and procedures* which can be achieved by, for example, documenting the process flow, training, automating tasks, etc., such that people can be freed to spend more time being creative on value-added work, (ii) *consolidating common processes* to eliminate non-value-added cost and duplicative efforts that customers are not willing to pay for, and (iii) *eliminating loop-backs or delay* which will result in improving productivity levels (Swank, 2003; George and Wilson, 2004; Hanna, 2007). The fast-paced characteristics and changing customer expectations of the markets lead apparel retail to the characteristics of short lifecycle and high impulse purchase which are sensitive to inventory shrinkage and product flow delay in the supply chains. Also, the perception of customers on retail services would affect their purchase decision. Realizing lean thinking in apparel retail operations with RFID technology creates a leaner operating environment which offers not only user-friendly shopping experience to customers but also more agile and responsive store operations to retailers with less wasteful sales and operations process. Adopting lean services in apparel retailing may equally beneficial to this industry with potential of creating both user- and eco-friendly retail environment.

The purpose of this research is to provide management and practitioners with insights on implementing and adopting lean services in contemporary retail environment enabled with RFID, a communication technology that add value to the customer chain in apparel retailing through providing smart and agile service operation. This paper presents supportive literature on the principles and the process of value creating activities based on lean thinking (Womack and Jones, 2003) and CCOR model (SCC, 2010a) aimed at improving profitability. A case study is presented to demonstrate how the convergence of these two management approaches can be applied to an apparel retailer based on a novel RFID-enabled smart apparel system aimed at improving its service operations that lead to increased customer conversion. Lastly, the implications of adopting this new initiative in creating leaner and smarter retail operations are discussed with the purpose to ensure the delivery of maximum value as a strategic tool for apparel retailers.

2. RFID technology and sustainability

2.1 Fundamental of RFID technology

RFID is an automatic identification (Auto-ID) technology developed by Auto-ID Center at Massachusetts Institute of Technology, relying on storing and remotely retrieving data using devices called RFID tags and readers (Auto-ID Center, 2002; Doyle, 2004; EPC, 2004; Finkenzeller, 2000; Shepard, 2005). With RFID technology, physical asset will have embedded intelligence that allows them to communicate with each other and with the tracking points (Auto-ID Center, 2002; IBM, 2003; VeriSign, 2004). Leading companies and business networks adopt management best practice enabled with new technologies and strategies such as lean thinking, eco-design, life-cycle assessment and close-loop production, which offer merchants improved resources management and greener value chains (UN, 2003). Information and

communication technologies (ICT), e.g. RFID technology, add great values to retail sales and operations processes through enabling consumers to find information and alternative products and services more easily online leading to a greener and less wasteful consumption practice by helping them to make sustainable choices (UN, 2011).

A RFID system essentially consists of three main components: RFID tag, RFID reader, and backend information system with middleware sitting between reader and backend system for carrying out data capturing, screening and routing (Glover and Bhatt, 2006). An RFID tag is a small object that can be attached to or incorporated into physical asset such as book, clothing, or person. When an RFID tag passes through the electromagnetic zone, it detects the reader's activation signal. The reader decodes the data encoded in the tag's integrated circuit (silicon chip) and the data is passed to the host computer for further processing (Finkenzeller, 2000; Hawrylak *et al.*, 2008; Shepard, 2005). RFID tags generally fall into two categories: passive, and active. Passive tags receive the most publicity and are currently being used by large retailers such as Wal-Mart and Metro to track inventory, and by the U.S. Department of Defense to track supplies (Hawrylak *et al.*, 2008). Unlike active tags, passive tags do not contain onboard power source and derive the power for operation from RFID interrogation signal in the course of communication (Finkenzeller, 2000; Hawrylak *et al.*, 2008; Shepard, 2005).

Passive RFID tags communicate using one of two methods: near-field and far-field (Hawrylak *et al.*, 2008). Far-field RFID tags support longer communication range than near-field tags, but they are comparatively more sensitive to tag orientation. The type of tags required for a RFID system would depend on their business applications, site conditions and system design requirements. In case of supply chain and retail applications, far-field RFID systems are used extensively. According to Hawrylak *et al.* (2008), the sensitivity of the system to RFID tag orientation is critical in many applications. The communication method used by far-field RFID system easily causes false detection and hence the design of middleware and upper layer application software becomes critical in order to effectively screen unwanted RFID signals emitted by nearby irrelevant product items.

2.2 RFID in enabling sustainable retail operations

Tracking the movements of product items in operations can be determined by three variables in a three-dimensional space, in which the first two are related to the "time" and "space" of item movement, while the third dimension concerns item identification by using RFID tags that carry Electronic Product Codes (EPCs) (Sarma, 2008). On this ground, RFID reader works with middleware to provide backend information systems with an "inventory snapshot" in its field of view which may cover a small corner of warehouse, distribution centre (DC) or backroom of retail store that essentially provides a series of item management function for improving the efficiency of supply chains including: (1) finding, (2) tracking, (3) tracing, (4) item count, and (5) time-intersections. Through querying of this corpus of data gathering from operations, two key metrics, i.e. *shrinkage* (caused by theft, damage, loss, and etc.) and *lead times* that concern operations visibility are evaluated (Hardgrave and Miller, 2008). In particular for apparel retailing, the "lost sales" causing by (1) misplacement, (2) damage, (3) theft, (4) shipping error, and (5) counterfeit of items can be reduced with the use of RFID which ultimately lead to increased product availability and total cost saving (Ustundag and Tanyas, 2009).

Back in June 2003, Wal-Mart, a US retailer, strictly required its top 100 suppliers to implement RFID technology by tagging the pallets and cases in the supplies for operation improvement through sending real-time inventory data from individual store to suppliers (Hardgrave and Miller, 2008; Roberti, 2004). Wal-Mart and its suppliers use the real-time data to improve replenishment with out-of-stocks reduced by 16% by tracking cases of goods with RFID tags carrying EPCs, where this data enables suppliers to measure the execution of promotions and boost sales which benefit to both parties (Roberti, 2005; 2007). The Wal-Mart case demonstrates an RFID implementation that only predominately affects only a small portion of the supply chain (from retailer distribution centre to store backroom) and makes use only limited RFID system capability (e.g. finding and counting items at pallet level and case level only). Given this limited scope of exposure and application, determining the payback and ultimately creating business value are challenging.

In supporting the lean thinking initiative, three mini-cases are presented to illustrate how the application of RFID technology combined with the EPCs benefits apparel retail management:

1. **Marks & Spencer**, one of Europe's largest retailers, has expanded its RFID deployment to include six clothing departments across 53 stores (Hess, 2008). The company uses RFID to track goods as they move throughout the supply chain into its stores. Apparel is individually tagged and eventually ends up on the sales floor. Store employees can quickly read racks of the RFID-tagged items by passing an RFID reader past the apparel. Tagging the items at the manufacturing point allows Marks & Spencer to monitor its shipments more accurately as they arrive in stores.
2. **Levi Strauss & Co.**, a U.S. apparel retailer, demonstrated the value of RFID technology in inventory management through item-level tracking (Wasserman, 2006). The company has reported that sales clerks can complete a storewide inventory in about an hour, a process that used to take two days. That inventory data is used on the sales floor to replenish sizes, colors and styles of clothing. Levi says the in-store use of item-level RFID on clothing in Mexico City, which started in 2005, has increased sales.
3. **American Apparel**, a U.S. apparel company, which operates more than 180 stores in 13 countries, is jumping into item-level RFID tagging and product tracking (O'Connor, 2008). The company saw quick benefits from the technology. The weekly process of taking inventory of all items in the store, which previously took four workers eight hours to complete, could now be accomplished with just two people in two hours. This gives employees more time to assist customers directly, and carry out other tasks.

As seen from these examples, many RFID-based apparel retail systems is mainly used to improve accuracy or efficiency of business logistics in relation to inventory management or checking out of product items but however do not address all the concerns on sales-floor management, e.g. improving shopping experience or item availability. RFID technology is traditionally offered to the retail segment for improving business logistics. Some apparel retailers use RFID technology in product authentication or article surveillance. Apparel retail is a season-driven and time-sensitive industry. In today's fast-paced society, customers with more sophisticated buying needs and increased choices but have less time to devote to shopping. Apparel retailers have to face the challenge of adapting quickly and efficiently to keep up with fashion and buying trends to meet customer demand, in view of the shelf-life of most product items are just around 20-40 days before their first markdown (Wasserman, 2006).

An innovative system design and new configuration are needed for coping with changes. By re-designing services with RFID and CCOR model, clothing items carried by customers can be automatically detected with mix-and-match recommendations provided in real-time.

3. Re-designing services with CCOR model

Service design is considered as part of operations management that concerns the production of goods and services. Shostack (1982, 1984) is one of the earliest contributors in designing services that are process driven and customer focus with the methodology named service blueprinting. Shostack (1982) identified three important concepts in service design: (i) *process charts* for illustrating the operations processes flow, (ii) *PERT charts* for visualizing the project yields, and (iii) *systems/software programs* for supporting the service operations. Shostack (1984) further introduced the process of designing a blueprint which includes the steps of: (i) *identifying processes*, through mapping the processes that constitute the service, (ii) *isolating fail point*, by identifying the vulnerabilities of the service delivery system on the process chart, (iii) *establishing time frame*, as standard execution time which is below the maximum delay time tolerable by the customers, and (iv) *analyzing profitability*, based on the service execution time which is considered as cost component of service that should be minimized. However, the leakage of sales prospects, i.e. customer conversion is not included as a measurement of service profitability and the metric should be used in designing customer focused retail services.

Developed by Supply-Chain Council's (SCC), CCOR model expands the application range of the supply chain operations reference (SCOR) model, which is also a methodology, diagnostic and benchmarking tool developed by SCC for standardizing the process of supply chain management, from improving supply chain processes to enhancing service operations of a firm at its customer touch points (Saegusa, 2010). CCOR model provides a standard framework of high-level customer chain definitions that enables firms to benchmark their processes with other firms that use the same approach, and then identify and implement the changes needed to improve their customer chain which aims at cutting cost and time for subsequent improvement programmes (SCC, 2010a). The process reference framework adopts a standardized approach to speeding up the improvement programmes (Magnusson, 2010; SCC, 2010a) which includes three major steps: (i) *reengineering business processes* by capturing the 'As-is' business activity structure and deriving the future 'To-be' state, (ii) *benchmarking* by quantify the operational performance of similar companies and establish internal targets based on the 'best in class' results which involve defining metrics for making comparison, and (iii) *best practice analysis* by adopting suitable management practices and software or technological solutions that result in superior performance.

CCOR model defines the value-creating processes in the sales operations of a firm as the collection of business activities along the customer chain in which both the pre-sales and post-sales activities in the sales execution processes are designed to convert customer needs into sales orders (Magnusson, 2010). According to SCC (2010a, 2010b), the sales execution processes are triggered by planned or actual events including customer visits, responding to customer inquiries, creation of customer solutions, processing of claims and support calls, which are organized into four major process groups:

- *Relate* - The process of establishing and maintaining relationships with customers,
- *Sell* - The process of establishing an understanding of the customer's needs and presenting and/or developing a solution to meet those needs,
- *Contract* - The process of pricing a solution and gaining customer agreement, and
- *Assist* - The process of providing after-sales support for products/services.

The sales operations and related service support tasks happened on the shop floor of a retail store that concern customer conversion involve mainly pre-sales activities, which are organized into three process groups, i.e. '*relate*', '*sell*' and '*contract*' (SCC, 2010b), and can be adapted as the basis for mapping the value creating activities to shopping process in retail operations.

Figure 1 depicts the concept of customer conversion in the customer chain processes. By visualizing the conversion of potential customers of the target markets to contract customers at each stage of the shopping processes, CCOR model measures the value of the services developed in the chain through enhancing the speed and flexibility of the operations in each process group leading the retailer to overall profitability improvement in response to the evolving markets and changing customer demands (SCC, 2010a, 2010b). The conversion metrics can be adopted for measuring the profitability of new service in two folds, i.e. overall profitability, and profitability by process group so that retailers can lay different emphasis on the process groups in performance tuning according to their business priority and resource availability.

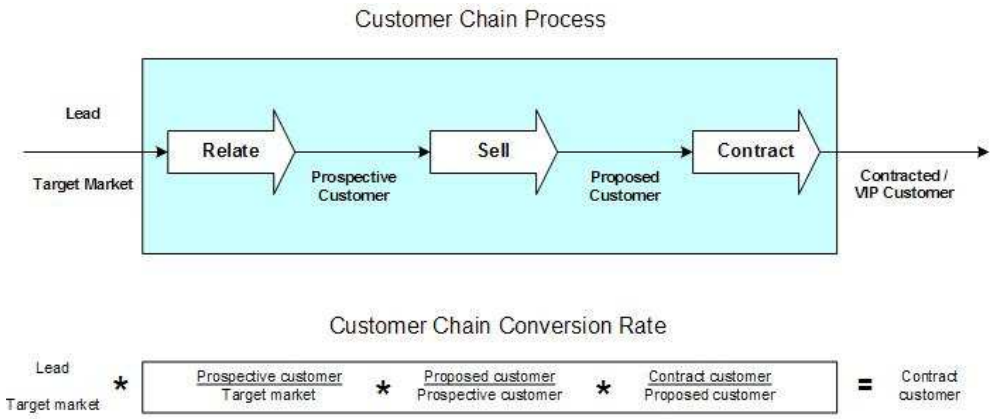

Fig. 1. Customer Chain Process and Conversion Rate

4. Realizing lean services with RFID technology

Lean thinking began in manufacturing and is originated in Toyota with names 'Toyota production system (TPS)' or 'Just-in-time (JIT) manufacturing' beginning back in 1960s, aiming for a total management system that works for any type of business and stresses value creation (Ohno, 1988; Womack and Jones, 2003; Womack *et al.*, 1991). It is a strategic move to adopt lean thinking as a total management system and the success is determined by how well a company coordinates all of its internal process, including activities with its

suppliers and customers that create *value* to products and services (Russell and Taylor, 2009). Lean thinking enriches customer value based on the principle that the final customer should not pay for such as the cost, time and quality penalties of wasteful processes and this is achieved by adopting five lean principles as a cyclical route to seek perfection (Harrison and Hoek , 2008; King, 2009; Womack and Jones, 2003):

- *Specify value* – value is specified in two fronts, (i) representing the customer value, which may include: increasing *delivery speed* and enhancing *service flexibility*, and (ii) representing the shareholder/management value in the business aspect which may include *reducing cost* and *inventory* or *acquiring new knowledge/skill*.
- *Identify and map value stream* – the whole sequence of process steps in the supply chain with all the activities required for a company's product and services, no matter value added and non-value added, should be identified for the next step.
- *Make value flow in the supply chain* – Wasteful tasks/processes are removed by lean principles in which JIT or pull systems enable flow.
- *Enable customer pull* – By working collaboratively with suppliers to make only on response to a signal from the customer in downstream supply chains. Pull enables the value stream to produce and deliver the right materials at the right time in the right amounts with minimal inventory.
- *Pursue perfection* – continuous improvement of all processes through empowering employees actually doing the work to remove waste and to design and implement more effective process, which is generally known as 'kaizen' in Japanese.

Lean service is the adoption of lean thinking in services, which are suitable nearly for any working environments no matter they are operational or support in nature (Aikens, 2011; Russell and Taylor, 2009; Voehl and Elshennawy, 2010). An important value created by the adoption of lean thinking is the reduction of customer order fulfillment time by eliminating non-value-added wastes from the processes (Ohno, 1988), and other value creating objectives such as reducing lead-time or inventory can also be applied to services by streamlining the processes so that businesses can be more responsive to changes (George and Wilson, 2004; Russell and Taylor, 2009). In the past decades, information technology (IT) has continued to expand into key manufacturing and service delivery systems, and more importantly, into their process workflows and supporting procedures where this expansion has been seen lately in the retail sector that implement lean thinking in the service operations (Husby and Swartwood, 2009; Martin, 2010). IT applications facilitate simplification, automation, integration, and monitoring of business processes, as well as the management and control of material and information flows that fully realized the lean thinking initiative in services (Martin, 2010). With the emergence of wireless computing, the "*Internet of Things*" is now happening where the things such as people and physical assets in organizations can be enabled with a wireless capability to provide visibility throughout the business and real-time tracking of inventories, movements, security and safety forms the basis of business process improvement (Hawrylak *et al*., 2008).

Through streamlining and automating operations processes with real-time asset and personnel visibility, RFID-based lean services in the "last 50 feet" of the supply chains resulting in improved item management in store management as well as enhanced customer experience which enables retailers to cope with customers of more sophisticated buying needs in the fast-paced society who have less time devoted to shopping (Doyle, 2004;

Hardgrave and Miller, 2008; Sarma, 2008). Hence, adopting lean services with RFID technology in retail operations supporting Martin (2010)'s IT capabilities becomes feasible and brings improvements to the operation as a whole. A case study of RFID applications in realizing lean services in apparel retailing is presented below aiming to provide insights on formulating relevant adoption tactics based on real-life experience.

5. Case study and discussions

5.1 Research design

Case study research is used in this study considering the strength of its likelihood of generating novel theory and replicating or extending the emergent theory (Eisenhardt, 1989). A comprehensive case study on an apparel retailer, Firm A and its technology partner, Firm S has been conducted by exploring various aspects of the design and implementation of RFID-based lean services in Firm A's retail stores aimed at improving customer conversion based on CCOR process model. In this research, an embedded single case study using qualitative approach (Remenyi *et al.*, 1998; Sanders *et al.*, 2000; Yin, 2009) was adopted to explore the details about the acceptance of a novel system-driven lean service in the context of apparel retailing from design, implementation to result assessment. Special emphasis is placed on RFID application in realizing lean services for retail sales support operations by improving customer experience, operation efficiency and item availability. Semi-structured interviews are conducted in Firm A, including staffs and customers at the retail stores who involve in using the new services and staffs at the back-office who make related decisions and provide figures about customer conversion. In addition, informal observations are carried out on site where the researcher participated as staff member or customer. Triangulation is used in the study to improve validity (Yin, 2009). Therefore, the members of Firm A and technical support staffs in Firm S are also interviewed. The findings that concern the experience and expectation from end-users are compared and contrasted with the implementation experience of the developer so that conclusions and strategic implications can be realistically drawn from the case study.

5.2 Background

Prior implementing the new initiative, mix-and-match suggestions on clothing were provided to customers in an old fashion way through staff members on the sales floor based on their experience and/or designers' suggestions by either showing photos in the product catalogues or locating the matched products on racks. Moreover, management of items on the sales floor and inventory in the back-store were relied on bar-codes. Due to the constraint of bar-code technology, store operation was highly manual-based where the availability of staff was crucial as their full participation in the operation processes was required. In order to streamline the operation processes and improve customer experience, Firm S has come-up a RFID-enabled smart retail apparel system in collaboration with Firm A to support the lean service initiative. With the new system, customers are now provided with computerized recommendations on mix-and-match of clothing items with on-screened product information details, which offer a unique shopping experience ensemble to meet their buying needs instantaneously. In addition to the customer relationship enhancement functions, the system enhances shop management by improving the security and inventory management and minimizing shrinkage at the store.

5.3 Approach of developing innovative retail services

The approach of orchestrating the service innovation project by Firm S includes two dimensions: (a) *project deliverables*, regard creating innovative lean services, and (b) *project management*, regards managing the process of creating project deliverables in a controllable manner. Unlike project management, obtaining project deliverables requires understanding of the product markets and has no established rules to follow. Products of apparel retail typically have **short shelf-life**, in which the markets are characterized by: (1) *short lifecycle*, as the product is designed to capture the mood of moment and hence the saleable period is very short, (2) *high impulse purchase*, as the buying decisions for these products are mainly made at the point of purchase, and (3) *high volatility*, which is sensitive to *shrinkage* and *dwell time* of the inventory and ultimately influence the efficiency, operations visibility and total cost of the store operations (Christopher *et al.*, 2004). Besides, customers' perception on the sales dynamics such as service levels and operation efficiency, could also affect their purchase decision.

The approach depicted in **Figure 2** aims at improving the 'As-is' processes with most suitable management practice (e.g. lean thinking, six-sigma, or CCOR model). Based on lean thinking, various value creating activities can be identified as the basis of new services for addressing corresponding market characteristics, and the 'To-be' processes of new services are created by automating/streamlining with suitable enabling technology. In practice, the metric for measuring proposed customer refers to all transacting customers, while it refers to repeated customers (VIP) when measuring contract customer. The approach can be applied to not only tangible services, but also online services considering value creation as the goal.

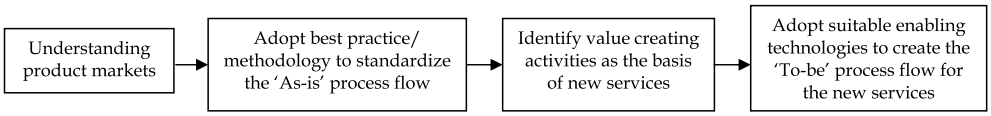

Fig. 2. A Generic Approach of Developing Innovative Service

The approach adopted in apparel retail operations is shown in **Table 1** in which the shopping processes are optimized with relevant value creating activities that are powered by RFID technology with associated systems aiming at simplifying shoppers to environment interaction and providing smarter decision support in the shopping processes so that sales can be closed faster than the conventional approach. Unlike service blueprint emphasizing

Shopping process	Value creating activities in new services	Market chars.	Enabling technologies for new services
Search and locate	Product catalog and inventory records	(3)	Clothing with RFID tags and clothing items with mix-and-match photos database for: (a) enhancing customer experience, and (b) improving operation efficiency and visibility
Dressing mirror	Mix-and-match suggestion on clothing	(1), (2)	
Fitting room	Mix-and-match suggestion on clothing	(1), (2)	
Checkout at POS	Automatic/contactless checkout process	(3)	Clothing with RFID tags and RFID-enabled ePOS application systems

Table 1. Identifying Value Creating Activities for Apparel Services

service delivery time reduction (Shostack, 1982;1984), lean apparel services are customer oriented which emphasize creating customer value through suggesting mix-and–match of clothing items in a smart (e.g. photo displayed in response to the detected RFID-tagged items) and agile (e.g. contactless and personalized services) way.

5.4 Adoption of lean services in apparel retail

Apparel retailers face the challenge of adapting quickly and frequently to keep up with product change and buying trend to meet customer needs. Lean services are introduced to better manage store operations in a more efficient manner as well as to bring customers with fresh new shopping experience so that the retailer will stay competitive in the markets through automating the customer touch points which are beneficial to both the customers and retailer. Based on the approach in **Figure 2**, a value stream map of the 'As-Is' processes is created where purchase orders are initiated to upstream suppliers based on customer purchase representing the ultimate business value and the retailer should maintain the value flow in the supply chain through improving customer conversion continuously. The approach is depicted in **Figure 3**.

Based on the CCOR model, value stream mapping of the in-store pre-sales activities was defined systematically through organizing the CCOR processes, i.e. '*relate*', '*sell*' and '*contract*' in the retail services operations so that value is created from the use of RFID-driven lean systems which improves customer conversion. Under these three CCOR process groups, lean services are developed based on the value creating activities shown in **Table 1**. **Table 2** illustrates the mapping of lean services and the operation processes from the perspective of CCOR, customer and retailer aimed at delivering target business value.

CCOR Process	Retailer Process	Customer Process	Lean Services and Systems	Values Contributed
Relate and sell	Remove product from shelf	Search and locate	Product catalogue and inventory management database	Locate product more quickly and accurately
			RFID-based article surveillance systems	Security control
	Mix-and-match suggestion	Dressing mirror	RFID-based dressing mirror systems	Enhance customer experience
		Fitting and changing	RFID-based smart fitting room systems	Enhance customer experience
Contract	Checkout and transaction automation	Payment	RFID-based point-of-sales systems	Automate the checkout process
			RFID-based article surveillance systems	Security control and alert

Table 2. Mapping of Processes and Lean Services with Intended Values

With far-field RFID technology, lean services are realized in the apparel stores through offering a variety of intelligent services that essentially extend the RFID application to the "last 50 feet" of apparel supply chains for improving the efficiency of store execution and in particular, sales-floor operations such as customer conversion and item management (Hardgrave and Miller, 2008; Heizer and Render, 2007; Magnusson, 2010; Russell and Taylor, 2009; Sarma, 2008). Providing suggestions on clothing mix-and-match is one of the new initiatives of lean services in apparel retail. Together with the following store management functions, interactions at the customer touch points in the retail operation can be improved with the expected values as detailed in **Table 2**.

- *Mix-and-match suggestions*: enhance customer experience, through providing suggestions personalized for VIP or registered customers based on their transaction history by discovering purchase patterns, i.e. estimating preferred choices through using data-mining technique or machine-learning algorithm. However, only standardized recommendations are offered to casual customers;

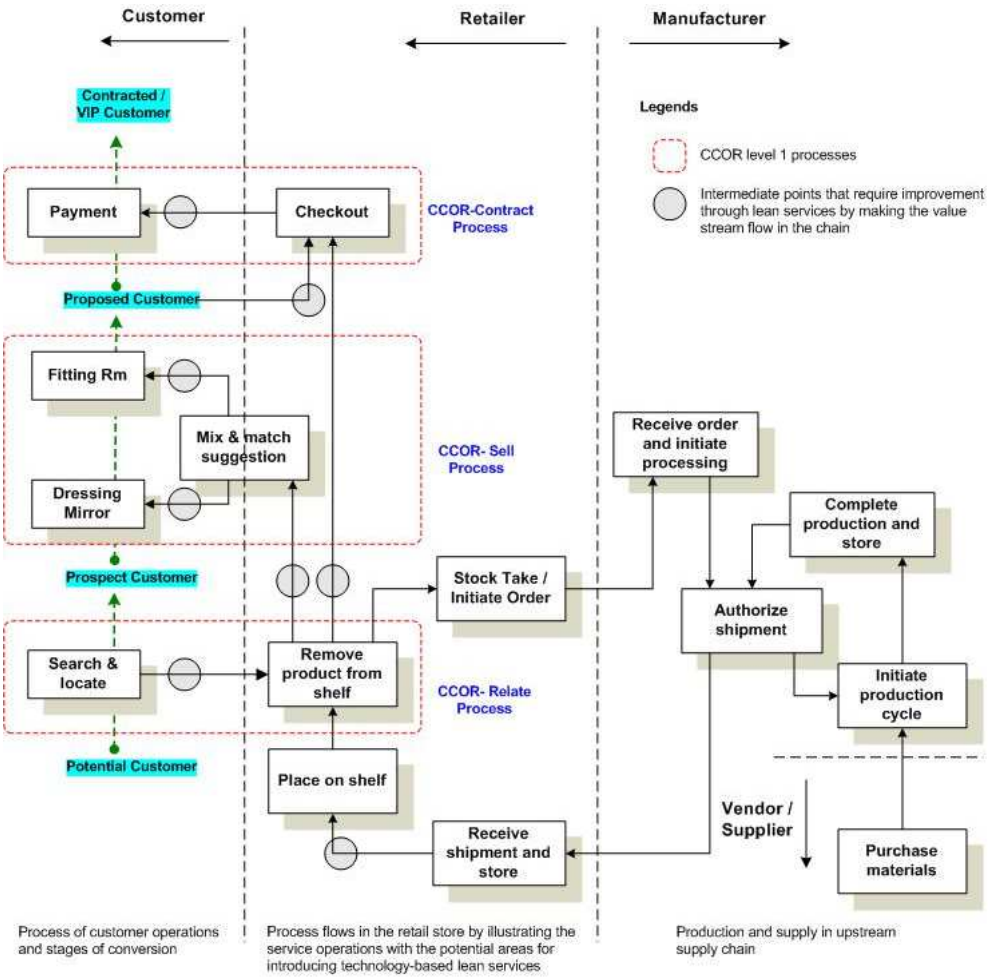

Fig. 3. 'As-is' Processes of Apparel Retail Service Operations

- *Product catalogue and inventory management*: enhance product visibility and improve search efficiency through tracking and tracing items automatically in the back-store and on the sales-floor;
- *Article surveillance*: brings *security control* capability by identifying and detecting items that are not check-out at the Point-of-sales (POS) locations, and
- *Transaction process automation*: includes the features like contactless check-out of items with bulk processing capability for improving POS process workflow and ultimately enhancing customer experience in which the contactless feature is not available in the conventional bar-code technology.

5.5 Lean service improvement with RFID-based apparel applications

The smart apparel retail system has a number of modules including *smart fitting room* and *smart dressing mirror* enabled with RFID technology with the promise to enhance shopping experience by offering responsive mix-and-match capability based on real-time analysis of customers' behavioral data stored in its database together with the implementation of essential shop management functions under a lean service environment in Firm A's retail stores. **Figure 4** shows the basic operations and flow of shopping process associated with the RFID-enabled smart fitting room and smart dressing mirror that were designed based on the process flow mapping in **Figure 3** and **Table 2**.

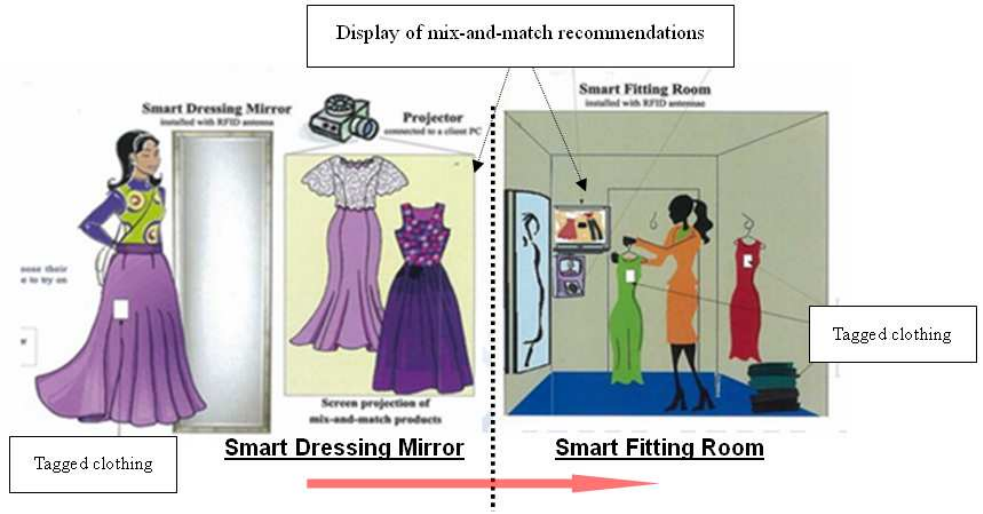

Fig. 4. Smart Fitting Room and Smart Dressing Mirror

Both smart dressing mirror and smart fitting room are equipped with RFID readers embedded with middleware and intelligent apparel application which respond to any tagged clothing item associated with registered product ID and can be further associated with relevant product data and photo image stored in the backend databases on the in-house networks. It is the design objective that *mix-and-match suggestions* are provided to customers in a faster and easier way than conventional human method. For arousing customer interest, smart dressing mirror is the first access point in fashion shop providing simple mix-and-match recommendations through image projection or high resolution TV display. When customer presents the tagged clothing items in front of the dressing mirror, the product images and mix-and-match image slide show of the products are displayed on the adjacent screen. Based on the suggestions, customer may proceed to smart fitting room equipped with a touch-screen display which has the capability of showing detail product information including product ID, price, color, size, and inventory status in an organized mean, while specific information such as VIP discount and preferred choices are customized for registered customers. **Figure 5** shows the screen displays of smart fitting room module. The product search flow is similar to smart dressing mirror previously accessed by the customer.

Fig. 5. Roll-up and Drill-down of Mix-and-match Suggestions

As shown in **Figure 5**, clothing items that are picked by customers are tracked and recorded by the smart apparel system with valuable "on-the-spot" business intelligent data associated with customer identity. With the new system, customers are able to resemble the style that they want to portray in a more autonomous manner and less relies on the staff on the sales-floor, not to mention unpacking clothing items for trial in virtually unlimited number of times, which is very inefficient and wasteful. Besides, retailers may gain instant access to the customer preferences and buying behavior captured in the shopping process, which enable them with the capability of offering personalized mix-and-match suggestions and formulating marketing strategies and business plans based on actual customer needs.

Lastly, the *electronic point-of-sales (ePOS)* module which is the last access point in the shopping process provides contactless check-out functions in the *inventory management* and *transaction processing* routines with the transaction records automatically updated in the database. Besides, the *article surveillance* module plays the role of gatekeeper by generating alert message to shop assistants via the ePOS if it detects any tagged item that is not properly check-out and the results are shown in **Figure 6**. The 'To-be' processes of lean services essentially collapse the manual tasks in the three process groups into different smart apparel system features delivered sequentially by the software for smart dressing mirror, smart fitting room, ePOS and article surveillance modules that are responsive to the

Fig. 6. Active Monitoring at ePOS and Display of Alert Message

detection of RFID-tagged clothing and human touches on the screen. The performance improvements in terms of customer conversion are summarized in **Table 3**, which indicates that the overall profitability has been significantly increased by more than twice after adopting the new approach.

Shopping process	CCOR process	Customer Conversion Rates (Based on the formula in Fig.1)	Before Implementation	After implementation
Search and locate	Relate	Prospective / Target market	48%	50%
Dressing mirror & Fitting Room	Sell	Proposed / Prospective	24%	38%
Checkout at ePOS	Contract	Contract / Proposed	57%	77%
		Overall profitability	**6.57%**	**14.63%**

Table 3. Customer Conversion Rates of Process Groups

5.6 Discussions and implications

The case study demonstrates the use of CCOR model that systematically creates the value stream of lean services for an apparel retailer based on a hierarchical process mapping method by walking through all the pre-sales activities happening on the retail shop floor (See **Figure 3**). The convergence of these two management systems was not explored in previous studies. Based on the interview results, the pre-defined values shown in **Table 2** based on the lean services objectives, help streamline the operation processes and enhance the customer experience on the service operations such that the bottom line and customer satisfaction of the retail sales are improved in two years' time which exceeds the management's expectation. As shown in **Table 3**, the number of contract customers is increased significantly by about 20% and contribute over 45% to the sales revenue in each year despite of the stringent competition. More importantly, the customer conversion rate is improved from about 6% to exceeding the market average, which is about 12% in apparel retailing (Conroy and Bearse, 2006). According to the retailer, casual customers, VIP customers and first-line staffs are all beneficial from the new initiatives with improved operational execution and decision-making assistance that lead to increased customer conversion rate by delivering a better customer experience.

The case study provides not only insights but also strategic implications to apparel retailers on realizing lean services with RFID technology. Both the merchant (Firm A) and its RFID supplier (Firm S) have to consider various practical issues in addition to merely look for obtaining business values when implementing the services that heavily rely on emerging technology. Hence, interview results obtained from the users in Firm A and staffs in Firm S are consolidated in association with the system functions and they are presented below:

- The strategic intent of offering *mix-and-match suggestions* based on visual effects and rich information is to close the sales faster than conventional approach. Addressing the complexity and security concerns of RFID technology is the key to success as the moment of truth can never be captured if customers do not actually use it. Based on the user feedbacks, there exist problems concerning *ease of use* and *data privacy* which should be resolved before launching the new technology.

- Improving the accuracy and efficiency of operations is the purpose of applying RFID technology to *product catalogue* and *inventory management*. Based on the user feedbacks, the new RFID application software need to be integrated with existing system and hence, product developer has to design and develop their RFID products compatible with major business applications in retail, for example, ePOS systems and ERP systems. Without proper compatibility with other retail business applications, the use of RFID technology could be limited. Besides, many ePOS systems have bundled with low cost bar-code reader as input device. RFID product suppliers may consider product integration through forming strategic alliance with ePOS vendors. Hence, *cost advantage* and *compatibility* are the critical success factors.
- Existing *electronic article surveillance* (EAS) devices based on magnetic technology are mature and competitive in prices. Although the apparel retailer expects the new RFID system to help save cost in the long term, the price of RFID-based EAS needs to be competitive in order to compete with existing technologies. Otherwise, the new product would be hard to survive alone. Alternatively, it can be sold in bundled with other products as a total solution before it comes to the end of product life cycle. Hence, *time to the market* and *cost advantage* are very important.

6. Conclusion

The study introduces an innovative RFID application that realizes lean thinking in the pre-sales service operations of an apparel retailer aimed at customer service excellence with improved customer conversion rate and greener operations. The study has made a contribution to practices by establishing a systematic approach in the creation of value stream for lean services with the use of CCOR model which has not been studied in previous research. Practitioners and researchers in the field of organizational improvement will systematically define the value stream of a retail firm and improve the services at customer touch points based on this approach. According to the retailer, various kinds of customer including prospective customers and contract/VIP customers are beneficial from this new initiative leading to an increasing customer conversion. However, in reality, getting new idea adopted, even if it has obvious advantages, is often very difficult which may take quite a lengthy period and may fail in the process of adoption (Rogers, 1995). Therefore, strategic implications of applying RFID technology to lean services are discussed with the purpose to alleviate the practical problems and user concerns so that lean services can deliver maximum value to apparel retailers. Four practical issues are identified based on the interview results: (i) *ease of use*, (ii) *data privacy*, (iii) *cost advantage*, (iv) *compatibility*, and (v) *time to the market*. Developers of lean services, RFID suppliers and apparel retailers need to take note on these issues when developing or acquiring the new services.

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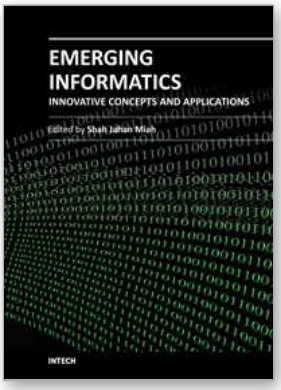

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The book on emerging informatics brings together the new concepts and applications that will help define and outline problem solving methods and features in designing business and human systems. It covers international aspects of information systems design in which many relevant technologies are introduced for the welfare of human and business systems. This initiative can be viewed as an emergent area of informatics that helps better conceptualise and design new world-class solutions. The book provides four flexible sections that accommodate total of fourteen chapters. The section specifies learning contexts in emerging fields. Each chapter presents a clear basis through the problem conception and its applicable technological solutions. I hope this will help further exploration of knowledge in the informatics discipline.

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