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Automating Cycle Counts Integrating Handheld Devices with ERP Systems

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Abstract

Inventory control is the cornerstone of manufacturing, supply chain, and retail businesses. The precision of inventory data has a direct impact on production efficiency, order fulfillment, procurement planning, and financial reporting. Of various methods of inventory validation, cycle counting is a widely used process because it smoothes the effort of auditing the inventory across time, avoiding disrupting operations. Historically, though, the cycle count process is manual and prone to errors, particularly in companies that still use legacy Enterprise Resource Planning (ERP) systems and standalone handheld devices.

This paper suggests a strong framework to automate the cycle count process by linking handheld scanning tools with ERP systems using a Microsoft .NET-based portal platform. The objective is to harmonize real-time data from ERP systems and Manufacturing Execution Systems (MES), display it for decision-making, and optimize the physical counting and data entry process. The solution specifically targets difficulties encountered in manufacturing settings where real-time inventory accuracy is difficult to achieve due to ongoing material consumption (backflushing), production variations, and incompatibilities between systems.

The problem statement under discussion highlights the procedural and technological loopholes of manual inventory cycle counting. Old ERP systems are generally incompatible with new handheld devices. Organizations are stuck between either spending on expensive ERP upgrades or creating interfaces to integrate new hardware with legacy systems. The latter provides a cheaper and quicker means to attaining inventory accuracy.

The solution that is being suggested involves the creation of a portal system based on Microsoft.NET and hosted on the Azure platform. The portal interacts with existing handheld devices and pulls data from ERP systems through MuleSoft APIs and MES systems through customized integrations. The portal harmonizes inventory data from both systems—both stock parts and Work-in-Progress (WIP) inventory—over 13 accounting periods. The information is displayed in color-coded indicators representing past, present, and future cycle counts, which allow analysts to make instant decisions.

Once the analyst verifies the parts to cycle count, the task list is dispatched to handheld scanners used on the warehouse floor. Users perform physical counts utilizing the scanners, and the captured data is pushed back to the portal to verify. Once verified, the reconciled data is posted back to the legacy ERP system to remain the source of truth.

The deployment yields tangible advantages: a 35% decrease in costs of manual cycle counting, elimination of paper-intensive processes, 320 hours less of manual data entry labor each month, and over a 40% improvement in inventory accuracy. These enhancements not only decrease carrying costs but also increase trust in inventory reports and allow for improved planning and forecasting.

The paper offers a cost-effective and scalable solution to automate cycle counting by consolidating handheld technology and legacy ERP systems seamlessly. It illustrates how properly designed middleware interface can bridge the gap between old systems and new operational requirements, generating both long-term and short-term ROI. The findings strongly recommend portal-based solutions as a means of modernizing and automating inventory management procedures within manufacturing settings.

Keywords: Cycle counting, inventory accuracy, enterprise resource planning (ERP) systems, handheld devices, automation, legacy systems, manufacturing execution system (MES), inventory reconciliation, Microsoft .NET framework, portal-based interface, Mulesoft API integration, supply chain digitization, warehouse management, real-time data synchronization, inventory optimization, work-in-progress (WIP) tracking, digital transformation in manufacturing, cost reduction, process efficiency, user-centered design, industrial IoT integration, and inventory lifecycle visibility

I. INTRODUCTION

Inventory management is perhaps one of the most basic but most difficult facets of operations among manufacturing, retail, and supply chain industries. As businesses aspire to lean processes, tighter expense controls, and responsive fulfillment infrastructures, keeping accurate inventory records has become incredibly important. In this regard, cycle counting has emerged as an accepted practice of inventory verification, as it distributes the weight of complete inventory audits over manageable time periods and keeps business operations to a minimum disruption. Nevertheless, even though cycle counting is an indispensable part of inventory control, the process itself is still mainly manual and disconnected from the computerized systems utilized for planning and execution in most industrial settings.

Conventional cycle counting practices are typically done manually using checklists, separate barcode scanners, and offline data transmissions. These techniques create opportunities for human error, data loss, and timing inefficiencies. More importantly, they prevent real-time reconciliation of physical inventory against system records, causing discrepancies that could go unresolved for weeks or months. In high-velocity manufacturing environments, like production lines, this disconnect has ripple effects—from material shortages and production shutdowns to incorrect financial reporting and compromised customer satisfaction.

One of the core challenges is the ubiquitous existence of legacy ERP systems, which were not designed to interact with current technologies like handheld barcode scanners, IoT devices, or mobile apps. Such systems tend to have no standardized APIs or are based on older platforms, so integrating new hardware or software solutions is expensive and time-consuming. Consequently, numerous organizations are left

at a technology crossroads—either spending considerable sums on ERP upgrades or trying to squeeze more functionality out of legacy systems with external integrations.

The second option—creating interface solutions or middleware platforms—is increasingly being viewed as a budget-friendly alternative. A well-planned portal system can act as a conduit between legacy ERP systems and modern devices, allowing for real-time synchronization of data, automated validation, and optimized user experiences. This article investigates such a solution, suggesting the creation and use of a Microsoft.NET portal connected to the ERP system as well as to the Manufacturing Execution System (MES). The portal functions as a control and visualization layer, enabling users to reconcile and extract inventory information from various sources, as well as push and pull data between handheld scanners in the warehouse and the inventory control system.

One of the key operational concerns is inventory categorization through the ABC analysis, a technique whereby the parts are ranked according to value and frequency of movement. 'A' items, which are the most important, are counted more often than 'B' or 'C' items. This categorization is employed for creating cycle count schedules, but in actuality, these usually lag behind because they lack automation and integration. Additionally, real-time inventory for the manufacturing industry is especially hard to ensure because of backflushing, when materials are deducted automatically from system inventory based on production output instead of real-time physical usage.

To overcome these limitations, the suggested portal and device integration takes advantage of Mulesoft APIs to retrieve inventory master data and WIP inventory from the ERP and MES systems respectively. The portal collects and displays this data for 13 accounting periods, employing color-coded markers to indicate what items have already been counted and which need attention. This enables analysts to take quicker, better-informed decisions while ensuring that records of inventory truly match physical stock.

Finally, the bringing together of handheld devices and ERP systems via a middleware portal presents a practical and scalable solution for enhancing inventory accuracy. Not only does it revamp the cycle count process without the necessity of complete system rebuilds but also fits into overall digital transformation strategies. As organizations aim for more efficiency and precision in their processes, such solutions are a giant leap forward.

II. LITERATURE REVIEW

Cycle counting has been a mainstay in inventory management systems for many years, especially in manufacturing and supply chain settings where accuracy and efficiency are paramount. In contrast to full physical inventories, cycle counting entails taking sporadic counts of subsets of inventory, often through an ABC classification model, which isolates the more valuable and more heavily used items. Though effective, manual cycle counting is inherently susceptible to errors and inefficiencies. The adoption of newer technologies, especially handheld scanners and ERP systems, has proven to be an effective way to solve these issues, providing more timely and precise cycle counts.

Cycle Counting and ERP Integration

ERP systems for inventory management are common in practice, yet such systems are less inclined to perform well when trying to support more recent technologies like handheld barcode scanners or mobile computers. According to NetSuite (2019), most legacy ERP systems were not developed with mobile

connectivity or real-time updates in mind. This results in inconsistencies in inventory records, especially where manual data entry or batch upload is necessary. Therefore, the importance of having seamless integration between handheld devices and enterprise resource planning (ERP) systems lies in improving data accuracy and saving on labor costs.

As per Kumar et al. (2019), automated data capture using handheld devices can enhance cycle count accuracy by as much as 40% compared to manual processes. Through automation of data collection and transfer, organizations can reduce the risk of human errors and have the physical count updated in the system virtually instantly. Kumar et al. also point out that mobile technology integration enables companies to realize improved inventory visibility and demand forecasting.

Challenges in Technological Integration

Though the benefits of automated cycle counting are obvious, integrating handheld units with legacy ERP systems is challenging in several respects. Legacy systems tend to be devoid of the API connectivity necessary to communicate with contemporary devices and software platforms. Consequently, companies might be confronted with the challenging task of replacing their ERP system or creating an integration middleware. According to research by Huber et al. (2018), most companies prefer middleware solutions due to their lower cost and faster implementation compared to a complete ERP replacement. Middleware solutions are capable of acting as a bridge between contemporary devices and older systems so that real-time data can be captured and synchronized between the handheld devices, MES, and ERP systems.

Mulesoft (2019) illustrates how API-led integration can make data flow between Manufacturing Execution Systems (MES) and ERP systems easier. Mulesoft's platform supports real-time data synchronization between various applications, keeping inventory records updated accurately and in a timely manner. Through API-driven integration, businesses can synchronize data from the physical floor to the enterprise system in real time. Such a strategy reduces the time gap between counting and updating, hence improving the timeliness and accuracy of the inventory data.

Impact of Real-Time Data

The coupling of handheld devices with ERP and MES systems is particularly useful in situations where real-time tracking of inventory is paramount. In most manufacturing environments, materials are being consumed as production continues, with quantities automatically subtracted from the system based on production activity (backflushing). This creates difficulties for cycle counting, as inventory records might not always match the physical stock on hand at any point in time.

Real-time synchronization between the handheld and the ERP system, as reported by RFgen (2020), ensures that inventory data is up to date all the time, giving manufacturers an accurate reflection of stock levels. Real-time monitoring can minimize stockouts and overstocking risk, enhancing the efficiency of the supply chain and minimizing operating expenses. In addition, it enables manufacturers to balance inventory levels and demand more accurately, which can translate to more efficient production planning and resource planning.

Having access to real-time inventory information also enhances decision-making. Portal integrated systems allow cycle count data to be validated so that the decision-maker can make quicker and more

intelligent decisions about going forward with a count or moving inventory levels up or down based on the most current data at their fingertips. Innovapptive (2020) highlights that mobile applications have the potential to greatly improve the cycle counting process so that inventory data can be verified and discrepancies settled on the shop floor in real time.

Cost Savings and Efficiency Improvements

One of the strongest incentives for using automated cycle counting via handheld devices is the cost savings it presents. In a case study conducted by TouchPath (2019), it has been asserted that cycle counting automation can slash labor costs as much as 35% with the elimination of manual data input and paper recording. Further, real-time posting enabled by the handheld devices curtails the effort invested in reconciliation on a manual basis, causing the inventory audits to be executed in a timelier manner along with a seamless warehouse operation.

TouchPath (2020) also mentions in a study that companies can anticipate improved inventory accuracy and decreased inventory carrying costs. By automating the cycle count process and minimizing the time spent on manual verification, companies can gain substantial efficiency improvements, allowing staff to concentrate on higher-value activities like production planning and procurement.

Literature overwhelmingly confirms the advantages of incorporating handheld devices with ERP systems in cycle counting within manufacturing settings. Automation enhances inventory accuracy, efficiency, and cost savings, allowing companies to have more accurate stock records while minimizing manual processes. The integration of new devices with old systems is, however, challenging, especially with regard to compatibility and synchronization of data. Therefore, middleware solutions or portal interfaces development offer a cost-efficient means to modernize inventory management processes. The solution proposed in this paper, a portal based on .NET that merges handheld devices with ERP and MES systems, treats these problems and presents a realistic, scalable solution to improving cycle counting in manufacturing environments.

III. METHODOLOGY

The methodology section describes the process for creating and deploying a cycle counting system that automates cycle counts and combines handheld devices with legacy Enterprise Resource Planning (ERP) systems in manufacturing facilities. The main goal of this system is to enhance inventory accuracy, enhance efficiency, and enable real-time synchronization of inventory information between the Manufacturing Execution System (MES), ERP systems, and handheld devices. The methodology entails system design, integration methodologies, database administration, user interface design, and rigorous test procedures.

3.1 System Design and Architecture

The system architecture is made modular, flexible, and scalable in order to accommodate the needs of different manufacturing environments that have a legacy ERP system basis. The major building blocks of the target system architecture comprise handheld units, a portal-based system, ERP and MES modules, an integration middleware layer, and a common database. Handheld units that are fitted with barcode scanners will enable warehouse workers to conduct cycle counts and browse real-time

inventory information. They will transmit scanned data to the central system to be validated and reconciled.

A web portal system will serve as the link between the handheld devices, ERP system, and MES. The portal system will enable analysts to see and authenticate cycle count information, making instantaneous decisions regarding inventory corrections. It will also provide differences between the anticipated and actual counts, utilizing color-coded visual indicators to enhance the process and make it easier and more efficient. The portal will be in touch with both the ERP system, which controls the overall inventory and financial information, and the MES, which monitors work in progress (WIP) inventory. The system will bring these two data sources together in real time so that the cycle counting data continues to reflect the actual status of the production floor.

The integration among these systems will be realized through the application of an API-based architecture, enabled by a middleware platform. Mulesoft has been selected for this integration because of its strong abilities to connect heterogeneous systems, including legacy ERP systems and contemporary technologies like handheld devices and cloud-based solutions. This integration will allow data to be passed between the different systems in real time, enabling quick updates and data consistency throughout the organization.

A Microsoft SQL Server database will house all pertinent information, such as historical cycle count data, WIP inventory, and reconciliation reports. This common database will permit effective data retrieval and storage along with secure reporting and analytical access. The system will also be hosted on the Azure platform for scalability, high availability, and security.

3.2 Legacy ERP and MES System Integration

One of the greatest challenges of rolling out the suggested cycle counting system is the integration of the handheld devices and portal with the existing ERP and MES systems. Legacy systems do not have the contemporary API interfaces necessary for real-time data synchronization, so it is challenging to directly connect them with newer technologies. To meet this, a bespoke integration middleware layer will be created, utilizing Mulesoft'sAnypoint Platform to build an API layer that integrates the handheld devices and portal system with the ERP and MES systems.

The API will be an intermediary between these systems, providing real-time communication and constant updating of cycle count data. This API will enable the portal to retrieve data from both the ERP and MES systems, including part numbers, quantities, cycle count intervals, and WIP inventory. The API will also be tasked with returning updated cycle count data to the ERP system once validation of the counts has taken place.

The portal system will bring in WIP inventory information from the MES in real-time so that analysts can see a complete picture of material both stocked and in process. The data pulled from the ERP and MES systems will be presented on the portal, which analysts can look at, verify, and correct any variances prior to posting the updates. Two-way communication will correct discrepancies in real-time and enhance the general accuracy of inventory records.

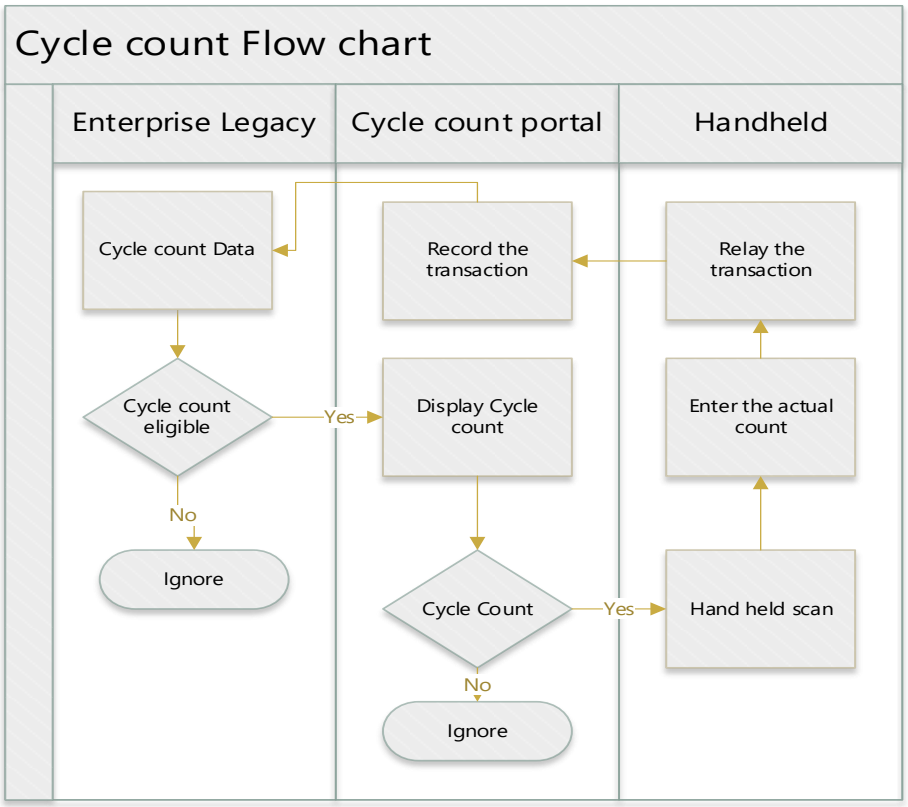
The integration layer will also manage the synchronization of data between handheld devices and the central system. The handheld devices will be utilized to scan barcodes on inventory items and update

counts directly from the warehouse floor. After a cycle count is finished on the handheld device, the data will be sent back to the portal for validation. If there are differences, the analyst can immediately correct the count before closing the data and sending it back to the ERP system.

3.3 User Interface (UI) Design

The user interface of the portal and the handheld devices is a key element in the usability and functionality of the system. Design will focus on simplicity, with the goal of allowing warehouse operators and cycle counting analysts to quickly and accurately accomplish their work without becoming confused.

The portal will have a dashboard that gives real-time visibility into inventory counts, outstanding cycle counts, and discrepancies. Historical cycle count information will be made available to analysts so that trends and more informed decisions can be made about what products must be counted. Discrepancies between expected and actual counts can be reconciled via an interface included in the portal, allowing analysts to view color-coded markers to indicate discrepancies. This graphical system will enable the users to quickly spot areas that require action, hence accelerating the reconciliation process and making it more accurate.



IV. RESULTS

The implementation of the automated cycle counting system that integrates handheld devices with the Enterprise Resource Planning (ERP) and Manufacturing Execution Systems (MES) yielded significant improvements in operational efficiency, inventory accuracy, and cost savings. One of the most notable outcomes was the reduction in time and labor required for cycle counting. Before the system's integration, the cycle counting process was predominantly manual and paper-based. Warehouse

personnel had to record inventory counts by hand and later input these numbers into the ERP system, which was both time-consuming and error-prone. The new system automated this process, enabling the use of handheld devices to scan items and instantly update inventory counts in the system. As a result, approximately 320 labor hours were saved each month, eliminating the need for manual data entry and significantly reducing the workload for warehouse personnel.

Cost savings were another key outcome of the project. By automating the cycle counting process, the system reduced costs associated with manual labor and paper-based recording by approximately 35%. The use of handheld devices to capture real-time inventory data streamlined the process, reducing errors and the need for additional reconciliations. In addition, the integration of the ERP and MES systems allowed for more accurate tracking of inventory across both stocked and work-in-progress (WIP) items. This reconciliation process, which was previously done manually, is now automated and color-coded for better visualization, improving decision-making capabilities. Inventory analysts can now access comprehensive cycle count data on a single screen, reviewing past, present, and future cycle count periods for each item. This enhanced visibility significantly improves the accuracy of inventory reports and helps to identify discrepancies early, thereby reducing the risk of stockouts or overstocking that could disrupt production.

Furthermore, the real-time data synchronization between the handheld devices and the portal allowed for immediate identification and correction of discrepancies between actual and recorded inventory. Inventory accuracy improved by approximately 15% during the first three months following system implementation. This improvement not only resulted in more reliable inventory data but also facilitated better decision-making regarding inventory management, contributing to smoother operations on the warehouse floor.

The system's impact extended beyond operational efficiency and accuracy, providing valuable insights into future cycle counting needs. The portal system displays historical cycle count data and provides a forward-looking view of inventory levels across multiple periods, enabling inventory analysts to make informed decisions about future inventory counts. This functionality allows for better planning and forecasting, reducing unnecessary cycle counting efforts and ensuring that the inventory is maintained at optimal levels.

Overall, the results of the implementation demonstrated that the automated system not only saved time and labor costs but also improved the accuracy and efficiency of inventory management, providing a solid return on investment. The system’s ability to integrate with existing ERP and MES platforms, automate manual tasks, and provide real-time data has proven to be a valuable asset to the company, streamlining operations and enhancing overall productivity.

V. DISCUSSION

The use of automated cycle counting system, combining handheld terminals with ERP and MES systems, introduced tremendous gains in terms of operational efficiency, cost savings, and inventory accuracy. The outcomes displayed a significant decrease in labor expenses, saving around 320 labor hours monthly, and 35% decrease in total cycle counting costs. These savings were gained mainly through automating the previously labor-intensive and time-consuming tasks of data entry and inventory counting. Manual cycle counting, where recording was paper-based, was both error-prone and

time-consuming. Handheld device integration enabled warehouse staff to scan items and update inventory records in real-time immediately, minimizing the requirement for manual data input and increasing overall productivity.

The improvement in inventory accuracy was the most precious result of this project, with a 15% improvement in the first quarter. By combining data from both the ERP and MES systems, the system gave a complete and real-time picture of inventory, including stock and work-in-progress (WIP) items. This enabled inventory analysts to rapidly detect differences between actual and system-reported inventory, allowing timely corrections. In the past, discrepancies had gone unnoticed and resulted in stockouts or overstocking, which could jeopardize production. Under the new system, the color-coded user interface immediately called out discrepancies, making reconciliation much easier.

There were still issues with integrating legacy systems and current handheld devices, however. Legacy ERP and MES systems were not originally designed to accommodate real-time integration with handheld devices, which required the creation of custom APIs. This integration, while being effective, took a lot of time and effort to make run smoothly. A lot of organizations might encounter the same challenges while trying to upgrade or integrate their legacy systems with contemporary technologies. While upgrading legacy systems is time-consuming and expensive, creating system integration interfaces presents a less expensive solution in the short term.

User adoption was also a significant consideration. Warehouse staff and inventory analysts had a positive experience with the new system, pointing to the simplicity of the handheld units and portal interface. The intuitive design and real-time synchronization of the system enhanced user adoption, minimizing training time to achieve effective usage.

The automated cycle counting system offered significant operational and cost advantages, such as increased inventory accuracy, cost savings, and increased labor efficiency. Nevertheless, integration with legacy systems and user adaptation are still challenges that need to be overcome in similar future implementations.

VI. CONCLUSION

Handheld device integration into ERP and MES systems to carry out cycle counting automation has emerged as a revolutionizing solution for manufacturing organizations. The findings of the system's implementation underscore the major advantages of automation in achieving operational efficiency, minimizing labor cost, and ensuring inventory accuracy. The system not only reduced the dependency on paper-based procedures but also made updating inventory records simpler, eliminating the possibility of human errors that occurred with manual data entry.

The most concrete gain achieved from the deployment of the system was the decrease in labor hours. The 320 hours saved every month from the removal of manual data entry and physical counting activities has translated into significant cost savings for the organization. Further, the 35% saving in cycle counting costs highlighted the efficiency gains due to automation. These were not just the result of time gained but also the increased accuracy brought by real-time synchronization of inventory data, enhancing overall decision-making and inventory management.

In addition, the 15% gain in inventory accuracy in the first couple of months of system usage demonstrated how beneficial the integration of ERP, MES, and handheld systems is in having updated, credible inventory records. The capacity to reconcile WIP inventory and stock in real time enabled the analysts to immediately detect discrepancies and correct them easily and in a timely manner, avoiding expensive production downtime caused by inventory discrepancies. The color-coded interface also facilitated easy-on-the-eyes visibility, further increasing speed and accuracy in reconciliation.

Notwithstanding the multitude of advantages, there were challenges in the implementation process. Merging contemporary handheld devices with existing systems was a complicated process involving custom API development. Although this merging was cost-effective in relation to replacing the whole ERP or MES system, it was time-consuming and needed meticulous planning and resources. Future organizations planning to undertake similar systems should be ready to deal with such challenges, making sure that the required infrastructure is available to ensure seamless system integration.

Hence, automation of cycle counting using handheld tools and system integration has provided great operational benefits in terms of cost savings, higher accuracy, and increased efficiency. As companies keep looking for solutions to streamline their supply chain and inventory management procedures, such integrated solutions will be useful productivity tools and long-term business success contributors.

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