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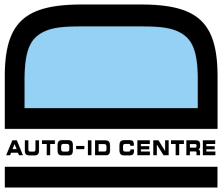

WHITE PAPER

The Impact of Auto-ID on Retail Shelf Replenishment Policies

Chien Yaw, WONG & Duncan McFarlane

AUTO-ID CENTRE INSTITUTE FOR MANUFACTURING, UNIVERSITY OF CAMBRIDGE, MILL LANE, CAMBRIDGE, CB2 1RX, UNITED KINGDOM

ABSTRACT

The final few metres of a retail supply chain may be the most critical. No matter how efficient the supply chain is before the retail store, inefficient backroom to shelf replenishments will lower the total supply chain performance. The motivation for this research came from realisation that there are possible future technologies that may be used in the retail environment to further enhance product sensing and information. Such technologies, namely Auto-ID technology, could potentially provide accurate and timely unique item level information to influence current shelf replenishment operations. This paper examines current replenishment policies and discusses the factors that may influence the effectiveness of these policies. We focus specifically on the timeliness of information, decision and operation and analysed the impact of Auto-ID technology on current and alternative policies.

WHITE PAPER

The Impact of Auto-ID on Retail Shelf Replenishment Policies

Biographies

Chien Yaw, WONG
PhD Candidate & Research Assistant

C. Y. Wong is reading for a PhD under Dr. Duncan McFarlane at Cambridge Auto-ID Centre, University of Cambridge. He completed his Bachelor of Arts and Masters in Manufacturing Engineering at Cambridge in 2001. During his Masters, he has worked on consulting projects with several organizations in the UK. He has also been involved in study tours on sustainability in Scandinavia, globalisation in China and e-manufacturing in Boston and San Francisco. While working with NetDecisions, he gained experience in the development of e-business solutions for one of the UK's leading media company. His research interest is on the application of Auto-ID technology in the retail supply chain.

Duncan McFarlane
Research Director Europe

Duncan McFarlane is a Senior Lecturer in Manufacturing Engineering in the Cambridge University Engineering Department. He has been involved in the design and operation of manufacturing and control systems for over fifteen years. He completed a Bachelor of Engineering degree at Melbourne University in 1984, a PhD in the control system design at Cambridge in 1988, and worked industrially with BHP Australia in engineering and research positions between 1980 and 1994. Dr McFarlane joined the Department of Engineering at Cambridge in 1995 where his work is focused in the areas of response and agility strategies for manufacturing businesses, distributed (holonic) factory automation and control, and integration of manufacturing information systems. He is particularly interested in the interface between production automation systems and manufacturing business processes.

WHITE PAPER

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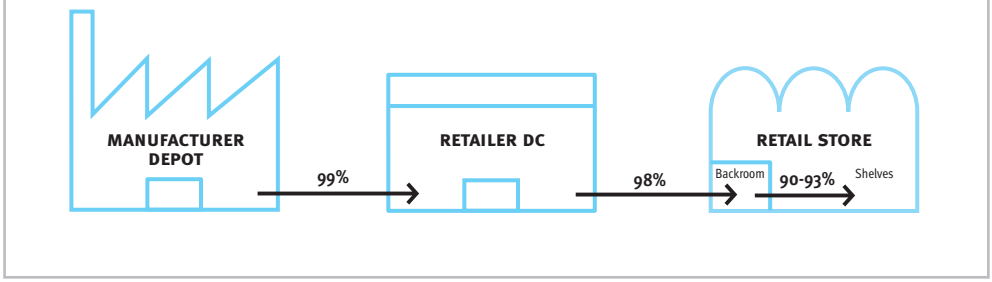
Contents

1. INTRODUCTION

The adoption of Auto-ID technology [1] in the retail industry seems imminent given the push by major retailers [2][3][4] and numerous field trials on-going [5][6][7] although admittedly the initial focus is on pallet and case level rather than item level tagging. The availability of Auto-ID technology provides accurate and timely unique item level information that are capable of influencing decisions and subsequently physical operations in supply chains [8][9]. This paper seeks to explore the impact of having such a technology at the very end of the supply chain – **the retail store**. The rationale for this research scope is motivated by both business and academic relevance.

Figure 1

SERVICE LEVEL ALONG THE SUPPLY CHAIN



In the real world, the final few metres of the supply chain may be most critical as no matter how efficient the backend of the supply chain is, inefficient shelf replenishment [1] will lower the total supply chain performance. A recent finding by ECR Europe [10] suggests that availability of products deteriorates along the supply chain from the manufacturer to the retailer in the manner shown in Figure 1. The survey indicates that the service level within the retail store is significantly lower than the stages before. A different survey by Accenture found that almost a third of off-sales [2] items could be found in the backroom of the retail store [11]. The focus of this research on **replenishment from backroom to the shelf** is therefore important in order to understand the cause behind such the problem.

In academic inventory control literature, retail supply chains are often examined from the echelons level [12][13][14] with the assumption that once the retail stores are replenished from the distribution centres, all the products will be automatically displayed on the retail shelves [15]. In other words, the occurrence of off-sales is treated to be the same as out-of-stocks. There are various studies on the impact of inventory accuracy [16][17][18] and delays [19][20][21] on supply chain performance and their approach is useful in examining the shelf replenishment process within the retail store. However, to limit the scope of this research, we will focus on the impact of various sources of delays on shelf replenishment policies. This was chosen with the realisation that even with an accurate inventory system, the **timeliness of information, decision and operation** will affect shelf replenishment performance.

There are growing trends in various innovative store replenishment such as Direct-To-Store [22] or One-Touch-Replenishment [23] [24] that replenishes directly onto the shelf and thereby reducing the role of the backroom. However, there are various reasons why backrooms may still be an integral part of retail stores. Theoretically, the backroom should be more space and cost effective than retail shelves.

In backrooms, products could be stacked higher than on the shelf space of retail shop floor, and the width of the aisles between storage compartments in the backroom are generally smaller than those between retail shelves. The backroom also forms an important buffer to cope with delivery uncertainties

[1] Shelf replenishment in this paper is defined as the process of restocking shelves by moving products from the backroom of the retail store. Store replenishment is therefore defined as the process of restocking the retail store from the warehouse, distribution centre, manufacturer or supplier.

[2] Out-of-stock is defined in this paper as temporarily unavailability of products in the retail store while off-sales is defined as temporarily unavailability of products on the retailer's shelves.

especially when the transportation lead time is long. Bulky and high velocity product lines may need a large shelf space allocation and hence it may not be economical to allocate all of these products on shelves. Backrooms are also used as buffers to cope with imperfect deliveries such as when the quantity delivered is higher than the maximum shelf space allocated.

In the next section, we will examine current shelf replenishment policies with the aim of identifying various factors that influences the effectiveness of these policies. Section 3 discusses the impact of having Auto-ID technologies in the retail store on current shelf replenishment. An alternative shelf replenishment policy will also be presented as a mean of exploiting full Auto-ID deployment within retail stores.

2. CURRENT SHELF REPLENISHMENT POLICIES

There are two main replenishment policies used in retail stores during the day and this depends on whether the first operation of the replenishment process (i.e. physical observation) starts from the shelf or the backroom. This is an important distinguishing factor as currently, simultaneous direct physical observations on both the shelf and the backroom are not possible. We differentiate between a "Pull" policy in which physical observation on product shelf level provide the basis for replenishment from the backroom to the shelf but in a "Push" policy, the physical observation is on the products in the backroom. Within these two main policies, there may be variations in the length of operation, frequency of operations, types of staffs involved, replenishment quantities and so on.

2.1. The "Pull" Policy

In this policy, products on shelves are directly observed by manual staffs and compared against the maximum allocated shelf space for each product types. Only product types that are below a certain threshold of quantity will be added to a picking list. With this picking list, the staff will determine the stock level of the product types in the backroom by actual physical observation in the backroom. Products that are available in the backroom will be placed in a cage, and will be rolled out to shelves for restocking. This way, products are "pulled" from the backroom from direct physical observations of products on the shelves.

More automated variation to this "Pull" policy arises from the use of barcode inventory system. When a product type is observed to be "low" in quantity, the product identifier (in barcode) will be scanned using a handheld barcode reader. At the same time, the quantity of product on the shelf will be manually recorded on the handheld reader and this information will be sent to the retail inventory system. Instead of physically counting the quantity of products in the backroom, inventory system will be used to estimate the quantity of products in the backroom by keeping track of deliveries into the store and the products registered at checkout counters (Point-of-sales or POS data). If any of these product types are estimated to be in the backroom, they will be included in the picking list for shelf replenishment.

Detailed UML Activity Diagrams [25] of the two versions of this policy are shown in Figure 2 and Figure 3.

The diagram in Figure 3 clearly illustrates how this version of the "Pull" policy relies heavily on inventory system. This inventory system provides an automated decision on whether or not to replenish the different product types on the shelf. However, any effective automated information system depends on accurate and timely input data to execute the appropriate decisions [26][27]. As will be discussed in Section 2.4, inventory system that uses POS data as input data may have an impact on the effectiveness of shelf replenishment policies.

Figure 2:

Customer
Staff

"PULL" REPLENISHMENT POLICY WITH MANUAL PICKING LIST

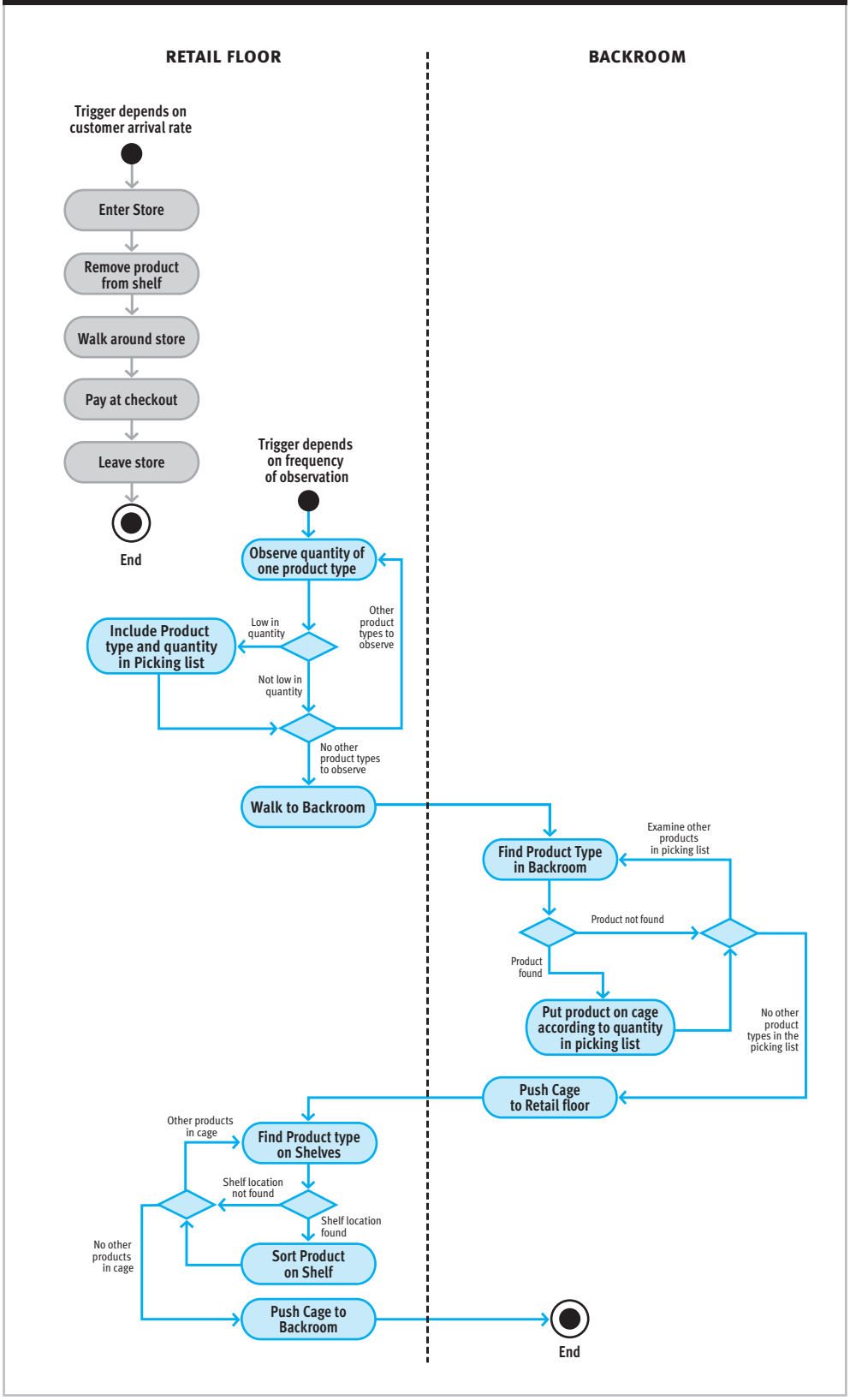
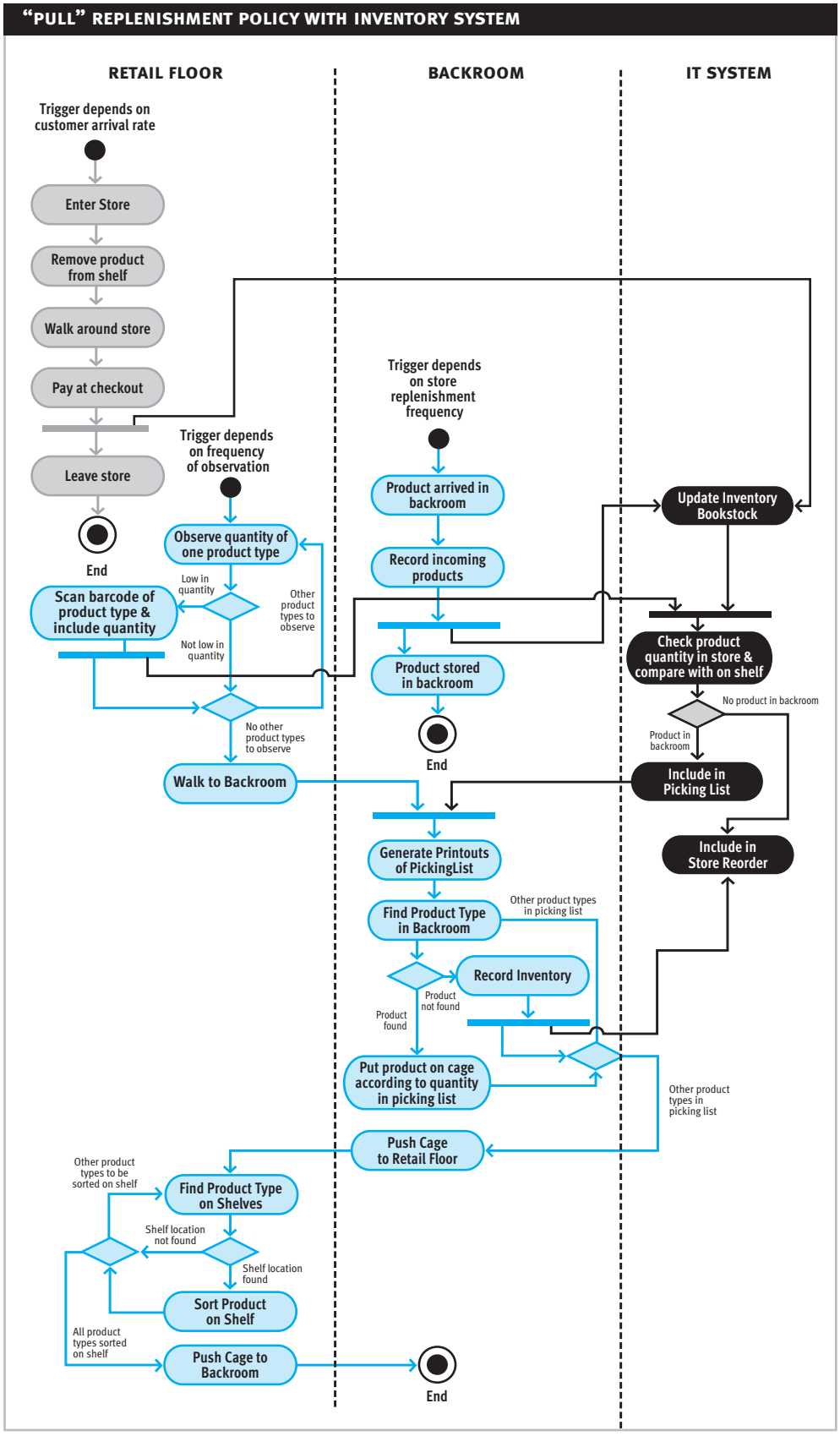


Figure 3:

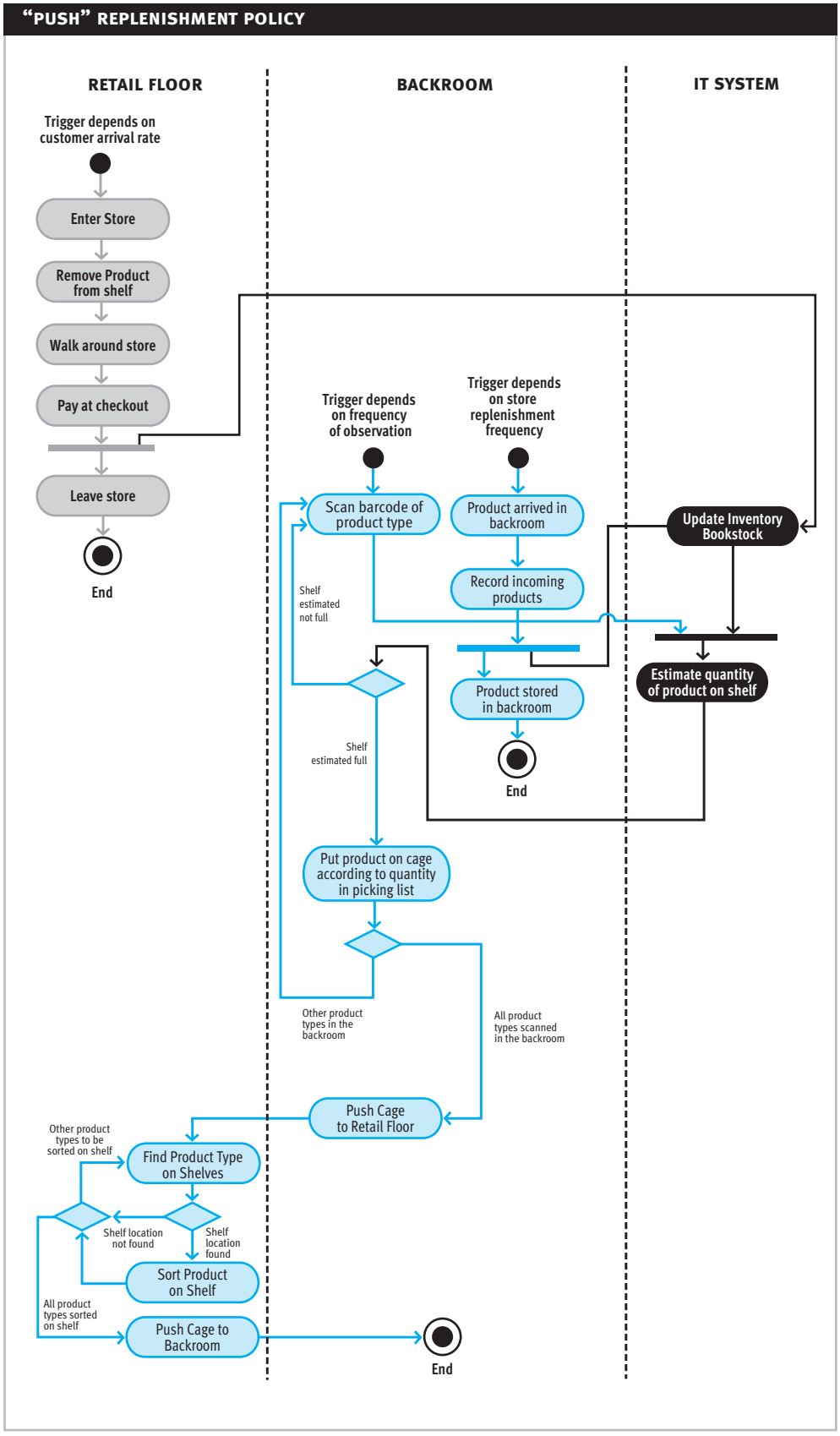

"PULL" REPLENISHMENT POLICY WITH INVENTORY SYSTEM
Customer
Staff
IT System
RETAIL FLOOR
BACKROOM
IT SYSTEM
Trigger depends on customer arrival rate
Enter Store
Remove product from shelf
Walk around store
Pay at checkout
Leave store
End
Trigger depends on frequency of observation
Observe quantity of one product type
Low in quantity
Other product types to observe
Scan barcode of product type & include quantity
Not low in quantity
No other product types to observe
Walk to Backroom
Trigger depends on store replenishment frequency
Product arrived in backroom
Record incoming products
Product stored in backroom
End
Update Inventory Bookstock
Check product quantity in store & compare with on shelf
No product in backroom
Product in backroom
Include in Picking List
Include in Store Reorder
Generate Printouts of PickingList
Find Product Type in Backroom
Other product types in picking list
Record Inventory
Product not found
Product found
Put product on cage according to quantity in picking list
Other product types in picking list
Push Cage to Retail Floor
Other product types to be sorted on shelf
Find Product Type on Shelves
Shelf location not found
Shelf location found
Sort Product on Shelf
All product types sorted on shelf
Push Cage to Backroom
End

2.2. The “Push” Policy

In this policy, a manual worker will directly observe the quantity of products in the backroom. They will scan through the products in the backroom according to sequence of arrangement using a handheld barcode reader. The inventory system will indicate if any products need to go onto shelf by estimating the stock level on the shelf (based on POS data, quantity of product in the store and the number of replenishments since the start of the day). Any product lines that are replenished will be recorded to the system to update the inventory bookstock. Therefore, products are essentially “pushed” out from the backroom to the shelves. For a detailed “Push” replenishment policy, refer to Figure 4.

When this “Push” policy is compared with the policies shown in Figure 3 and Figure 4, note that the trigger for shelf replenishment begins from the backroom instead of the retail floor. This eliminates the walking time from the retail floor to the backroom as well as the time to find a specific product type, but the sequence of product replenishment is that of the sequence of arrangement in the backroom, and not according to the product types that are “low” on the shelf. As will be discussed in Section 2.4, as this policy uses the POS data as input data, it may have an impact on the effectiveness of this policy.

Figure 4:


"PUSH" REPLENISHMENT POLICY
Customer
Staff
IT System
RETAIL FLOOR
BACKROOM
IT SYSTEM
Trigger depends on customer arrival rate
Enter Store
Remove Product from shelf
Walk around store
Pay at checkout
Leave store
End
Trigger depends on frequency of observation
Trigger depends on store replenishment frequency
Scan barcode of product type
Product arrived in backroom
Update Inventory Bookstock
Record incoming products
Shelf estimated not full
Estimate quantity of product on shelf
Product stored in backroom
End
Shelf estimated full
Put product on cage according to quantity in picking list
Other product types in the backroom
All product types scanned in the backroom
Push Cage to Retail Floor
Other product types to be sorted on shelf
Find Product Type on Shelves
Shelf location not found
Shelf location found
Sort Product on Shelf
All product types sorted on shelf
Push Cage to Backroom
End

2.3. Factors Influencing the Effectiveness of Current Policies

There are various factors that influence the performance of shelf replenishment policies. In this section, we will examine these factors in isolation.

- **Observation delay.** In the "Pull" policy, observation delay depends on the frequency in which the quantity of product on the shelf is observed to determine whether that particular product type is low in quantity or off-sales. Hence, this delay is essentially the time between quantity inspections. In the "Push" policy, this observation delay is defined as the time interval between product scanning in the backroom.

- **Checkout delay.** Checkout delay is the time it takes from the moment a product is removed from the shelf until it is registered as paid at the counter. This delay includes customer walking time (which may be significant if the size of the store is large) and customer queuing time (which may be long during peak hours). When the product is finally registered at the checkout counter, it will be recorded in the POS data to update the inventory bookstock.

- **Picking list.** A paper-based picking list, whether generated off from inventory system or recorded manually by the staff workers, records the quantity to be replenished from the backroom to the shelf. If the execution of operation takes a significant time, this picking list may be obsolete depending on the rate of product removal on shelf. The quantity in the picking list may not be accurate if it is manually estimated.

- **Locating products in backroom or on shelf.** The ability to locate different product types in the retail store is necessary for a quick and efficient shelf replenishment process. This task may seem trivial on the retail shopfloor (although multiple shelf displays on different locations may confuse manual staffs) but in an often cluttered backroom, it may be a non-trivial, time-consuming task. Even with an accurate inventory system, manual workers that are working under time pressure may "write-off" unobserved or misplaced products, thereby setting the inventory level for that product type to zero. Experienced staffs often rely on their memory or their experience to locate products quickly.

- **Physically moving products from backroom to shelf.** Once the product to be replenished is located in the backroom, it will be put into a cage. Depending on the picking list, there may be various other product types that need to be put into the cage before the cage could be rolled out. The correct amount of quantity should be replenished over a single replenishment trigger to avoid double handling.

- **Maximum Shelf Allocation.** Maximum shelf allocation is the maximum number of product quantity on the shelf. The allocation of product quantity is usually based on previous sales pattern according to marketing requirements and it usually changes by the week.

- **Product Removal Pattern.** Product removal pattern is the rate in which products are removed from the shelf by the customers and is differentiated from the demand pattern. When a customer pays for a product during checkout, that transaction influences the demand pattern. However, before the transaction occurs, products are first removed from the shelf and this influences the product removal pattern. As such, the demand pattern is a function of the removal pattern, customer walking time, and customer queuing time at checkout counters.

Product removal pattern depends on the characteristics of product. Demanding categories such as detergents, spirits, carbonated soft drinks, ice cream, confectionery and fresh ready meals have higher off-sales level. Impulse driven products like confectionary are another prime candidate for off-sales. Promoted products were also surveyed to have higher off-sales [10].

2.4. Summary of Factors and the Impact on Delays

This section highlights how the different factors introduced in the previous section influence the effectiveness of current shelf replenishment policies are subjected to delays. In this section, we will briefly describe these delays in isolation as shown in Table 1.

Table 1: Factors Influencing the Effectiveness of Current Policy

FACTORS	IMPACT ON CURRENT POLICIES
Observation Delay	Observation delay is the trigger for current shelf replenishment policies and therefore the frequency of observations affect the frequency of shelf replenishments. Less frequent shelf replenishments may mean lower on-shelf-availability of products.
Checkout Delay	Checkout delay is essentially the time when product is removed off from the shelf until is registered in the system. Any inventory system that uses this POS information to infer the state of actual quantity of product on the shelf will be inherently inaccurate due to checkout delays.
Picking List	Quantity of product to be replenished based on a picking list may be obsolete if the execution of shelf replenishment operation is significantly time consuming and the product removal rate is high.
Locating Products in Backroom or on Shelves	A timely execution of shelf replenishment process depends on the ability to find product locations anywhere within the store in a fast and efficient manner.
Physically Moving Products from Backroom to Shelf	The layout of the retail store will determine this delay. Backrooms that are large or separated into multiple floors will potentially experience significant delay.
Maximum Shelf Allocation	High shelf allocation will increase the time spent on product presentations. During the start of the week, products may not be shelved although deliveries have taken place [10].
Product Removal Pattern	While there is no specific delay in this factor, if the product removal rate is high, shelf needs to be replenished in a shorter time to maintain the same on-shelf-availability. Currently, product removals are not monitored directly, but inferred from either physical observations or from demand data (POS data).

Table 1 shows several types of delays that affect decisions and operations of shelf replenishments. Any technologies that could reduce the time delays of these factors could potentially have a significant impact on shelf replenishment performance. Specifically, we examine the impact of Auto-ID system in the next section.

3. THE IMPACT OF AUTO-ID INFORMATION ON SHELF REPLENISHMENT

In this section we will first examine the impact of having minimal Auto-ID technology deployment on current shelf replenishment. We then propose an alternative shelf replenishment policy that exploits the availability of full Auto-ID technology deployment.

3.1. Impact on Current Policies

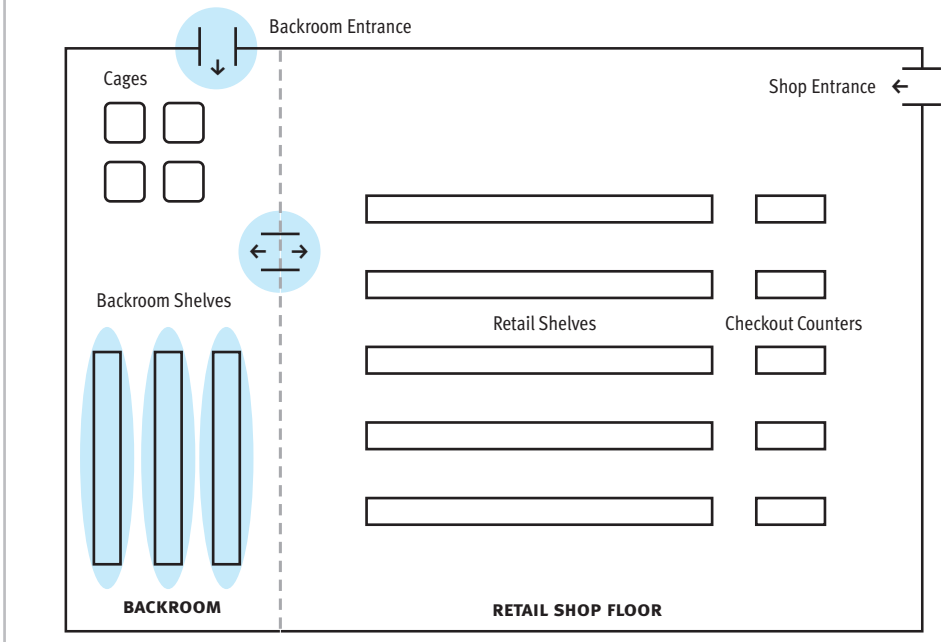
In this section, we assume a minimal Auto-ID technology deployment as shown in Figure 5. Specifically, the areas where tag readers might be deployed permanently to read tagged product are:

- **Backroom entrance** – Products that arrive from distribution centres will be detected and recorded automatically on the inventory system
- **Backroom shelf** – Products that are stored on shelves in the backroom could be identified automatically to obtain information about product type and its associated quantity
- **Backroom to retail shopfloor door** – With the ability to read tagged products in this area, we could determine which products are being physically moved from the backroom to the shelves after they are placed on the cages.

We also assume the availability of a handheld tag reader instead of barcode tag reader. With a handheld tag reader, products on retail shelves could be counted automatically and updated in the inventory system by moving the tag reader near the products on the shelves. The handheld reader could also provide location and quantity information about all the products in the store.

Figure 5

RETAIL STORE LAYOUT WITH MINIMAL AUTO-ID DEPLOYMENT



With these configurations, the current shelf replenishment policies could be improved without changing the process. Specifically, factors that could be improved are summarized in Table 2 in which the impacts of these factors on current policies are discussed.

Table 2: Impact of Minimal Auto-ID deployment on current policies

FACTORS	IMPACT ON CURRENT POLICIES
Observation Delay	This delay will be reduced with the ability to automatically count the quantity of products on the shelf by simply moving the handheld tag readers around the shelf. Unlike barcode tag reader, manual workers do not need to visually estimate the quantity of product for each product types and input the quantity individually into the handheld reader. Besides that, quantity of products on the shelf could be estimated and recorded into the inventory system for all the product types, instead of just products that are "low" in quantity.
Picking List	A manual picking list or generated printouts may not be necessary. Instead, a picking list shown on the mobile handheld reader could be used to provide a much more real-time product quantity in the store by taking into account of incoming deliveries and product movement within the store.
Locating Products in Backroom or on Shelves	With tag readers on all the shelves in the backroom, finding the current product location is almost effortless. Inexperienced staffs need not rely on familiarity and memory to locate products in the backroom. With visibility to what is actually in the backroom, inventory system will only include products that are actually in the backroom into the picking list, instead of listing all the possible product types may be in the backroom.

Even with just minimalAuto-ID technology deployment in the backroom of retail store, **inventory location determination** increases considerably because if products are not detected in the backroom, the inventory system could assume that all the remaining inventories are located on the retail floor. In any case, manual workers, often without knowing if products are in the backroom, could eliminate the amount of time they will spend looking for products in the backroom.

3.2. Alternative Policy

In this section, we discuss implications of having a full Auto-ID deployment in the retail store and the impact of that on new replenishment policies.

We assume that Auto-ID could be deployed in the manner shown in Figure 6. The shaded area represents the field where tagged products could be read with tag readers at all times. Specifically, these "extended" areas from that shown in Figure 5 are:

- **Cages** – The "cages" shown are mobile, and tag readers that are attached to them will move around the store together with the cages to provide information about the products inside.
- **Retail shelf** – Products that are replenished or removed from the shelf will be updated in the inventory system.
- **Checkout Counters** – Individual products that are bought by the customers could be recorded and updated in the inventory system. This is different from POS data as POS data does not record unique item level information.

Figure 6

RETAIL STORE LAYOUT WITH FULL AUTO-ID DEPLOYMENT

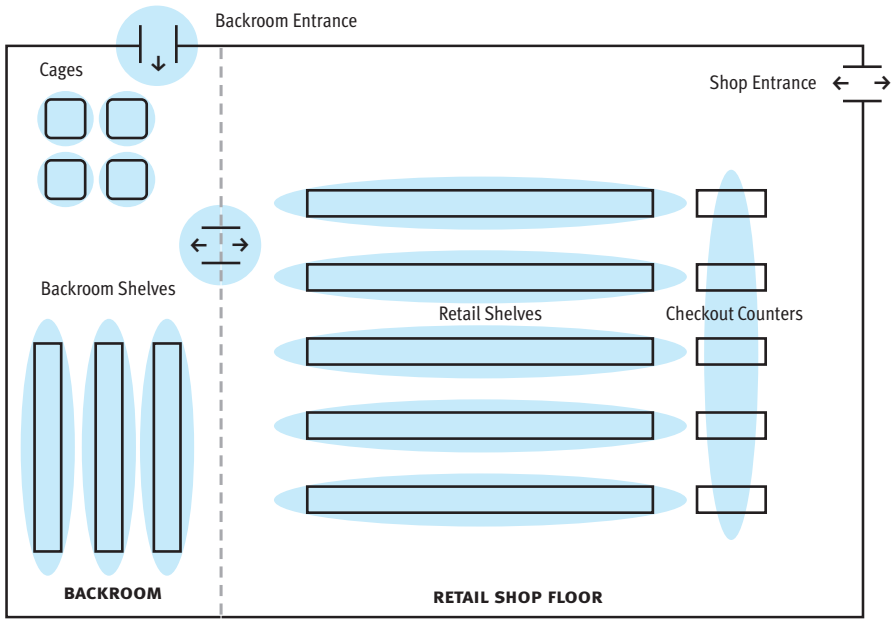
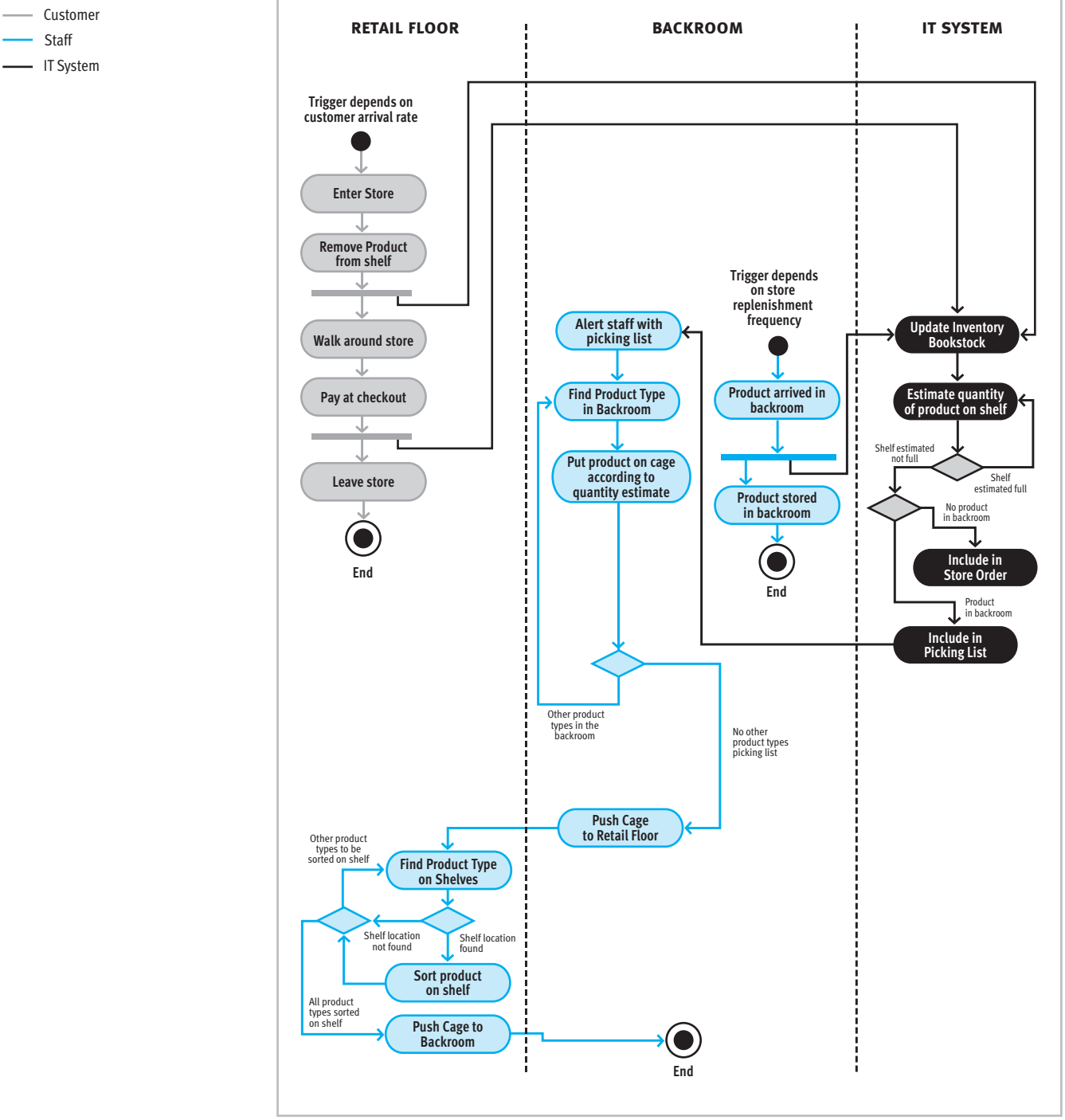


Table 3: Shows the impact of full Auto-ID deployment on each factor that influences shelf replenishments.

FACTORS	IMPACT ON SHELF REPLENISHMENT POLICIES
Observation Delay	With the ability to obtain information about products on the shelf directly via tag readers, physical observation by manual workers will not be necessary. The time between observations will essentially be the same as the refresh rates of tag readers on the shelves which may be near real-time. Tagged products on the shelf will be directly read to obtain unique product information such as quantity, product type as well as product due-dates.
Checkout Delay	With tag readers on the shelf, inventory system will be able to obtain quantity information for each product types on the shelf without inferring from POS data. Hence, checkout delay will not affect shelf replenishment decisions.
Picking List	As described in Table 2.
Locating Products in Backroom/on Shelves	As described in Table 2.
Physically Moving Products from Backroom to Shelf	Having full deployment of Auto-ID on the shelf will not affect the actual time to move products from the backroom to shelves. To reduce this time, the layout of retail stores must be changed.
Maximum Shelf Allocation	With timely information of actual product levels on the shelf, total inventory in the store as well as in the supply chain may be able to alter the maximum shelf allocation from a periodical basis to almost real-time based on events for better shelf space management.
Product Removal Pattern	Product removal patterns may no longer be inferred from POS data which is subjected to checkout delay. It will be "observed" directly through tag readers. This information will be used to provide faster response to shelf and store replenishments and to also to predict future behaviours.

Figure 7:



With full Auto-ID deployment in the retail store, estimation based on POS data and incoming deliveries into the backroom may not be necessary. Direct sensing or observability of products at the appropriate locations with subsequent relevant information retrieval about the product will provide faster closed-loop replenishment control to meet the desired target [8].

Comparing this policy with current replenishment policies as discussed in Section 2, a distinct difference is that the trigger for shelf replenishment is not the frequency of observation but rather a decision taken by the inventory system based on the product removal pattern. In this way, we have moved away from observation-based shelf replenishment policies to **shelf-level based replenishment policy**. The decisions about what and how much to replenish will be decided by the inventory system instead of manual decisions. In this way, shelf replenishments could be triggered and managed based on different merits, such as:

1. "Remove one, Replenish one" policy
2. Priority-based replenishment for different product types
3. Minimizing replenishment distance for each replenishment
4. Variable replenishment quantity based on dynamic maximum shelf allocations
5. Auction-based shelf replenishment based on bidding of retailers shelf space by manufacturers

4. CONCLUSION AND FUTURE WORK

The use of Auto-ID technologies in retail stores provides a new level of product visibility currently not possible using barcode technologies. The availability of timely and accurate item level information will not only improve current shelf replenishments policies but more importantly, it will provide a basis for altering shelf replenishment processes for incremental and possibly step-change improvements.

Research is still on-going at Cambridge Auto-ID Centre to model, simulate and evaluate the impact of Auto-ID information on shelf replenishment policies. There will also be a greater focus on the role of backroom and maximum shelf allocation that may directly impact the effectiveness of these policies. This research will ultimately provide a guideline for retailers to adopt the appropriate shelf replenishment policy based on different operating environment.

5. REFERENCES

1. **Auto-ID Centre, www.autoidcenter.org, last accessed on September 2003.**

2. **RFID Journal (2003), "Wal-Mart draws line in the sand".**
http://www.rfidjournal.com/article/view/462/1/1/, last accessed on September 2003.

3. **RFID Journal (2003), "Wal-Mart expands RFID mandate".**
http://www.rfidjournal.com/article/articleview/539/1/1/ last accessed on September 2003.

4. **RFID Journal (2003), "Tesco Deploy Class 1 EPC Tags".**
http://www.rfidjournal.com/article/articleview/587/1/1/ last accessed on September 2003.

5. **Metro Store of the Future.**
http://www.future-store.org, last accessed on September 2003.

6. **RFID Journal (2003), "Tesco Tests Low-Cost RFID system".**
http://www.rfidjournal.com/article/articleview/472/1/1/ last accessed on September 2003.

7. **RFID Journal (2003). "Giant Eagle to Trial RFID WMS".**
http://www.rfidjournal.com/article/articleview/518/1/1/ last accessed on September 2003.

8. **D. McFarlane, (2002), "Auto-ID Based Control".**
Auto-ID White Paper.

9. **D. McFarlane & C. Y. Wong et al (2002), "The Intelligent Product Driven Supply Chain".**
Auto-ID White Paper.

10. **Roland Berger Strategy Consultants (2003), "Optimal Shelf Availability".**
ECR Europe Publications.

11. **Accenture (2003). "Auto-ID in the Box: The Value of Auto-ID Technology in Retail Stores".**
Auto-ID White Paper.

12. **B.M. Beamon & V.C.P. Chen (2001), "Performance analysis of conjoined supply chains".**
International Journal of Production Research 39(14).

13. **E. Chen, (1998), "Echelon reorder points, installation reorder points, and the value of centralized demand information."**
Management Science 44: 221-234.

14. **A.J. Clark & H. Scarf (1960), "Optimal Policies For A Multi-Echelon Inventory Problem".**
Management Science 6(4): 475.

15. **T. Urban, (2001), "The interdependence of inventory management and retail shelf management".**
International Journal of Physical Distribution and Logistics Management, 32(1)

16. **A. Raman, DeHoratius & Z. Ton, (2001), "Execution: The Missing Link in Retail Operations."**
California Management Review, Spring2001, Vol. 43 Issue 3.

17. **W. Wayman, (1995), "Inventory Accuracy through Warehouse Control".**
Production & Inventory Management Journal, 1995, Vol. 36 Issue 2, p17.

18. **K.L. Brown & R. Inman, et al (2001), "Measuring the effects of inventory inaccuracy in MRP inventory and delivery performance".**
Production Planning & Control, 12 (1).

19. **J.W. Forrester, (1969), "Urban Dynamics".**
MIT Press, Cambridge, MA.

20. **F. Chen, (1999), "Decentralized Supply Chains Subject to Information Delays".**
Management Science 45(8): 1076.

21 **H.L. Lee, (1997), "Information distortion in a supply chain".**
Management Science 43: 546-558.

22. **A. Guptill & J. Wilkins, (2001), "Buying into the food system: Trends in food retailing in the US and implications for local foods".**
Agriculture and Human Values, Vo. 19, page 39-51.

23. **Encore Consulting Group, Inc., "Retail Business Continuity and Disaster Recovery".**
www.emc.com/pdf/vertical/retail_bc_dr.pdf, last accessed on September 2003.

24. **D.T. Jones & P. Clarke (2002), "Creating a customer-driven supply chain".**
ECR Journal, Vol. 2, No. 2.

25. **S.W. Ambler (2003), "The Elements of UML Style".**
Cambridge University Press.

26. **W. DeLone & F. McLean (1992), "Information Systems Success: The quest for dependent variable".**
Information Systems Research 3, 1, 60–95.

27. **D. Ballou, R. Wang, H. Pazer & G.K. Tayi, (1998), "Modeling Information Manufacturing Systems to Determine Information Product Quality".**
Management Science, Vol. 44, No. 4.

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