RFID-Based Automated Shared Drop Box for Laundry Business: A Process Model

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ABSTRACT

Collection and delivery of laundry is an important process in the laundry business. The laundry businesses have adopted diverse models such as over the counter collection/delivery, online booking etc. The laundries are collected or delivered from customers' doorstep or from customers' desired location at a convenient time. In this paper, business process re-engineering concept has been incorporated to improve the collection and delivery process of laundry using RFID (Radio-Frequency Identification) tagging and Automated Laundry Collection Drop Box. The Devil's Quadrangle has been used as a tool for evaluation. The proposed model will result in reduction in cost, time and improvement in service quality. It ultimately results in customers' loyalty, economic efficiency and gain of a competitive advantage over competitor. Other advantages for laundry business include automatic collection and delivery, enhanced customer convenience, enhanced flexibility and industry economic savings, enhanced customer satisfaction and decreased labor work. In the proposed automated laundry collection model, reputed laundry businesses will make a consortium and outsource collection and delivery process to a courier company. Different collection and delivery options are proposed in the model.

Key Words: Business Process Reengineering, Radio-Frequency Identification Based Shared Laundry Drop Box, Business to Business Solution, Technology Integration in Business Process, Devil's Quadrangle.

1.   INTRODUCTION

The objective of re-engineering of a business process is to eliminate unnecessary steps and adopt a state of the art technology in order to achieve desired goals such as boosting business performance, reduction in cost and time, improvement in business productivity, achieve customers' satisfaction and loyalty [1]. Technology integration in business processes bring several benefits, including process automation and remote working, reduction in cost and time, effective communication and collaboration between stakeholders [2-3].

The advancement in technology has changed the aspects of every field. Before the 19th century, household laundry was pretty laborious job. With introduction of electro-mechanical technologies, the labor work in household

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laundry has significantly decreased [4-6]. The utilization of technologies in internal operations of commercial laundry business provides good results compared with traditional laundry operations [7]. Internal operations not only include washing and ironing of clothes but also tagging, sorting, categorizing, record keeping, collection and delivery of laundry. RFID tag based hangers improve collection, tracking and delivery process efficient and are cost effective, by automating identification, sorting and grouping of laundry. Status of laundry can be tracked locally and remotely [8]. For identification and monitoring the status of laundry during laundry operations, barcode laundry tickets are also utilized [9].

Collection and delivery of laundry is an important process for the commercial laundry businesses and different models have been adopted for collection and delivery of the laundry such as over the counter service [10], pick/drop the laundry from home [11], online booking and picking of laundry [12] and self-service KIOSK where customer puts/collects laundry in specified lockers [13]. For providing convenience and flexibility to customers, different models for process of collection and delivery of laundry have been adapted. In this study, different models for collection and delivery of laundry have been studied and a new model for commercial laundry business in Pakistan scenario has been proposed.

The core concern of the proposed model is B2B (Business to Business) solution between laundry companies' consortium and Courier Company based on RFID enabled automated shared drop box, which has been utilized systematically to get flexibility and convenience for customers. The shared drop box contains RFID scanner placed at sales points of the courier company which scans the dropped soiled laundry of customers and provides different laundry facilities options to customers. It also creates customer's convenience and can help the goodwill and reputation of the laundry company. The provided facilities have much broader access in different parts of the city and cover urban along with sub-urban areas. The model decreases labor work and human error, both for customer and the laundry company.

The rest of this paper is divided into five sections. Section 2 discusses the related work and existing laundry system for collection and delivery of laundry. Section 3 shows the detailed analysis of the existing laundry methods used. Section 4 discusses the proposed model. Section 5 describes performance evaluation and limitation. Section 6 illustrates conclusion.

2.   RELATED WORK

Washing soiled laundry is an everyday activity of human life either performed domestically or through laundry service providers [14]. Washing clothes domestically is a laborious job, during which considerable amount of water, energy, detergents and time is consumed. In a study conducted in Germany [15], it was estimated that 380 million-meter cube of water, 600,000 units of detergent and 5.5 billion kWh of electricity is consumed in the domestic washing of clothes. Washing of clothes consumes 12% of the total drinking water [16]. Pakistan is facing acute shortage of both energy and water [17]. Different detergents are available in the market for washing laundry at home but their exposures to children can cause tremendous negative effects on their health [18]. The use of chemicals such as carbon tetrachloride, trichloroethylene and tetrachloroethylene cause death of launderers and dry cleaners due to exposure to the solvent of the detergents. Grey water, if not treated, can increase the toxicity of land and as well as causes death of fishes when it is dropped in the river [19]. Laundry waste water

can disturb the growth of plants and animals [20]. In Pakistan, 8% of the population uses commercial laundry, 83% uses home laundry while 9% uses both commercial as well as home laundry services [21].

Commercial laundry businesses can be divided into two categories (i) deals with industrial laundry; and (ii) deals with general population [22]. The customers of the first category of the laundry business are industries, hospital, hotels or armed forces, where, generally the clothes are of the same type such as uniforms, bed sheets, covers, and are bulk in quantity. Collection and delivery of laundry is either the responsibility of the customer or the laundry service provider is responsible for collection and delivery.

The second category of laundry business deals with general population and they can also be further divided into three categories according to quality of service and price models. These categories, available in different cities of Pakistan [23], are (a) lower level i.e. Dhobi (launderer); (b) middle level laundry business and (c) high level laundry business. There exists significant difference in quality of cleaning service as well as in prices between them. Lower level launderer i.e. Dhobi, wash clothes at dirty places such as channels of dirty/drainage water (Nalla) and use harsh chemicals for cleaning of all clothes, irrespective of type of clothes, which decreases the life of clothes. They generally charge Rs.10/- for each piece of laundry. The waste water is flowed into the channel without any treatment.

Middle level laundry businesses often run with a medium level shop and either have their own laundry cleaning plants or use other laundry business' plants for washing of clothes. The cleaning plants are often run in small places such as a house, where no industrial standards are observed. They utilize better quality detergents than a Dhobi but standardized cleaning practice is not observed. They charge different amounts for different clothes [24].

Higher level laundry businesses provide quality cleaning service by observing all standards i.e. cleaning clothes according to their mentioned specification, treating water/ other waste before dumping and follow other industrial standards of local laws but they charge relatively higher cost than low level or medium level laundry service. These high level laundry businesses are generally located and provide services in posh areas of city, where people can bear the cost of cleaning service they offer.

Commercial laundry is more efficient in terms of energy and resource consumption. Both commercial and home based laundries have negative impacts on surrounding of living, however, quality commercial laundry has less impact on the environment as less utilization per cloth and less energy and resource is consumed as compared to home based laundry [2] due to the treatment of waste laundry before condemnation. Due to commercial laundry services, microbial attacks and different skin infections are also reduced [3]. This is a common observation that all sort of laundry is washed at a time in homes. It leads to mixing of all sorts of laundries, wastage of time, detergent and water, while utilizing commercial laundry services save time, money, detergent and water. This may lead to mixing of colors and inefficient washing, while in commercial laundry; all clothes are sorted and washed [25].

The laundry businesses opted different collection and delivery model according to their feasibility. Dhobi collects/delivers laundry from home on specified days. Medium level laundry business collects and delivers laundry on shop counter. Higher level laundry services

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offer both type of service i.e. collection and delivery from home and over the counter. This research is about re-engineering the process of collection/delivery of laundry for higher level laundry service providers as they offer quality cleaning service and observe industrial standards for treating waste. However; due to higher cost and lower reach-ability to middle class areas of the city, these business loose a big customer base. In this paper, the collection/delivery of the laundry process is re-engineered to enhance and boost business performance by providing convenience and flexibility to customer, which will increase the customer base.

2.1 Business Process Re-Engineering

Different methodologies have been adopted for enhancing/re-engineering business processes. Each practice is linked with its advantages and drawbacks, but the "Devil's quadrangle" is considered having more positive impacts on evaluating parameters of business processes like cost, quality, time and flexibility. It is used for the validation of re-designed business framework [26]. The devil's quadrangle methodology has been successfully used for the evaluation and validation of re-designing the "Purchase Request Process of TAM Iran Khodro Company" and gets significant improvements [27]. Devil's quadrangle is also successfully utilized when the processes of "Green Business Process Management" needs improvement in its different parameters including cost, quality and flexibility [28]. It is used for evaluation of measuring the performance of business process mining [29].

One of the only frameworks, which both, the industry and research believes is the best suited for performance evaluation of a workflow is the Devil's quadrangle [30]. Devil's quadrangle methodology is mostly used in re-

designing business processes in business process re-engineering. During re-engineering processes, different parameters i.e. cost, quality, time and flexibility are observed. The main focus of the said methodology is to decrease cost/time, while increase quality/flexibility in the re-engineered processes. The dimensions of time, cost, quality, and flexibility are interpreted differently at different maturity levels. It is not necessary that betterment in one of the mentioned dimension will lead to betterment of the other one as well for re-engineered process [31].

3. EXISTING PROCESSES FOR COLLECTION AND DELIVERY OF LAUNDRY

In commercial laundry business, the collection and delivery of laundry is an important process. People need flexibility and convenience in collection and delivery of laundry process without compromising on quality and fear for the misplacement of the laundry. Numerous models have been proposed/adapted by commercial laundry businesses to improve the traditional method of over the counter collection/delivery and manual registration of the laundry.

Collection and delivery of laundry process consists of two steps (i) customer interaction i.e. collection of laundry, noting down requirements and delivery after cleaning, (ii) internal pre-process i.e. marking of codes and sorting clothes before cleaning process and post-process i.e. placing clothes into shelves or hangers after cleaning. To automate and speedup the process of collection and delivery of laundry, different technologies have been implemented, which aim at better customer experience and convenience while reducing cost and labor work. Barcode and barcode scanners are used to remove paper based records while RFID tags are used for tracking laundry in

real time [32]. RFID, wireless sensor network and IoT (Internet of Things) have been used for tracking of laundry on real-time basis, to inform customers about the status of laundry and send SMS (Short Message Service) alert for picking-up their laundry [33]. In the armed forces, industries and hospital, RFID-based laundry KIOSK with special software called CATAMARAN are used for periodic collection/delivery of laundry in an automated way [34].

Existing models for collection/delivery of laundry can be categorized as follows:

(1)   From customer doorstep

(2)   Over the counter

(3)   Specialized laundry locker for drop-off and collection

(4)   Specialized Laundry KIOSK

3.1   Collection/Delivery of Laundry from Customer Doorstep

In this model, a representative of laundry business visited customers at their home for the collection of soiled laundry and after the cleaning of clothes; the laundry was delivered back to the customer's home.

This model has two variations; a traditional and long practiced variant in which representative of the laundry business visited customer place for collection and delivery of laundry at specified day/time. It is an inconvenient way and if a customer missed the trip then he/she has to wait for the next turn.

In the today's digital era, this traditional model has gone online and shifted to the Smartphone App. Different entrepreneurs have started services for collection and delivery of laundry at customer convenient schedule.

Customer can book a laundry pick-up and delivery time using mobile App and company's representative will collect and deliver laundry at the customer's doorstep, even in the absence of customers. Using specialized laundry bags with 4-digit pattern lock and special door clasp for locking the bag to door or any other fixture such as handrail, the service is offered in absence of customers. Customer put their laundry in bags, lock it with pattern and put the bag outside the door or clamps with door, representative of laundry service provider, already having the clasp code, unlock it and collects the laundry. In the same manner, laundry is returned back to the customer [35-36].

3.1.1   Over the Counter Collection and Delivery of Laundry

In this model, customer handed over the soiled laundry to representative of the laundry business at sales point (office or shop). After the receiving of laundry, the representative marks the laundry with suitable tags for identification, notes down any specific requirement of customer and issues a receipt note to customer in which number of laundries received and return date is mentioned. Barcode tagging is implemented by some service providers, in this model, to automate the inventory process of laundry collection [32,37].

It is a traditional but inconvenient method for the collection and delivery of laundry, in which customer is required to follow the business hours of laundry service provider and there may be chances of occurrence of labor related errors.

3.1.2   Specialized Laundry Locker for Drop-off and Collection

Some laundry service providers offer specialized laundry locker facility to their customers on 24/7 availability.

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Specialized laundry lockers are placed in a facility which can only be accessed through authorization using specific cards. Customer can book a locker, using website or App and a locker is temporarily assigned which can be opened by PIN code. PIN code is sent to customer directly through message and by using PIN code, customer drop-off his/her laundry in the locker. Laundry service provider collects laundry, cleans and then puts the laundry back into the same locker and then sends alerts to customer for collection. After collection of the laundry, the locker will be free to be assigned to any other customer [38].

These specialized laundry lockers are great at providing convenience and flexible service for customers but they are available in only few selected areas of the city.

3.1.3   Specialized Laundry KIOSK

Self-service KIOSK has become a common practice in the modern world and offers wide variety of services such as automated bill collection, cash deposit/retrieval, information provision, and many more. A model, based on specialized laundry KIOSK, is proposed in [13] for collection/delivery of laundry for Hospitals, Industries or forces where laundry is mostly of the same type such as uniform and it is periodically received and returned to employees. Garments grade RFID tags are embedded to laundries and special card is issued to employee for identification, which is used when employee drops off soiled laundry into the KIOSK or collects clean laundry from KIOSK.

A fully automated self-service laundry KIOSK is available 24/7 for general public [39]. These KIOSK offer greater convenience and flexibility but as these facilities are not wide-spread and limited to specific locations of the city, people living in sub-urban areas of the city, could not be facilitated.

3.2   Analysis of the Existing Methods

Laundry procedure for receiving, cleaning and then returning to customers is pretty laborious and costly. For receiving, cleaning and then returning laundry to the customers, different models have been implemented. The implemented models are specific to a department's internal laundry operation such as hospital, Industry or for general public. This study is focused on collection and delivery of laundry process for general public. For the purpose of customer satisfaction, convenience, flexibility, financial savings gain, automated transport and tracking, different technologies i.e. Barcode, RFID and sensors have been adapted to automate the process.

All models discussed in section 2.2 are from re-engineering and by observing a lack of usability and flexibility in the implemented methods for collection and delivery of laundry, the paper introduces new functionality for achieving customers' satisfaction and loyalty. To outline the key characteristics of different works presented in research and implanted through laundry service providers, Table 1 is maintained. A few limitations are listed below.

(1)   Some models are lacking in customer convenience and flexibility such as over the counter model.

(2)   Some models might have trust issue i.e. counting of clothes, quality of cleaning, which are faced in second variant of picking / dropping laundry from customers' doorstep in the absence of the customer.

(3)   Some laundry service providers offer specialized KIOSK and specialized laundry locker but these facilities are limited in number and mostly available in specific areas of the city. People living in sub-urban areas are not able to avail this facility either due to reach-ability issue or due to increased service charges.

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(4) Specialized KIOSK are specific to a laundry service which means customer cannot choose other laundry service providers which possibly offer competitive service charges.

In the Laundry Model of Figs. 1-2, the dropped soiled laundries of the customers is collected by the agents of the laundry company and cleaned laundry is delivered back at the specified time and location of the customer. Comparatively this process is inconvenient; as if a customer missed the trip then he/she has to wait for the next turn, which may cause disturbance in normal routine. It also causes customer's inconvenience and may harm the goodwill and rapport of the laundry company. The

laundry process as a whole is rigid and less flexible, which is the main cause of the inconvenience.

In the Laundry Model of Fig. 3 , customers drops soiled laundry in laundry company shop; the representative of the company allots a tag or number to the specified laundries of different customers. Similarly, a collection slip is issued by them where an exact date and time is mentioned to collect it from a specified collection point. The collection of various laundries to be collected from specified collection points is a type of drawback of this system. If a customer does not collect his or her cleaned laundry at a specified collection point, then he/she will have to wait for the next turn which is also a blot on the

TABLE 1. COMPARISON TABLE OF COLLECT/DELIVERY LAUNDRY MODELS

System	Model	Process Eliminated	Technology Integration	Benefit Achieved	Limitation
RFID-based automated collection/delivery of laundry using KIOSK [34]	Specialized laundry KIOSK	Manual collection and delivery of laundry	RFID tags and scanner, Laundry KIOSK	● Reduction in cost and time ● Customer Convenience and flexibility ● automate inventory record	Service provided within a specific location, such as hospital
Laundry KIOSK [39]	Specialized laundry KIOSK	● Manual collection and delivery of laundry ● Internal sorting and managing of laundry	RFID tags and scanner, Laundry KIOSK	● Reduction in cost and time ● Customer Convenience and flexibility ● Automated inventory record	Service provided within a specific location, such as a hospital
Online Cleanry [10], Dhobi online [11], Dhobi Saab [12]	Collection /delivery of laundry from customer doorstep	Day and time specific collection and delivery	Website and Smartphone Apps	● Time flexibility to customer	Service available to specific area of the city
Sudzee [36]	Collection / delivery of laundry from customer doorstep	● Day and time specific collection and ● Laundry collected and delivered in absence of customer	Website and Smartphone Apps	● Time flexibility to customer ● Never wait for laundry boy	Service available to specific area of the city Customers should trust the service provider for their laundry
Automated dry cleaning delivery system [35]	Specialized laundry KIOSK	Manual collection and delivery of laundry	RFID, RFID scanner, barcode, card reader	● Reduction in cost and time ● Customer convenience and flexibility ● automated inventory record	Service available to specific area of the city
Laundry Locker [38]	Specialized laundry locker for drop-off and collection	Manual collection/ delivery of laundry	Smartphone App, Website, Electronic Laundry Locker	● Reduction in cost and time ● Customer convenience and flexibility ● automate inventory record	Service available to specific area of the city

company's profile as well as it is also a traditional, inconvenient method for collection and delivery of laundry, in which customer requires to follow the business hours of laundry service provider and there may be chances of occurrence of labor related errors.

In the Laundry Model of Fig. 4, a specialized laundry locker has been utilized which can be opened through a PIN code assigned by the authorized company. Customers put their soiled laundry in the specialized laundry locker; laundry service representative collects it and after processing, put it back in the locker and generate SMS alert to customer for collection. The main drawback of this model is its rare availability, because it is available to only selected areas of the city.
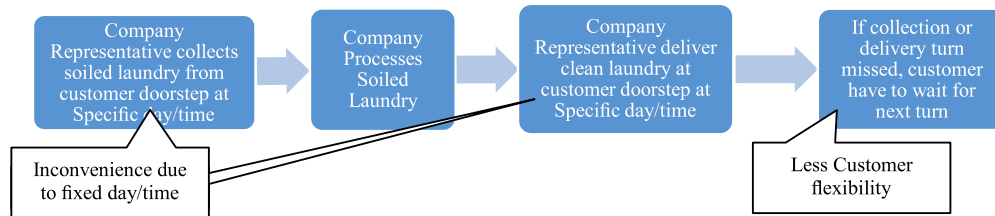
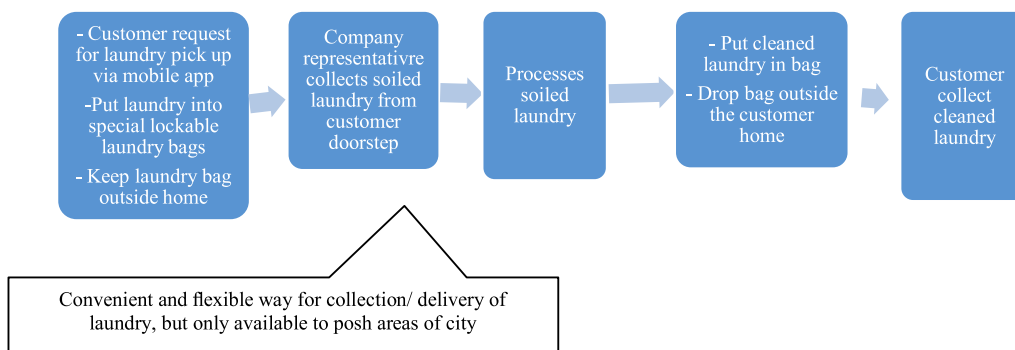*FIG. 1. COLLECTION / DELIVERY OF LAUNDRY FROM CUSTOMER DOORSTEP BY DHOBI*

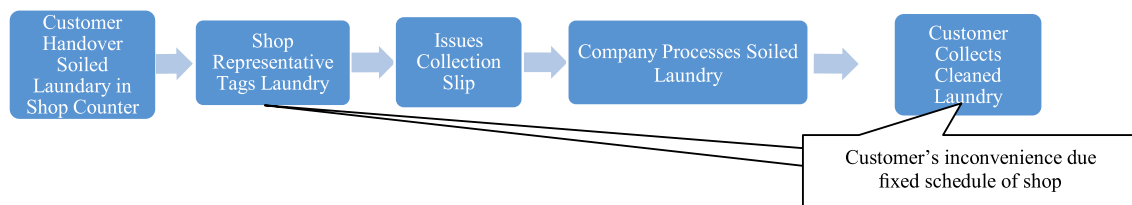*FIG. 2. COLLECTION / DELIVERY OF LAUNDRY FROM CUSTOMER DOORSTEP USING APP*

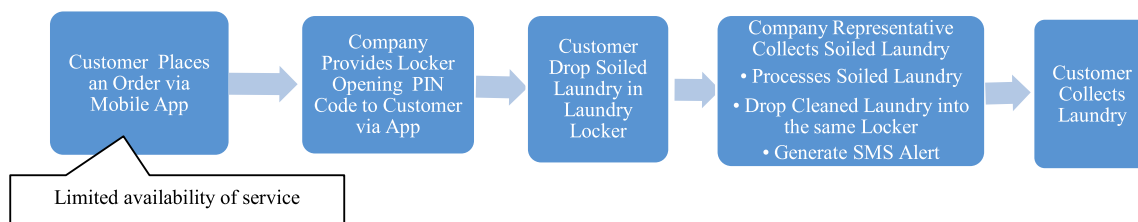*FIG. 3. OVER THE COUNTER COLLECTION / DELIVERY OF LAUNDRY*

FIG. 4. SPECIALIZED LAUNDRY LOCKERS FOR DROP-OFF AND COLLECTION

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4.   RFID BASED AUTOMATED SHARED DROP BOX FOR LAUNDRY - B2B SOLUTION

Keeping in view the limitations of existing models, this paper proposes a B2B solution for collection and delivery of laundry for general public. In the proposed model, the collection and delivery of laundry is be assigned to Courier Company. The prime objective of the proposed model is to facilitate the customers with enhanced convenience, flexibility and increased reach-ability for Laundry Company. The proposed model comprises of three modules (i) Customer Module, (ii) Courier Company Module, and (iii) Laundry Company module. The workflow between these modules is depicted in Figure 5 and description of different components is given in section 4.1, 4.2 and 4.3. In the proposed model, the collection and delivery of laundry will be responsibility of Courier Company. The core concern of the proposed model is an automated shared drop box, which has been utilized systematically to get flexibility and convenience for customers. The shared drop box contains RFID scanner which scans the dropped soiled laundry of customers and provides different laundry facilities options to customers. It also creates customer's convenience and can help the goodwill and reputation of the laundry company. The provided facilities have much broader access in different parts of the city and cover urban along with sub-urban areas. The model decreases labor work and human error, both for customer and the laundry company.

A courier company is specialized in delivery and supply operations with distinguished features like security, speed, signature, tracking and has much broader access in different parts of the city. It has a very fast system of delivery, as the service is richly provided with the proper sources of transportation to ensure time based delivery of goods and services. Courier service companies have expertise in collection and delivery, so most of the organizations are outsourcing such operations to couriers. In such a contract, couriers' service is responsible for handling these operations which is beneficial for both parties. In the proposed laundry business model, collection and delivery services are outsourced to courier Services Company [40]. By automating the collection process using RFID based shared drop box, customer can drop soiled laundry without interacting with sales representative. RFID based shared drop boxes are placed at courier company's sales points, therefore a customer can easily search and locate the nearest point to drop/ collect laundry (Fig. 5).

4.1   Customer Module

The customer module deal with the issues directly related to customer such as Mobile App, customer registration, tagging of cloths, association of tagged cloths to their customer ID.

Mobile Application: Mobile app is an important part of the customer module. It will be used for registration of customer, records of the clothes, changing preferences, locating nearby sales point, ordering clothes pickup from home, changing the receiving location/time and manage payments. In the proposed App, customer can add their family members in family tree.

Customer Registration: Customer will register themselves using either Mobile App or through website or by visiting laundry company office. After providing required information, such as personal detail, preferences and payment options, a unique Customer ID will be

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assigned to the customer. After acquiring Customer ID, family members of the customer will be added so they could also use the services. Each family member will be assigned sub-ID which belongs to main customer ID. All correspondence, order placing and payment detail will be executed using the customer unique ID. Customer ID and related information will be placed in shared database so that different laundry companies have access to this information.

Association of Clothes: After registration, customers associate their clothes with their customer ID. In the proposed model, it is assumed that each laundry will be RFID tagged either by Garment Company or will be tagged by Laundry Company. The RFID tagged clothes will be associated to family members of the customer.

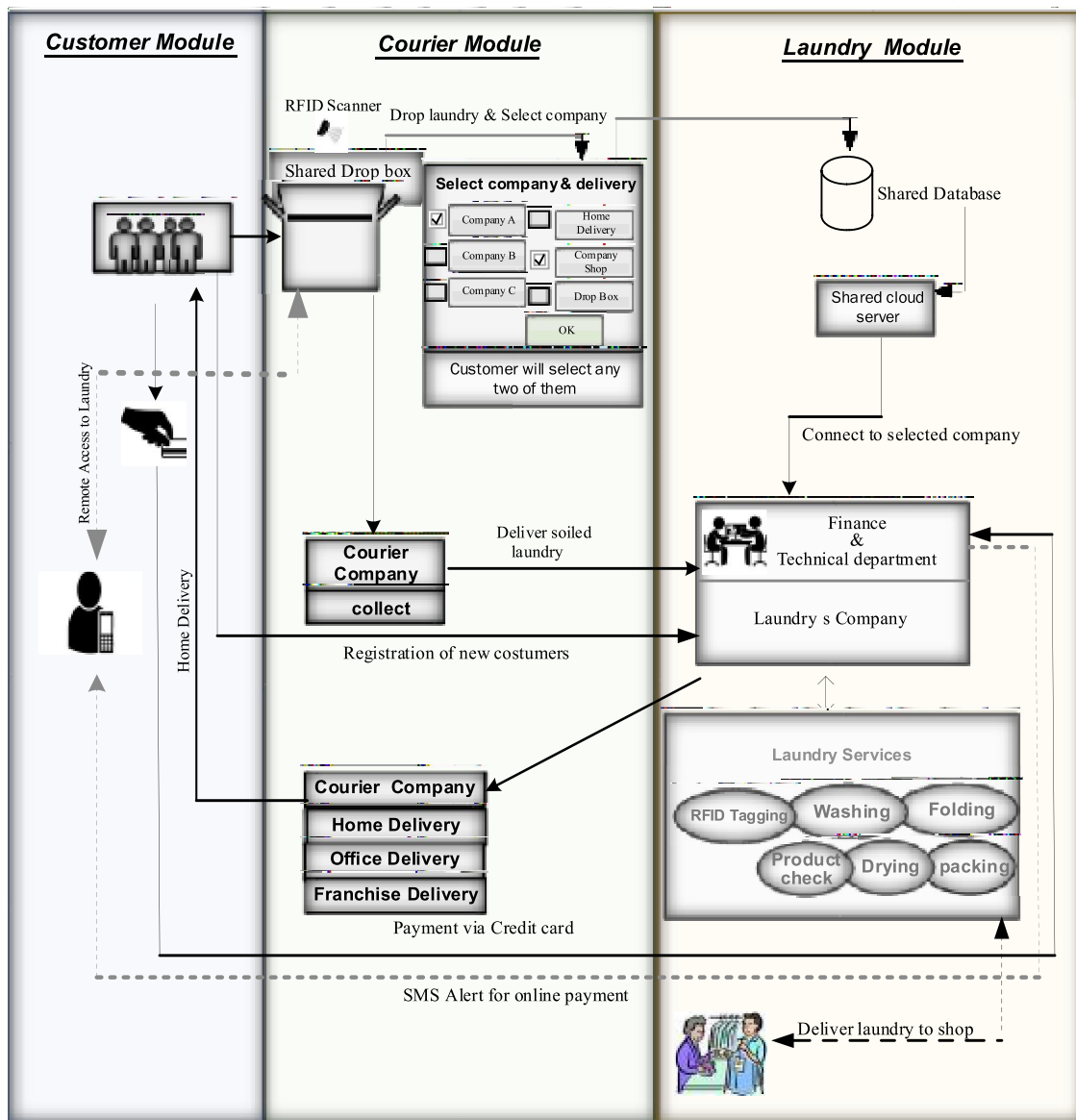**Mode of Payment:** After registration, customers select mode of payment. For customer facility, different mode of

FIG. 5. MODEL DIAGRAM

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payments could be offered by laundry companies such as Cash payment at sales point, association of the credit/ debit card, e-payments, and m-payments.

4.2   Courier Module

Laundry companies' consortium outsources the collection/delivery process to Courier Company. Couriers Company will arrange placement of RFID based shared drop boxes at different sales point, collections of soiled laundry from drop box/customer desired location, soiled laundry delivery to laundry companies (whichever laundry company selected by customers) and taken back processed laundry from Laundry Company, delivery of processed laundry to customers preferred location.

RFID Based Shared Drop Box: RFID based shared drop box is a single drop box for multiple laundry companies which is placed in the sales points of contracted courier company. Placement of the shared drop boxes in customer sales point is important, in order to avoid the chances of theft or damage by any intruder, furthermore, it will reduce the chances of dropping any harmful material into drop box because of presence of representative of courier company at sales point. The proposed drop box will be similar to book collection drop box used in library [41]. It will only use for dropping soiled laundry. It has one wide opening in which RFID scanner will be installed. It also has a touch screen panel and drop box is connected to Courier Company's main server. Courier company server has access to laundry company shared database. RFID tagged plastic bags will be available at side of the drop box. The bag is capable of holding up to 10 medium sized or 7 large sized or 15 small sized clothes.

When a customer wants to put the soiled laundry into drop box, he/she will pick a plastic bag, put their laundry into it and drop the bag into drop box. Multiple bags can be used, if the laundry is more than the capacity of one bag or customer wants to keep separate different clothes. After dropping, system scans the bag as well as laundry and detects the customer ID from shared database and displays the message on screen as well as sends message to customer App. At this point, customer has option of using drop box screen or using App for selection of Laundry Company and other options. If no options is selected by the customer then customer preferences will be followed. The information is sent to concerned laundry company.

RFID Scanner: In each shared drop box, standard RFID scanners like UHF RFID scanner [42] and portable scanner has been utilized [43]. It scans RFIDs of laundries which customers drop in the drop box. Once RFID tag of dropped laundry is scanned, the system provides selection option of the Laundry Company and delivery through the attached interface.

Home Collection and Delivery of Laundry: Instead of directly using shared drop box, home collection and delivery is another service in the proposed model. In this case, customers place order for washing their soiled laundry to their preferred laundry company. During order placement, customer mentions location from where to pick and deliver the laundry. Courier Company agent visits to the customer doorstep to collect soiled laundry. Courier Company agent has a portable RFID scanner and RFID tagged plastic bags. Agent collects the laundry, put them into bag, scans the laundry/bag and generate digital receipt of the laundry. The courier company delivers laundry to the preferred laundry company. The processed laundry will be delivered to customer at their preferred location.

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Delivery of Soiled Laundries and Collection of Processed Laundry from Laundry Company: After collection of soiled laundry from drop boxes/customer doorstep, the laundry will be sorted according to the customers' preferred laundry company and then delivered to respective laundry companies. During the entire process, customer can check/track the status of laundry.

After processing the soiled laundry, laundry company updates the status of laundry and Courier Company collects processed laundry from laundry companies. The processed laundry is then delivered to customers at their preferred/desired location.

4.3 Laundry Module

Laundry companies make a consortium and any laundry company could take membership. The consortium is responsible of developing system, managing shared database, making agreement with Courier Company and other responsibilities.

Laundry Company: Laundry companies offer services of washing, ironing, tagging and smart laundry care. Registered laundry companies are using single shared drop box. Laundry Company has own database for maintaining the record, which is connected to shared database.

Outsourcing Services to the Courier Company: In the proposed model, collection and delivery of Laundry Company is outsourced to Courier Company. This is beneficial for both laundry companies and Courier Company. Courier Company is responsible for collecting soiled laundry from both, shared drop boxes as well as homes. Whenever Laundry Company washes the soiled laundry, then the courier company delivers it to the concerned customers in their preferred location.

RFID Tagging of Laundry: Each cloth will be tagged using RFID tags. In the proposed model, it is assumed that clothes are tagged by Garment Company. If the clothes are not tagged by Garment Company or in case of any other untagged clothes; the laundry company will arrange RFID tagging of clothes. Laundry grade RFID tags will be used such as Logi Tag Disc [44] which can easily be sewn in laundry using standard stitching equipment and can be read via standard RFID reader. Its different specifications are LF 125 kHz or HF 13.56 MHz, ISO 15693/18000-3 (HF), High chemical and mechanical resistance, Temperature resistant up to 347°F (175°C) and options for mounting on metal or non-metal surfaces. The material in which the RFID tags are coated is metallic alloy which is non-rusting, flexible and thin [45].

Shared Database for Different Laundry Companies: Registered laundry companies have their individual databases. Laundry consortium manages a cloud shared database and registered laundry companies and contracted courier company can access by using credentials. Whenever customer places an online order for specific laundry, the system sends the information to concerned laundry company. After receiving of the laundry from Courier Company, Laundry Company processes the laundry according to the preferences of the customer. After processing, it will put the information into shared database and send information to Courier Company. Courier Company then collects the processed laundry and delivers to customer at his/her desired location.

Finance and Technical Department: Each laundry company has finance and technical department which is responsible for maintaining database. It receives customers online placed order for further processing. Finance department of the laundry consortium manages

the payment related issues such as contract with different banks, cash management in case of payment at sales point, any finance related dispute between Courier Company, Laundry Company and customer.

5.   PERFORMANCE EVALUATION

In the proposed model, Devil Quadrangle is used for re-engineering the collection/delivery of laundry process. The main aim behind the use of Devil quadrangle in business process reengineering is to decrease cost and time and increase quality and flexibility. The methodology is used to check how the introduction of each step will affect each of the mentioned methodology parameters.

Workflow Reengineering Steps

- Elimination of unimportant Tasks
- Arrangement of tasks
- Combination of similar tasks
- Reduction of Task completion Time
- Removal of Blockages and Resource Shortages

5.1   Automated Workflow after Reengineering Laundry Processes

Transformation and Elimination of Un-Important Tasks: Those tasks which do not give benefits to business or customers are unimportant tasks. In laundry services different unimportant tasks like waiting for manual dropping of soiled laundry in laundry shops and customer waiting during collection of washed laundry. All these

are unnecessary task and are eliminated as shown in Fig. 6. Elimination of unnecessary task in business workflow results in reducing time, cost while flexibility and the quality increases [46-47]

Arrangement of Tasks: With the serial performing of a task, length of process cycle increases. Processes should be performed in parallel, so that tasked could be performed in short period of time. In the proposed model, shown in Fig. 6, the processes are arranged in such a way that each activity is assigned to the responsible individuals who have expertise in it. The proposed model automate the dropping and selection of laundry companies along with the delivery services at a desired point.

Combination of Similar Tasks: In laundry systems, all the activities like manual collection of soiled laundry, keeping laundry details in registers and manual collection of cleaned laundry are removed. It leads to increase in efficiency, reduced cycle time and cost and improved quality. The information which is put in the laundry service, either done locally or remotely, is sent to the technical department of the target company and by doing so the quality enhances.

Reduction of Task Completion Time: Cost of a product is directly related to the time in which a task is to be completed. In the proposed model, as shown in Figs. 7-8, each task is allotted to different individuals who have expertise in it. With the adaptation of such mechanism, the time is reduced which ultimately enhances the efficiency and quality of the product/service.

Removal of Blockages and Resource Shortages: When workflow processes are slowed down at a point, blockages
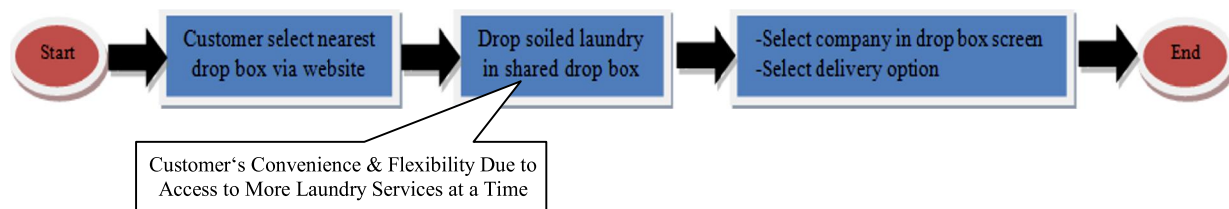

FIG. 6. LOCALLY SOILED LAUNDRY DROPPING PROCESS

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occur. Transfer of objects from one place to another also becomes slow due to which many processes are lined up in queue. In the proposed model, each activity is allotted to the individual company who has experience or is working on the specified service independently. In this case the time needed for process decreases but flexibility and cost increases [47].

5.2 Limitations

There are same limitations in the proposed model for collection/delivery of laundry system. These limitations are outlined as following:

- It is assumed that dropped soiled laundry is in normal condition in its all aspects; however, customer could drop their defected laundry into drop box as no representative of Laundry Company will check at time of dropping. This could cause dispute between customer and Laundry Company.

- The shared drop boxes are openly accessible for public to drop their soiled laundry. This open access of public to the shared drop box may lead to the threat of dropping harmful materials. Instead of soiled laundry, if someone drops explosive or harmful materials in shared drop box it may cause damages and threats to human life.

- In the proposed model access is provided through mobile application which connects with the laundry company via internet network. In case of network problem, delay in communication between laundry company and courier company will occur.

- In case of damage or error in the drop box system, the whole laundry processes will be delayed. In case of off day/time of the contracted courier company, customers will not be served.

FIG. 7. LOCALLY COLLECTION/DELIVERY OF LAUNDRY

FIG. 8. REMOTELY COLLECTION/DELIVERY OF LAUNDRY

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6. CONCLUSION

In this paper, a B2B solution based on RFID enabled shared drop box has been proposed for re-engineering of the laundry process of collecting soiled laundry and returning cleaned laundry. It provides efficient and easy laundry services to an extended area. The picking and dropping services are outsourced, that benefit both the laundry company and the courier company. The re-engineered laundry processes are fast and economically efficient as compared to the existing systems. The model consists of shared drop box for numerous laundry companies, where customers have an open option to select any laundry company for processing their soiled laundry. Along with company selection, customers can select preferred laundry company along with the location where to be dropped via Courier Company. The location of each drop box is predefined in laundry company systems. Several additional enhancements will improve customer and industry economic savings, speed up the laundry process, increase customer satisfaction and decrease labor work.

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