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IMPROVED BACK-OF-THE-HOUSE PROCESSES WITH RFID ENABLED IT MODEL FOR HOSPITALITY INDUSTRY IN SINGAPORE

by

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ABSTRACT

Improved Back-of-the-house Processes with

RFID Enabled IT Model for

Hospitality Industry in Singapore

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This is a research paper exploring the ability of Radio Frequency Identification (RFID) technology to cope with challenges of back-of-the-house of the hospitality industry in Singapore. Focused on supply chain, food safety and security, the paper reviewed the three integrated service support processes of back-of-the-house that drove the service delivery processes of front-of-the-house in meeting the critical reliability dimension of SERVQUAL model. The RFID mobile technology's advantages were studied in mitigating risks and meeting compliances within the three back-of-the-house areas. The RFID was further examined as a viable IT solution based on the potential impacts associated with cost-of-not-doing and the improved ROI over cost-of-doing. Constructed by using service blueprinting technique, the RFID enabled IT model was proposed for real-time tracking and interfacing with systems and processes. The advantages of the model were illustrated to improve efficiency and enhance capability of back-of-the-house processes. Explaining the limitations of the model, the paper also recommended the five-step approach of RFID implementation and future research on lifecycle tracking benefits.

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The idea of exploring RFID's applications in the hospitality industry was started in August 2009. Mentored by Dr. Brewer, the green project I researched for IT module expanded the possibility of implementing RFID in various areas of hospitality industry. From conceptualizing the idea for professional paper topic to constructing the literature review outline, I am grateful that my chair, Dr. Brewer had provided valuable advices and comments in guiding me through the professional paper writing. In the learning of APA format for professional paper writing, I sincerely thank Dr. Sammons for her tireless review of my drafts and valuable feedback. My appreciations are also extended to Dr. Andy, Jennifer and my fellow course mates for the helpful supports.

PART ONE

Introduction

As the world's number two financial hub and leading international aviation hub, visitor arrivals to Singapore reached 9.7 million in 2009 during the economic crisis ("MediaCorp", 2008; "Singapore Tourism Board", 2010; Wilson, 2009). Driven by the US$60 million Building On Opportunities to Strengthen Tourism (BOOST) campaign, the Singapore Tourism Board (STB) had raised the country's tourism in 2009 by targeting both leisure travelers, as well as business and MICE visitors ("Breaking Travel News", 2009a). With the recovering of the global economy, the STB is expecting to see an increase in the number of business travelers to Singapore in 2010 (Wong, 2010). However, expanding hospitality businesses in Singapore will have to cope with the surge of room amenities and many consumable goods, including perishable goods like food and beverage (F&B). Most of these goods are imported from all over the world. Global events such as health scares like the Swine Flu (H1N1) pandemic and Avian Flu, had a significant impact on Singapore tourism ("Breaking Travel News", 2009b). The issues of global terrorism and global warming also posed risk to the security and goods supply within the hospitality industry. Radio frequency identification (RFID) technology that allows the authentication and location tracking control should improve the security and supply chain management (SCM) aspects of a hospitality operator.

According to RFID Journal, RFID is the method of identifying unique items using radio waves (2010). Typically, a reader or interrogator communicates with a tag or transponder, which holds digital information in a microchip. There are chipless forms of RFID tags that use material to reflect back a portion of the radio waves beamed at them. RFID tags can be active, passive or semi-passive. Active tag has a transmitter to send back information to a reader using a battery or

gathering energy from other sources. For passive tag, the microchip in the tag is powered by using the chip's antenna to convert the radio waves from the reader into electricity, and reflecting back a signal from the reader. Semi-passive tag or battery-assisted tag uses the battery to run the microchip's circuitry and not to broadcast a signal to the reader. Developments in open standard technologies had found new opportunities for RFID applications (Muta, 2006). Furthermore, the Real-Time Locating System (RTLS) achieved by the second generation active RFID and the Ubiquitous Sensor Network (USN) where the tag doubled as a reader in the third generation active RFID would unleash limitless potential of the future mesh network ("IDTechEx", 2008).

As a technology adopted by Wal-Mart to manage its large scale supply chains since 2003, Wal-Mart has detailed its RFID requirements for compliance by its top suppliers, and has been actively pursuing ways in which to use the technology to improve its operations. David Grooms, CIO of McDonald's Corporation also indicated that RFID was included as ways to better mange its supply chain, one of the largest in the world (Roberti, 2010a). In Singapore, a pilot project led by SPRING Singapore, a government body that establishes industry standards had helped the top 20 small and medium-sized businesses (SMB) suppliers of Singapore's largest supermarket chain NTUC Fairprice, in setting up inventory systems based on RFID technology. The automated and streamlined processes provided significant benefits in increasing productivity, reducing pilferage, and tracking expired goods (Tan, 2005).

Tapping on the tourism growth and contributing revenue of 40% by the F&B department, many hotels are hiring top-notch chefs and putting an upscale stamp on their menu offerings (Prior, 2002). In Singapore, more than 90% of all foods are imported. The food-borne diseases control and food safety are legislated by stringent laws to provide high standards of hygiene and food safety, and are governed by the National Environment Agency (NEA) of the Ministry of the

Environment and the Agri-Food and Veterinary Authority (AVA) of the Minister for National Development ("Food and Agriculture Organization", 2004). However, as volume of processed food imports increase, food safety breaches increased by 24% from 176 in 2007 to 219 in 2009 ("Allworld Exhibitions", 2010). Many F&B outlets have implemented quality management system and food safety management system to comply with legislations to avoid penalty and risk of their reputations.

Within hospitality industry, RFID would be a feasible solution for hotel operators to improve their SCM, where information technology (IT) application tracks the inventory movement of respective stores, particularly the receiving, storing, and issuing of amenities including F&B items. From both finance and housekeeping perspectives, RFID will mean better fixed asset tracking for capital expense (CAPEX) items and linens as well. Additionally, RFID could improve the food safety management system, where IT application tracks the cold chain management of F&B items and First-In-First-Out (FIFO) protocol to enhance the compliance to hygiene standard like Hazard Analysis and Critical Control Points (HACCP). RFID technologies could also connect with security department's IT application to enforce authorized personnel and controlled access to high value stores, including owner's arts and vintage wines collection, expensive liquor store and general cashier room to protect the valuable goods and cash floats.

Purpose

The purpose of this professional paper is to explore RFID technology's ability to help Singapore's hospitality industry cope with back-of-the-house processes. This study will focus on supply chain management, the risks of goods' supply and storage, food safety, and security and how these issues might be mitigated by leveraging the technology advantages of RFID while

helping with compliance with various internal control policies and external legislation requirements.

Justification

To expand along with the economy and tourism growth in Singapore, the hospitality industry has to cope with the rising challenges of supply chain management to mitigate the risk of continued supply, food safety and security. An accurate end-to-end tracking and identification technology that provides the exact supply status and goods' condition will be crucial to keep the processes in control. While RFID had been commercially available for decades, it was generally adopted by manufacturers and retailers for managing their supply chains. In the recent years, the contactless identification and traceability features of RFID had been driving the implementation of RFID applications by various hospitality operators for many front-of-the-house processes, primarily guest services such as contactless door-locking key card, cashless payment, and easy access of full facilities (Muta, 2006; O'Connor, 2009; Swedberg, 2008). However, the overall guest's satisfaction of the service relies on the seamless delivery of the end-to-end process. Many of the back-of-the-house processes play an important role in completing a delighted guest experience, such as the supply chain management process, food safety management process, and security management process.

Constraints

The paper will focus on the back-of-the-house processes, including the SCM process such as purchasing, receiving, storing and issuing of goods, food safety management processes such as cold chain delivery and storage status, and security management processes such as authorized personnel and access control to restricted areas. Front-of-the-house processes and guest services such as contactless room keycard and cashless payments will not be covered.

PART TWO

Literature Review

Introduction

The hospitality industry had broadly adopted information technology (IT) to enhance operational efficiency, reduce costs, and most importantly to improve customer experience and service quality (Law, Leung, & Buhalis, 2009). From IT software solutions such as Property Management System (PMS), Customer Relationship Management (CRM) system and SCM system, to IT hardware solutions such as Automatic Identification (Auto-ID) control system, High Speed Internet Access (HSIA) system and in-room entertainment system, IT continuously innovates the service delivery while enhancing the service quality. In the following literature review, reliability will be firstly established as the most important SERVQUAL dimension for connecting back-of-the-house processes to service delivery processes of front-of-the-house to satisfy and retain guests. Based on hospitality researches, IT will be examined as an enabler to meet the reliability dimension of SERVQUAL model in hospitality industry. Subsequently, focusing on the three major areas of back-of-the-house processes and compliance, the mobile technology's advantages of RFID will be studied for seamless service delivery of the end-to-end process in achieving overall guest's satisfaction. Next, weighing on the cost of doing and the cost of not doing, RFID will be examined as a viable IT solution to mitigate the risks associated with the three major areas of back-of-the-house processes while helping with compliance with various internal control policies and external legislation requirements.

IT as An Enabler to Meet Reliability Dimension of SERVQUAL Model

Service quality was one of the key factors in achieving competitive advantages in the service-based hospitality industry since high service quality presumably resulted in increased

customer satisfaction, and thus increased future patronage (Madanoglu, 2004). This has driven the hospitality operators to spend a tremendous effort in improving and measuring the service quality of their businesses.

SERVQUAL and reliability

In Parasuraman, Zeithaml, and Berry's (1988) initial work on the development of a 22-item instrument for assessing customer perceptions of service quality in service and retailing organizations, the SERVQUAL's five dimensions were defined as follows:

1. Tangibles were the physical facilities, equipment, and appearance of personnel;
2. Reliability was the ability to perform the promised service dependably and accurately;
3. Responsiveness was the willingness to help customers and provide prompt service;
4. Assurance was the knowledge and courtesy of employees and their ability to inspire trust and confidence; and
5. Empathy was the caring, individualized attention the firm provides its customers.

The study also found that reliability was consistently the most critical dimension in predicting overall quality. Although the importance of the original five SERVQUAL dimensions seemed to differ across industries or study contexts, reliability seemed to be among the key dimensions in determining customers' service quality perceptions of hotels (Mount & Mattila, 2009).

Hospitality processes are often categorized by front-of-the-house service delivery and back-of-the-house service support. Service delivery processes performed by front-of-the-house are those that deal with the guests directly. Service support processes managed by back-of-the-house refer to support processes behind the scenes but form a crucial part of the business to ensure everything operates effectively. Typically, front-of-the-house handles service encounters with guests such as arrival, check-in, in-room service, recreation and dining services, check-out,

and departure. In the sequence of front-of-the-house service encounters, the enhanced first encounter experiences such the First Ten program developed by Marriott which streamlined check-in had not only improved operational efficiency, but also boosted customer satisfaction (Knight & Amsler, 1998). Further, Hansen and Danaher (1999) showed that the beginning of the encounter might not be as important as previously thought and a buildup to a strong ending resulted in higher perceived service quality. In the pursuit for higher level of guest's overall satisfaction, luxury hotels such as Ritz-Carlton adopted both the first and last encounter as the most important service encounters of guest experience (Zeithaml, Bitner, & Gremler, 2009).

While hospitality operators may choose to focus on some encounters to achieve better results of customer satisfaction, Zeithaml, Parasurama and Berry (1990) found that the most important thing a service company could do was be reliable (p.31). In the study of customers' expectations of service providers, reliability was also concluded as the most important dimension to customers (Berry, Parasuraman, Zeithaml, & Adsit, 1994). Getty and Getty (2003) further defined reliability as performing the service right the first time. It basically demands the front-of-the-house staff to deliver services correctly and consistently. Drawn from the pioneer works, Zeithaml et al. (2009) found that the service blueprinting was a useful technique for designing and specifying intangible service processes. By simultaneously illustrating the evidence of service from the guest's perspective, the service contact points with the guest, and the service delivering process, the reliability dimension for front-of-the-house service delivery processes can be specified as an important component of the service standards.

In lodging adaptations of the SERVQUAL instrument, reliability was defined as providing a problem-free stay, generally deals with the tangible, product issues (Mount & Mattila, 2009). It includes check-in where correct room type is assigned with a working key

(card) to enter the room. While staying with the hotel, room's amenities are correctly in place and facility such as Heating, Ventilation and Air Conditioning (HVAC) systems and in-room entertainment system are fully functioning. And upon check-out, the itemized billing is accurate with correct amount charging to the guest. In the study of the reliability dimensions of the hotel's service quality model and its correlation to intent to return and overall satisfaction, Mount and Mattila (2009) reported a dramatic impact of a simple problem experience where the intent to return and overall satisfaction dropped 17% and 18% respectively. To achieve better result of overall guest satisfaction, hospitality operators are exploring various process improvements amid competitions including leveraging IT solutions to drive problem-free experience.

IT and integrated processes

Hospitality traditionally lagged other sectors in adopting IT but this had changed for the past years and IT applications were actively studied by the industry (Buick, 2003; O'Connor & Murphy, 2004). By helping to fulfill the guest's demands for accurate and timely information, the diffusion of IT in the hospitality and tourism industries had sped up recently (Connolly & Lee, 2006; Singh & Kasavana, 2005). This was clearly demonstrated by the widely adopted IT systems that helped managers to enhance control costs and operational efficiency while delivering quality service to their guests (Law et al., 2009). To improve front-of-the-house processes in hospitality industry, Inge (2002) addressed the following systems as required for general-purpose operational areas:

- Property Management System (PMS), for overall management of a property operation and it is the center of all IT systems. Its main functions cover check-in, check-out, charge posting, end-of-day, reservations, PBX operators, housekeeping, account receivable, and interfaces with other systems.

- Point of Sale (POS) system, for management of with a bar or restaurant operation. Its main functions cover order entry and settlement.
- Sales and Catering (S&C) system, for management of multiple function rooms and high volume group meeting or banquet/wedding operations. Its main functions cover group sales and function rooms.

Apart from the above, there are also many sub-systems that administer functions such as electronic door locks for the guestrooms, voice mail, telephone charging and call accounting, in-room entertainment, minibars, and recreation bookings for spa/tennis/golf.

For back-of-the-house processes, the systems required for general-purpose operational areas included accounting system, which covers main functions of general ledger, account payable, payroll, and fixed asset accounting, as well as SCM system, which covers main functions of inventory and purchasing (Inge, 2002). Due to the competition and ever-changing macro environment, various IT solutions have been adopted to enhance the SCM system, Food Safety Management system, Customer Relationship Management (CRM) system, HVAC system, Security management system and High-Speed Internet Access (HSIA). In this study, the three focused areas of back-of-the-house processes are identified as follows:

- SCM processes such as purchasing, receiving, storing and issuing of goods, including guest amenities, F&B items, CAPEX items and linens;
- Food Safety Management processes such as cold chain delivery, FIFO protocol and storage status of F&B items; and
- Security management processes such as authorized personnel and access control to restricted areas including owner's arts and vintage wines collection, expensive liquor store and general cashier room.

In developing the conceptual framework that integrated the "pyramid model" with the quality-value-loyalty chain, Parasuraman and Grewal (2000) emphasized the growing importance of technology-company, technology-employee, and technology-customer linkages in delivering services to guests. In a restaurant context, Lee and Lambert (2008) tested this integrated framework empirically and demonstrated that perceived service quality evaluated by participants in the non-customized service lower than in the customized service through CRM technology for all five dimensions of service quality. Fundamentally a back-of-the-house marketing tool, Fitzgibbon and White (2005) defined CRM as a data-driven approach that enabled companies to assess each customer's current needs and potential profitability, and tailored sales offers and services accordingly. Through acquiring customer information, knowledge and insight about customers can be obtained by analyzing the database (Gordon, 2002; Winer, 2001).

When CRM is implemented for a hotel, the guests may be greeted by name at all service encounters such as check-in and in-room dining; their preferences such as preferred room and bed types and smoking preferences are recognized; and products and services that match their needs and wants are offered such as preferred newspaper and room amenities. The finding in Lee and Lambert's (2008) study also suggested that there would be a direct effect of service quality on customer loyalty as well as an indirect effect of service quality on customer loyalty through perceived value. By integrating front-of-the-house service delivery process with back-of-the-house marketing process, the ultimate goal of CRM was to develop long-term relationships with guests in order to retain existing guests (Fitzgibbon and White, 2005).

CRM is just one of the many IT solutions adopted in hospitality industry that integrate both front-of-the-house processes with back-of-the-house processes in service delivery where

accurate information are used to boost customer loyalty and satisfaction. IT is also able to deliver the promised service accurately and dependably for the three focused areas of back-of-the-house processes in the perspective of the reliability dimension. For SCM processes, IT solution will provide the much needed systematic coordination of all supply chain activities such as purchasing, receiving, storing and issuing of goods, to improve customer service and reduce inventory-related costs. Advances in IT might then enable firms to build partnerships and re-engineer business processes to speedily exchange funds, products and information, while optimizing supply chain operations by collaborative methods (Boyaci & Gallego, 2004). By enhancing demand planning and generating accurate order forecast, the data of Point of Sales (POS) could be used for determining the next competitive advantage in supply chain efficiency and demand planning (Gallucci & McCarthy, 2008). Also, the benefits in having POS data included minimizing bullwhip effect, providing customer insights and gaining cross-functional alignment.

For Food Safety Management processes, IT solution will enhance the food hazard control process and monitor the end-to-end cold chain delivery and storage status to prevent food safety problems. The control of the microbiological safety of food was fundamentally important and Food Safety Management systems had to be supported by objective scientific and technical information (Stringer, 2003). Based on the two major research areas, temperature and time of storage and cooking, and probability estimation using statistical tools and modeling, IT techniques could be applied to assess and reduce the food safety risk (Miles & Ross, 1999; Rodgers, 2005; Rybka-Rodgers, 2001). One of the examples is a computer software package, called Food MicroModel that aided in the prediction of the spoilage potential and microbiological safety of food products (Pegg, 1999). Researchers also found that the storage

and processing temperatures had a greater impact over the shelf-life and the retention of vitamin (Nyati, 2000; Rodgers, 2006; Uckiah, Goburdhun, & Ruggoo; 2009). More often food poisoning was traced to poor time/ temperature control, cross contamination or infected food handlers (Howard, 2004). By installing IT interfaces with the controller units of chillers and freezers, accurate real-time data of the storage time and temperature at each of the critical control points within Food Safety Management processes could be recorded and regulated. It also drives the compliance with food safety standards such as HACCP, and great advantages in terms of consumer safety, storage retrieval, data accuracy and costs (Hodges, 1996).

For Security management process, IT solution will enhance the access control process for entering the property and monitor the activities of authorized personnel within the restricted areas to protect the property asset and the safety of employees together with the guests. The technology-intensive approach to security was crucial in managing the impact of terrorism (Jain & Grosse, 2009). Drawing from the Olympic Games experience in 2004, the advance of information and communication technologies revolutionized the way security, reliability, and efficiency of administration action was assured in large-scale events (Papagiannopoulos, Xenikos, & Vouddas, 2009). Various hospitality operators had acknowledged the potential benefits of IT such as biometric technologies offered and implemented them in day-to-day operations, mainly in the areas of time and attendance, security, access control and asset protection (Jackson, 2009). By integrating the employee database and surveillance system with the access control system, accurate real-time data of the authorized personnel and the access of restricted areas could be recorded and tracked to maintain the high level of security within back-of-the-house of the property.

RFID as One Of The IT Solution

To expand along with the economy and tourism growth in Singapore, the hospitality industry has to cope with the rising challenges in the three focused areas of back-of-the house to mitigate the risk of continued supply, food safety and security. An accurate end-to-end tracking and identification technology will be crucial to keep these processes in control and meet the required compliance requirements.

Back-of-the-house compliances and RFID's advantages

As the hospitality industry improves the service quality, many cross-industry standards and compliances are also added to the SCM, Food Safety Management, and Security management systems. They may include ISO standards, HACCP standard, and OHSAS 18001 standard.

ISO standards cover various standards such as ISO 9000 the international quality management system standard, ISO 14000 the international environmental quality management system standard, ISO 22000 the international food safety management system standard, and ISO 28000 the international supply chain security management system standard. The early review showed that accredited hospitality organizations would likely gain operational benefits since ISO 9000 was based on formalizing and documenting operating processes, and an increasing number of hospitality companies would likely choose ISO accreditation (Nield & Kozak, 1999). The survey results conducted with 146 Singapore-based companies suggested that ISO 9000 certification improved overall financial performance (Chow-Chua, Goh, & Tan, 2003). More effective communication among employees, higher perceived quality of services or products, and better documentation procedures were also experienced in non-listed certified firms. The documented processes address the workflow and accountability which are important for SCM, Food Safety Management, and Security management systems.

Initiated within the World Health Organization, HACCP standard is established by the Codex Alimentarius. It demands to develop the effective Food Safety Management systems by applying a systematic approach to risk and hazard analysis. Within food supply chain, hazard analysis and critical control points (HACCP), good hygiene practice (GHP) and good manufacturing practice (GMP) were the main building blocks of the food safety management systems (Aruoma, 2006). To effectively apply HACCP principles to the catering sector for controlling the hazards and producing safe food, the approach should not be complicated, onerous and bureaucratic (Taylor & Zaida, 2004). Since HACCP implementation has been mainly legislation and customer driven, it is imperative to ensure a well-managed maintenance, verification and audit of HACCP standard for safeguarding Food Safety Management system.

OHSAS 18001 standard covers occupational health and safety management system, which enables organizations to improve performance and control risks in this area. Contributing positively to a healthier working environment and helping to reduce accidents, employee illness and lost time, OHSAS standard provides a systematic approach to identify hazards and control the risks of the hazards as part of the Security management system. Apart from the above external compliances, various internal control policies governing purchasing, inventory, accounting, F&B preparation, security functions also detail the role and responsibility of the personnel, the standard operating procedures, and the communication and escalation paths.

As the businesses expand in the hospitality industry of Singapore, the sheer volume of administrative works for recording, tracking and validating the information will push for higher manpower needs and data accuracy issues. The surge of guest amenities and many consumable and perishable goods will also increase the loads at various points of supply chain, including the loading bay and storage facility. The forecasting and delivery of the goods will be significantly

affected by global events such as Flu pandemic and natural disasters. These constraints will pose higher risk to the food safety as well. The issues of pilferage, security breach and global terrorism will continue to challenge the safety of property, employee and guests. These challenges in terms of capacity of labor, facility and equipment will affect the reliability dimension of service quality in delivering services to the guests. Hospitality operators have since invested into various IT solutions to mitigate the risks. One of the solutions is RFID, which has been massively adopted by various industries for real-world wireless applications such as SCM, security and privacy systems, asset tracking systems, library management systems, healthcare and commercial applications, industrial tracking systems and geographic surface location identification (Reaz, Uddin, Hussain, Nordin, Ibrahimy, & Mohd-Yasin, 2009; Roberts, 2006).

The following are examples of RFID applications in daily activities in the areas of SCM, food safety and security (Bayraktar, Yilmaz, & Yamak, 2010; Srivastava, 2007; Swedberg, 2010a):

- At Metro Group, Germany, dockdoor RFID technology were rolled out to equip all the Metro Cash and Carry Grossmarkets product-incoming entrances with RFID systems to track the product shipments.
- At Marks and Spencer, the number of items tagged by the retailer had reached 49 million. Bluetooth retail handheld devices from an RFID systems integrator were used by staff in the retail stores to scan garments in a weekly stock check, and RFID scanners were used to read 61% of the pallets that moved through its food distribution centers.
- At Princeton Baptist Medical Center, RFID-enabled hand-washing stations were used to track usage and also provide display messages to educate or entertain staff members while sanitizing their hands.

- At Klinikum Saarbr¨ucken, Germany, patients were equipped with tagged wristbands to monitor their condition and adjust dosages of their medication. For healthcare service providers, by integrating RFID into all areas of the internal patient supply chain, timely information on patients, processes, and equipment could be provided to save time and reduce costs while simultaneously improving quality and patient safety (Revere, Black, & Zalila, 2010).
- At the U.S. military and aerospace industry, the use of RFID technology by a market that was expected to reach $2 billion by 2011 would be in maintenance and repair applications.
- At Snagg, RFID chips no bigger than a grain of rice were created to protect valuable instruments.
- At the Vatican library, RFID tags were used to secure their books.
- At Texas Instruments, together with an Austrian company, hands-free RFID access systems were deployed for ski lifts to enable more efficient customer processing at the gates and also track skiers for security reasons.
- At Legoland in Denmark, RFID-enabled wristbands were offered to parents to monitor their children.
- At Rikko Primary School in Tokyo, Japan, RFID was used to secure the comings and goings of their students in real time.
- At the Spring Independent School District, Houston, TX, 28,000 students were equipped with ID badges containing RFID chips that were read when the students got on and off school buses.

RFID placed technology in the context of collaborative relationships among supply chain partners to achieve a high level of mass customization at the lowest cost possible for the entire supply chain (Bayraktar et al., 2010). Major retailers such as Target and Wal-Mart in the United States, and Metro in Germany, along with other institutions such as the U.S. Department of Defense and Boeing, adopted RFID for its advantages in terms of identification, traceability and localization of tagged items. In providing benefits for the company in its internal operations, RFID's greatest contribution was to improve materials and information flows within the end-to-end supply chain (Spekman & Sweeney, 2006). In the research of evaluating a cheap and reliable technology to locate objects or humans within indoor environments, comparing with various technologies such as Wi-Fi, Bluetooth, IrDA and ultrasound, a passive RFID-based indoor location system was tested to be a viable solution with improved accuracy and precision of the system technology performance (Tesoriero, Tebar, Gallud, Lozano, & Penichet, 2010). Furthermore, capability of RFID for indoor localization was useful to guide people who were unfamiliar with a facility and to locate objects or people that attention was urgently required (Pradhan, Ergen, & Akinci, 2009). New active RFID system could capture the ID numbers of more than 10,000 tags in benign circumstances, or more than 1,000 tags per second each small enough to be attached to a jewelry ring, from a distance of 20 feet to hundreds of feet, in densely packed, highly metallic environments with a great deal of background RF noise (Swedberg, 2010b). It can determine a tag's location, and provide information regarding the tag's movement and any activity around it.

Based on RFID-enabled mobile devices, a complete farm management system could accurately identify livestock (Voulodimos, Patrikakis, Sideridis, Ntafis, & Xylouri, 2010). RFID can be used to enforce legislation for identifying and tracking the F&B products from potentially

diseased or contaminated live stocks. In Québec, Canada, the government agency adopted stringent RFID livestock traceability requirements to RFID-tag calves within the first week of birth, and the tags could only be detached at the slaughterhouse, thus guaranteed the birth-to-death traceability (Wasserman, 2010). Long-term tagging of citrus and other woody plant species also worked well with no significant effect on plant health and growth (Bowman, 2010). The implementation of RFID at the food source allows accurate tracing of the food supply and responsive actions against the tainted supply. In terms of cold chain management, temperature control and monitoring are vital mechanisms to maintain food safety and quality. RFID enabled the advancement of Multi-Temperature Joint Distribution (MTJD) system that provided a new scheme for continuously temperature-controlled logistics, which could jointly deliver and store multi-temperature goods (Kuo & Chen, 2010).

Based on the studies on RFID and its mobile technology's advantages, a RFID-enabled IT resolution will drive for a reliable and efficient back-of-the-house. By tagging all incoming goods and existing fixed assets, correct goods can be received dependably and the disruption caused to operations due to scheduled inventory count can be potentially minimized. The discrepancies or displaced items can be accurately and quickly identified for immediate investigative actions. By tagging the perishable goods for the end-to-end cold chain, the food safety compliance in terms of temperature-controlled storage and FIFO expiry status can be accurately tracked from external suppliers to in-house chillers and freezers. Non-conformance can be monitored in real-time for incorrect storage condition of F&B items and expiring items not being consumed by FIFO. By tagging the ID cards for all employees and back-of-the-house visitors, the security control can be tightened for the access to the entrances of back-of-the-house as well as restricted areas. Alarm can be triggered to alert on unauthorized access attempt and

suspicious movement of goods or assets. The integrated IT solutions leveraging RFID's mobile technology's advantages are capable of connecting various back-of-the-house systems and processes to identify, trace, and locate all objects and peoples in real-time.

Cost of doing and cost of not doing

While IT could improve organizational efficiency within hospitality industry, there were major barriers to implement new technology, including the lack of strategy within management, lack of information sources, and cost of adoption (Cobanoglu, Demirer, Kepeci, & Sipahioglu, 2006; Oronsky & Chathoth, 2007). In terms of RFID implementation, the cost of doing covers the costs of tags, readers, software application and data integration. In 2005, the Singapore's SMB RFID-upgraded inventory system project stated the cost of RFID equipment such as tag readers and gantries at US$48,136, and back-end inventory systems at US$54,153, summing up to US$100K for each SMB participated (Tan, 2005). Recognizing the budget constraints of SMBs, 50% of the cost of setting up their RFID infrastructures was subsidized by government's Domestic Sector Productivity Fund. Presently, equipment costs ranged in US$1,000–US$2,500 for readers and US$0.07–US$1.00 for tags in implementing passive RFID program (Bayraktar et al., 2010). A starter kit of new active RFID system that comprised of 100 tags, 10 reader modules, 3 hubs and standard software would be sold for less than $10,000 (Swedberg, 2010b). Additional tags and reader modules would be sold for under $30 a piece in small volume, and additional hubs for less than $350, also at small volume. Based on the tested coverage of 400-square-foot space using a single hub with two or more USB connected reader modules, 1,200-square-foot space could be covered by the starter kit.

According to the latest IDTechEx's report, the value of the entire RFID market was forecasted to be $5.63 billion in 2010, up 12% from $5.03 billion in 2009, and 2.31 billion tags

to be sold in 2010 versus 1.98 billion in 2009 (Das & Harrop, 2010). The report also saw a rapid growth in retail apparel tagging, transit tickets, and animals tagging such as pigs, sheep and pets as a legal requirement in many territories such as China and Australasia. Most of that growth was from passive UHF RFID labels. The trend of increased adoption of RFID technology, coupling with revolutionary breakthrough in RFID chip manufacturing technology, had brought down the unit cost of RFID tags. The passive tags were priced from US$1.15 in over 100,000 units shipment back in 2001 to reach as low as US$0.05 in sufficient large quantities (Moscatiello, 2003). The ubiquitous RFID sensor systems and Real-Time Location Systems (RTLS) also continuously drove the demand for active tags, which were priced from US$19 in 100 units to US$6.50 in high volume market (Harrop & Das, 2010; “RFID Infotek”, 2010; “VertMarkets”, 2009). When constructing a business proposal for RFID implementation, the tag-to-system ratio could be used for calculating ROI and future system costs. The tag-to-system ratio varied in terms of the scale of RFID implementation, ranging from 10% for 250 tags to 70% for 6 million tags (Moscatiello, 2003). As the decreasing trend of tag cost drives a lower cost of ownership and faster ROI, the advancement of RFID technology will promote the widespread of RFID adoption. In fact, in addressing the up-front cost concerns, as well as internal infrastructure issues, a software-as-a-service (SaaS) model allowed pay-as-you-go solution at dramatically lower cost would require little or no software installation (Caudill, 2010).

Virtually all companies had reusable assets they could track with tags that cost more than US$0.05 each and still could get an ROI (Roberti, 2004). Potential and existing RFID users need to be educated not to scrutinize on the cost of an RFID tag alone, but also the value created by it. If there is no value offered, a tag will still be too expensive even at US$0.01. The fact is that RFID's potential value differs in various applications across industries and companies. It could

be a lifesaver at any cost in some cases and could be useless even if it was free in others (Carrender, 2009). Within hospitality industry, the cost of not doing covers costs of inventory carrying, cost of incompliance in food safety, cost of security breach, and cost of service recovery. It causes negative impact to the revenue as well as the bottom line when back-of-the-house processes do not provide the required control and support in delivering reliable service quality for front-of-the-house. The inventory carrying costs included the opportunity cost of money tied up in inventory, the cost of pilferage, cost of deterioration of perishable items, cost of inventory insurance, handling costs, and the cost of maintaining and financing storage space (Guilding, 2002, p. 185). Several studies found that the degree of loss due to pilferage could be as high as 9% of cost of sales (Baker, 1998). Based on the US Food and Drug administration report, spoilage within the supply chain caused as high as 20% disposal of foods ("IDTechEx", 2005). Without RFID, lower visibility and accuracy of supply chain can be expected and inefficiencies of supply chain will include poor inventory forecasting, longer workflow, excess inventory, and human errors. This will result in higher inventory carry costs, labor cost and write-downs on expired perishable goods, and the loss of sales due to out-of-stock.

In the perspective of the cost of incompliance for food safety, the National Environment Agency (NEA) adopted a Points Demerit System (PDS) for Singapore restaurants to comply with the food safety legislation, where getting 12 demerit points within 12 months would lead to a suspension of license for two weeks (Tay, 2010). The suspended restaurants will suffer loss of revenue and reputational risk. In the perspective of the cost of security breach, the safety of the property, employees, and guests could be compromised, where losses of valuables and lives were possible due to theft, sabotage and terrorist attack (Aronson, 2006; Clausing, 2008). The damage to the business can be critical considering the impacts of a combination of issues of SCM, food

safety and security, and the cost of service recovery due to delinquency caused by back-of-the-house processes.

By widening RFID spectrum to interoperate with the U.S. and European systems in 2004, Singapore had been seeking a leading RFID role by investing millions of dollars on research and training to create a RFID ecosystem (Chan, 2004; Shameen, 2004). In February 2008, the RFID Innovation Platform Fund made its debut to further spur RFID adoption in Singapore. The S$4.5 million fund, administered by National RFID Centre (NRC), was set up to co-fund innovative RFID adoption projects for a period of five years (Lim, 2009). With 11 innovative RFID projects awarded under the Fund to date, the hospitality operators might consider to initiate a funded project in enabling a more reliable back-of-the-house. Comparing the cost of doing to the cost of not doing, the uncompromised hospitality services in terms of food safety and security clearly point to harnessing RFID technology in these areas. The potential value of RFID tags in hospitality industry lies in its technology's advantage to provide accurate visibility of remotely tagged objects and human in real-time. Furthermore, the decreasing trend of tag cost will continue lowering the cost of ownership while improving the ROI.

Conclusion to Literature Review

Based on extensive literature reviews, the viability of RFID-based IT solution were studied for the three focused areas of back-of-the-house processes. The risks could be effectively mitigated by leveraging the mobile technology's advantages of RFID in terms of contactless identification, remote traceability and indoor localization for back-of-the-house processes. Various internal control policies and external legislation requirements associated with the processes could also be accurately and dependably supported by RFID to achieve the required compliances. Finally, considering the cost of not doing in terms of the impact towards delivering

reliable hospitality's service quality, the cost of doing is justifiable with the improved ROI of cheaper tag cost. To meet the reliability dimension of SERVQUAL model in hospitality industry, RFID has been shown to be a viable IT enabler solution. In the Part Three, a RFID enabled IT model will be discussed and analyzed for the three focused areas of back-of-the-house processes.

PART THREE

Introduction

Leveraging the mobile technology's advantages of RFID in terms of contactless identification, remote traceability and indoor localization, a RFID enabled IT model will be proposed for real-time tracking at three focused areas of back-of-the-house processes. The model will be constructed by using service blueprinting technique to connect the RFID interfaces with various IT systems, and the processes of back-of-the-house and front-of-the-house. The advantages, limitations and interfaces of the proposed model will be presented. The conclusion will be drawn on the viability of the RFID enabled IT model for hospitality industry in Singapore.

Proposed RFID Enabled IT Model

By simultaneously illustrating the evidence of service from the guest's perspective, the service contact points with the guest, and the service delivering process in the service blueprinting, the reliability dimension for the service delivery processes of front-of-the-house and the required service support processes of back-of-the-house can be specified as part of the service standards (Zeithaml, Bitner, & Gremler, 2009). In Appendix A, the support processes of are extended to include the IT systems and processes of three focused areas of back-of-the-house processes. The three separated silos of the three IT systems and processes of back-of-the-house processes are interfaced via RFID enabled network where RFID readers and tags are linked and managed in real-time on a secure open-platform system. The secure open-platform RFID system had been adopted by VingCard Elsafe, a leading hospitality security provider and it was compatible with the three leading RFID ISO standards (ISO 14443A/MiFare, ISO 14443B, ISO 15693) as well as the new NFC transaction platform for cell phones (Aramayo, 2010).

Driving from the top of four major service encounters with the guest, the data of reservation, check-in, staying and check-out will be passed through the centralized IT core system such as PMS to interface with the sub systems of back-of-the-house, including SCM system, Food Safety Management system and Security Management system. While most of these back-of-the-house processes can be supported by separated IT systems, they are usually not interfaced or loosely connected through manual data exporting and importing that does not happen in real-time.

Advantages at individual level

By building a RFID enabled network, valuable data can be captured in real-time and tracked by the respective management systems for any corrective actions. The advantages of the proposed model will include the improved process efficiency at individual level and the enhanced process capability at interfaced level.

At individual level, the RFID enabled SCM system will improve the inventory visibility and accuracy. The movement of all RFID tagged items will be tracked in real-time at various locations including receiving and loading bay, general and operating equipment stores, back-of-the-house office areas, as well as F&B chillers and freezers. The real-time tracking will ease the load of manual checking and receiving goods for each purchase order and supplier's invoice at loading bay, especially for huge volume delivery of the same items. It will ensure the items are received and stored at the correct location. It will shorten the downtime required for performing routine inventory cycle counting activity on general, F&B, linen and operating equipment items. It will also minimize the impact to the service operation of housekeeping linen and F&B stewarding departments during the period of counting. Furthermore, the finance department will

have better fixed asset management of CAPEX items located at different areas across the property.

The RFID enabled Food Safety Management system will enforce the food safety compliance of hygiene standard such as HACCP, and maintain the F&B quality across the cold chain. The location and storage condition of F&B items will be tracked in real-time to feedback on possible non-conformance of hygiene standard and deterioration of storage condition based on programmed policy. The real-time tracking will monitor the temperature sensitive and perishable F&B items at various control points of cold chain including supplier's delivery trucks. It will capture the non-conformance immediately when a particular item is held at loading bay for longer than maximum allowable time or the ambient temperature is higher than the required storage temperature of hygiene standard. It will also implement the First-In-First-Out (FIFO) protocol automatically to ensure the perishable item taken out of the location has the earliest expiry date. Furthermore, it will ensure the temperature sensitive item such as raw meats, diary products, wines and liquors are received and stored at the correct location such as freezer, chiller, and wine cellar respectively to prevent cross contamination.

The RFID enabled Security Management system will enforce the security compliance of the property. The access to the property and restricted areas of back-of-the-house will be tracked in real-time to feedback on possible violation of security standard based on programmed policy. Assisted by the surveillance system, the real-time tracking will regulate the movement of personnel carrying the RFID tagged staff passes as well as the third-party contractors and suppliers within back-of-the-house areas carrying the RFID tagged temporary passes. It will manage authorized personnel access to high value stores, including owner's arts and vintage wines collection, expensive liquor store and general cashier room to protect the valuable goods

and cash floats. The attendance of employees and the presence of day-off employee will be monitored and reported immediately for security validation purpose. The monthly attendance report will be useful for human resources department to track headcount productivity, and automate the reconciliation of off-days, annual leaves and overtime hours for each employee. It will also clearly define the roaming area for the third-party contractors and suppliers performing maintenance works and delivery services.

Advantages at interfaced level

At the interface level, the three back-of-the-house management systems can share the data and communicate in real-time on the secure open platform to enable a higher level of process efficiency. The interfaces with other IT systems will also maximize the benefits of adopting RFID enabled network for the SCM system, Food Safety Management system and Security Management system.

Linking SCM system with Food Safety Management system, immediate actions can be taken to rectify and contain the hygiene and F&B quality issue when it occurs. The exact location and balance of stock of affected F&B items as well as incoming deliveries and supply sources can be identified and isolated quickly to minimize the impact of the issue reported. The availability of real-time data will also enable the F&B team to change the recipe quickly in delivering the F&B services uninterruptedly. By linking SCM system with Security Management system, all scheduled deliveries of goods and associated suppliers will be shown on the authorized list at security check in real-time. Security enforcement of third-party personnel can be tightened due to the added control that only the authorized suppliers on the list will be allowed to exchange for the RFID tagged temporary pass.

When Food Safety Management system and Security Management system are linked up, food safety and overall safety of the employees, guests and property can be managed on one common platform. The relationship data of the personnel access of F&B storage areas and the movement of F&B items will be established. When a staff contracted infectious virus, accurate trace of possible contamination of F&B items and associated personnel can be identified for more objective and effective actions. The combined policies of two management systems can also help to better achieve the property wide compliance such as OHSAS.

The highest level of process efficiency and control can be achieved when all three management systems are interfaced. Various severe impacts of food poisoning and food recalls can be managed concurrently at all three back-of-the-house areas as data is shared across the secure open-platform in real-time. For example, if there is a food poisoning case reported by a guest on a specified date, hygiene team can validate the movement, expiry and storage condition of the raw ingredient used in the guest's order at all cold chain's control points, while purchasing team can validate the supplier's source and batch code of affected items simultaneously with security team validating possible unauthorized access to the storage areas.

Furthermore, the interface of RFID enabled network primarily through SCM system with the central IT systems (PMS and POS) will allow real-time feeding of forecast and consumption data. It will improve the forecast accuracy at the item level to plan and control the foreseeable shortage or over-stock scenario. The synergy of the RFID enabled network will shorten the lead time for validating the issue and root cause within the three back-of-the-house areas, as well as source tracing to prevent recurring impact of the same issue. By programming the compliance policies into the respective management systems, control process can be further tightened in

back-of-the-house to drive higher level of reliability dimension of SERVQUAL in service delivery.

As the RFID enabled IT model drives process automation and improves process efficiency, the labor cost will be lowered at the three focused areas of back-of-the-house processes due to reducing workload in manually managing the systems and processes. The improved inventory visibility and forecast accuracy will minimize the pilferage of goods and wastage of perishable F&B items, which contributing to better bottom line in terms of cost control at item level. The tightened control of food safety and overall security will mitigate the relevant risks and comply with various internal control policies and external legislation requirements. It will also boost guest satisfaction and loyalty that drives long-term growth of revenue.

Limitations

The innovation and development of RFID technology over the past decades have been tremendous and leading by manufacturers and retailers. The complexities of RFID hardware and software have been amplified by solutions of different generations and various vendors on both open platform and proprietary design. Getting the best out of the multiple systems depended on the extent and ease of data exchanges across systems (Inge, 2002). To construct computer interfacing standards that would lower automation costs and accelerate the hospitality industry's technology usage, the Hospitality Industry Technology Integration Standards (HITIS) Advisory Committee reviewed the HITIS standards in 1999 and eXtensible Markup Language (XML) was unanimously endorsed for primary platform mapping standard (Cover, 2000). Leading PMS vendor, Micros Systems had since created Micros-Fidelio Exchange, a two-way interface using

XML-based technology for seamless inventory availability between central and property operations ("AllBusiness", 2001).

Over years of development, while leading RFID solution providers were adopting XML standard for RFID interface, RFID interface was usually vendor dependent (Gupta & Srivastava, 2004; Harrison, Moran, Brusey, & McFarlane, 2003; “Intermec”, 2007; “SAP”, 2004). IT implementations such as RFID can take many stages and across years for different operations and various areas within the property, covering both front-of-the-house and back-of-the-house. The tag's difference resulting from varying used-time of built-in battery and different manufacturer types has an impact to the RFID’s accuracy in indoor localization. While algorithm such as RFDiffFreeLoc could be used to increase the location precision drastically by minimizing the variation of tags, 100% might not be achievable depending on various noise conditions (Zhang, Chen, Ouyang, Hao, & Xiong, 2009). In the face of these challenges, the key to a successful multi-vendor RFID rollout was selecting compatible vendors, establishing a communication strategy, and creating clear troubleshooting procedures (Robkin, 2009).

Riding on diminishing cost and the huge potential for automation, the widespread adoption of RFID would have an inevitable increase in attacks and security problems as RFID entered into consumer markets (Sparkes, 2006). In terms of security feature of RFID, the cheaper passive RFID tags that draw power from the receiver have made them less secure. The data on passive RFID tags could possibly be hacked without the consent or knowledge of the owner (Gupta & Srivastava, 2004). Various researches had pointed out flaws in RFID security, including the vulnerability of an RFID authentication protocol conforming to EPC Class 1 Generation 2 Standards (Han & Kwon, 2009; Sparkes, 2006). The attacks included impersonating of a valid tag temporarily, forging a tag permanently, and making a valid tag

useless. Many of the methods previously proposed to prevent such attacks did not adequately protect privacy or reduce database loading. While a recent study found that a new authentication and encryption method that conforms to the EPC Class 1 Generation 2 standards could ensure RFID security between tags and readers, RFID systems would still susceptible to attacks as wireless transmission was used (Chen & Deng, 2009).

Conclusion

Projected to be among the world's fastest-growing countries with 13% to 15% GDP growth in 2010, eight months of uptrend had boosted Singapore's tourist arrivals to achieve one-million mark in July 2010 for first time in single month and driven the growth in the hospitality and tourism industries (Adam, 2010; Hong, 2010). To expand along with the fast tourism growth in Singapore, the hospitality industry has to cope with the rising challenges in the three focused areas of back-of-the house to mitigate the risk of continued supply, food safety and security. Based on the mobile technology's advantages of RFID in terms of contactless identification, remote traceability and indoor localization in real-time, the proposed RFID enabled IT model is a viable IT solution to keep these processes in control and meet the required compliance requirements. By reducing the manpower constraints for manual administration of back-of-the-house systems, the process automation improves data accuracy with real-time visibility across various control points of supply chain, food safety and security management systems.

Creating a common platform for the three back-of-the-house management systems, the RFID enabled network boosts the process efficiency at individual level as well as the process capability at interfaced level. By mitigating the risks in supply chain, food safety and security areas, the reliability dimension of service quality is further improved for front-of-the-house to deliver services correctly and consistently. Better result of overall guest satisfaction and loyalty

can be consequently achieved for long-term revenue growth. The proposed RFID enabled IT model can also contribute significantly to the bottom line by reducing asset and inventory losses, lowering labor cost, and improving forecast-consumption cycle.

A "Hospitality 2010" report found that RFID was increasingly becoming a component of the hospitality IT spending as the industry recognized the benefits of RFID, especially in the high value assets tracking such as liquor, linens and casino chips (Wasserman, 2007). As Singapore government continues to spur RFID adoption in private sectors, hospitality operators concerning the IT investment costs can tap on incentives such as the S$4.5 million RFID Innovation Platform Fund and the extensive RFID portfolio of the NRC expertise. Supporting by a decreasing trend of RFID tag cost, hospitality operators are now able to achieve higher ROI in adopting a RFID enabled IT model and gain a much needed competitive advantage in enticing global travelers.

Recommendations

Implementing the proposed RFID enabled IT model for the three focused back-of-the-house areas of hospitality industry in Singapore requires adaptation (see Appendix A). No matter the type or size of property, the fundamental elements of successful IT project management require top-down approach. Firstly, management commitment is crucial to achieve continuous process improvement through allocating staff and funding. The proposed model has demonstrated the competitive advantage hospitality operators stand to gain from the efficient and capable back-of-the-house processes in meeting the reliability dimension of service quality. Designated by the executive committee of the property, one of the IT personnel will lead a dedicated project team that comprises of cross-functional managers. The improvised process

policy will be instituted to provide the foundation for setting performance goals and integrating RFID enabled IT model into the property's culture and operations.

Secondly, performance assessment of existing back-of-the-house processes in terms of supply chain, food safety and security management systems will be conducted by the team to establish a baseline for evaluating future results of improvement efforts. Measurable performance may include cost of labor monthly by department, cost of inventory loss by storage area, number of purchase orders processed monthly by item type, number of non-conformance reported monthly by control point, number of security breach reported monthly by area, and other tangible benefits expected as a result of implementing the model. It helps to prioritize the area to focus on for improvements through analysis of the process trends and patterns. The technical audits and assessments will also assess the operating performance of respective IT management systems and available RFID solutions from the local vendor to determine improvement potential, particularly on the RFID interfaces of hardware and software. The team may tap on the expertise of NRC and the RFID Innovation Platform Fund as well.

Thirdly, goal setting is an important step to guide daily decision-making and served as the basis for measuring and tracking progress. Based on SMART methodology, a set of objectives that is specific, measureable, achievable, realistic and time-bound can be defined (Ambler, 2006). SMART. Aligning the goals with the available technologies and ROI will help to determine the potential and order of upgrades, and conduct technical assessments and audits. Depending on the size of property and budget constraint, priority may be set for the implementation in phases. A detailed action plan will be drafted to ensure a systematic process to implement the model and regularly updated to reflect shifting priorities, changes in performance, and recent achievements. The scale and scope of the action plan will also be defined to align with

the project's goals. Request for Proposal (RFP) will be developed to match the improvised back-of-the-house process flow with the required RFID applications, as well as the approved budget for minimal customization.

Next, implementation of action plan is critical for the success of the project. It starts with the RFID vendor selection and re-alignment of implementation schedule with the vendor. Internally, the success factors include creating an effective communication plan for key personnel in back-of-the-house, raising awareness at all levels of the property, building capacity of RFID knowledge, and training employees on improvised processes. Tracking and monitoring the project progress regularly will keep the schedule on track. Information collected from the formal review process and evaluation results can be analyzed to set new performance goals, identify best practices, and construct new action plans. By comparing the current performance to established goals, the project team will be able to find out what performed well and what did not for formulating the best practices.

Lastly, providing recognition to those who helped the property achieving the project's goals motivates employees and brings positive exposure to the RFID enabled IT model. This includes internal recognition giving to individuals and teams, and external recognition receiving from government agency such as NRC, and the media.

In this paper, the RFID enabled IT model focuses on the three back-of-the-house areas, including the supply chain, food safety and security management systems. With some categories of items such as uniforms and linens moving around various areas and being managed by different departments, RFID solution can be extended for full lifecycle tracking to close the gap of accountability. In the case of uniform, the real-time tracking control by SCM system will usually end when the item is issued over the housekeeping uniform counter and received by the

employee. The success story of a Buenos Aires luxury hotel in tagging every jacket, shirt, pair of pants and other article of clothing in its uniform inventory, had shown that the lifecycle tracking of the uniform helped to plan the replacement and ensure employees always working with perfect uniform grooming (Falkner, 2009). Future research may be extended to study the lifecycle tracking benefits of on-the-move items in housekeeping, engineering and other back-of-the-house areas.

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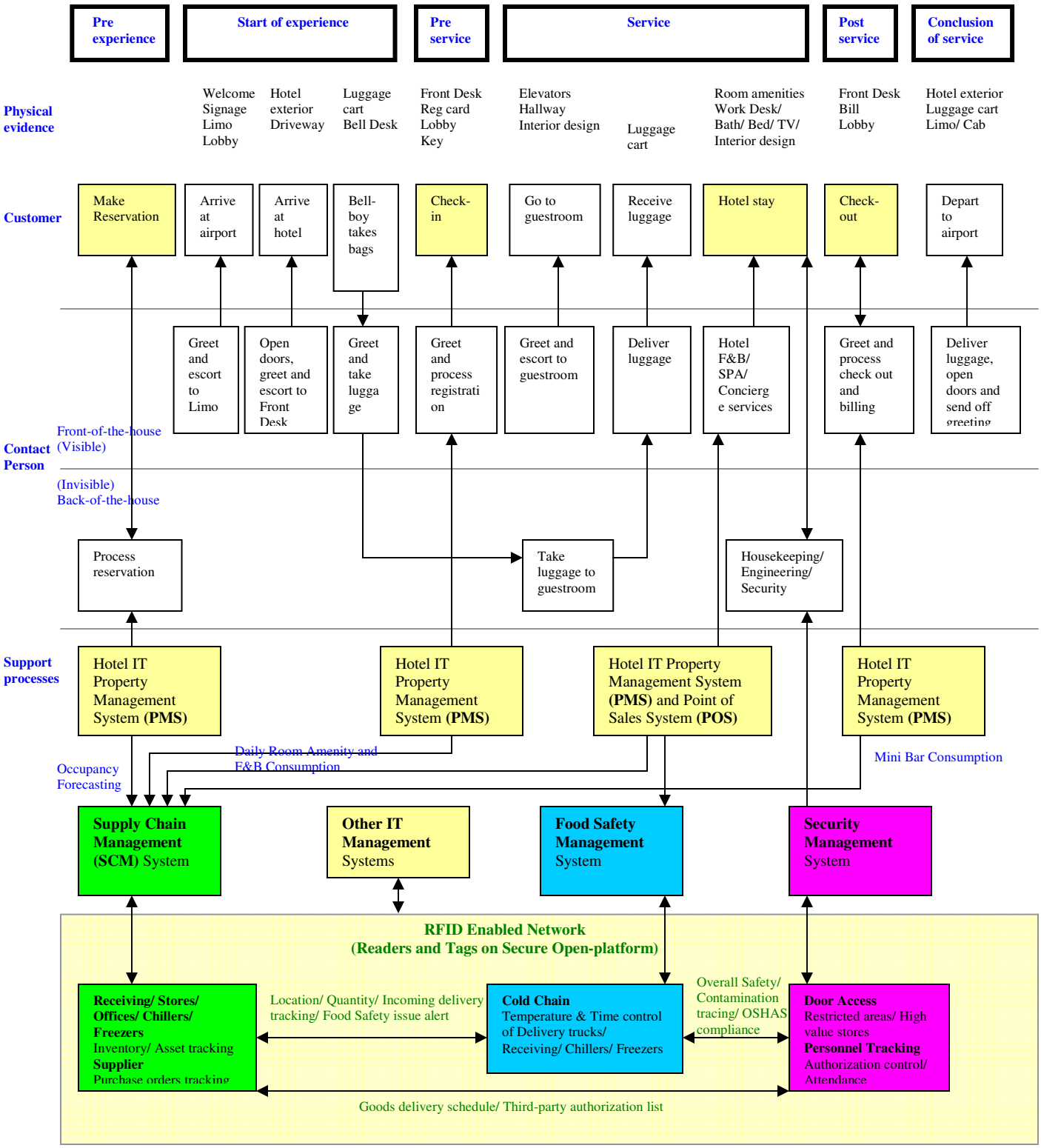
Appendix A

Proposed Model



Appendix B

Glossary

Term	Definition
Active Tag	An RFID tag that has a transmitter to send back information, rather than reflecting back a signal from the reader, as a passive tag does. Most active tags use a battery to transmit a signal to a reader. However, some tags can gather energy from other sources. Active tags can be read from 300 feet (100 meters) or more, but they're expensive (typically more than US$20 each). They're used for tracking expensive items over long ranges. For instance, the U.S. military uses active tags to track containers of supplies arriving in ports.
Asset Tracking	One of the most common applications for RFID. Placing RFID transponders on or in high-value assets and returnable transport containers enables companies to gather data on their location quickly and with little or no manual intervention. Tagging assets allows companies to increase asset utilization, identify the last known user of assets, automate maintenance routines and reduce lost items.
Authentication	The verification of the identity of a person, object or process. In RFID, the term is used in two ways. For contactless smart cards and other payments systems, the reader must make sure the transponder is a valid device within the system. That is, someone is not using an unauthorized device to commit fraud. There is also some talk of using Electronic Product Code (EPC) technology to authenticate products as a way of

	reducing counterfeiting.
Cold Chain	A temperature-controlled supply chain for perishable goods such as foods and pharmaceuticals, as well as for some chemical applications. In the cold chain, storage and distribution activities must maintain a given temperature range to prevent product spoilage. Specific temperature tolerances vary, depending on the actual items being shipped.
Passive Tag	An RFID tag without its own power source and transmitter. When radio waves from the reader reach the chip's antenna, the energy is converted by the antenna into electricity that can power up the microchip in the tag. The tag is able to send back information stored on the chip. Today, simple passive tags cost from U.S. 20 cents to several dollars, depending on the amount of memory on the tag, packaging and other features.
Reader	A device used to communicate with RFID tags. The reader has one or more antennas, which emit radio waves and receive signals back from the tag. The reader is also sometimes called an interrogator because it "interrogates" the tag.
Real-Time Locating System (RTLS)	A system of finding the position of assets, using active RFID tags. The tags broadcast a signal, which is received by three reader antennas. The time each signal is received is passed on to a software system that uses triangulation to calculate the location of the asset. RTLS is used to find containers in a distribution yard, and many automakers use it to track parts bins within a large factory.
RFID Tag	A microchip attached to an antenna that is packaged in a way that it can

	be applied to an object. The tag picks up signals from and sends signals to a reader. The tag contains a unique serial number, but may have other information, such as a customers' account number. Tags come in many forms, such smart labels that can have a barcode printed on it, or the tag can simply be mounted inside a carton or embedded in plastic. RFID tags can be active, passive or semi-passive. RFID tags are sometimes referred to as transponders.
Supply Chain Management (SCM) System	The process of planning, implementing and controlling the operations of the supply chain to efficiently satisfy customer requirements. Supply-chain management spans all movement and storage of raw materials, work-in-process inventory and finished goods, from the point of origin to the point of consumption.
Semi-passive Tag	Similar to active tags, but the battery is used to run the microchip's circuitry but not to broadcast a signal to the reader. Some semi-passive tags sleep until they are woken up by a signal from the reader, which conserves battery life. Semi-passive tags can cost a dollar or more. These tags are sometimes called battery-assisted tags.

Note. Source: RFID Journal. (2010). *Glossary of RFID terms: A - E.* Retrieved from http://www.rfidjournal.com/article/glossary/