

The Multi-Modal Warehouse: Getting the mobile worker in the loop

When warehouse workers have immediate information to act, they are more effective. Multiple modes of interaction between workers and the warehouse system pay off with new levels of productivity, performance and accuracy.

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Introduction

The final loop of information from a warehouse management system to a warehouse worker and back is the most critical. This is where actual transactions occur.

Warehouse workers execute more than 95 percent of physical inventory transactions in most facilities.

Each inventory event, receipt; putaway; pick, shipment; etc. represents a change in condition and even ownership and/or condition. The host WMS initiates these transactions by sending orders (instructions) to mobile workers who execute them and confirm their completion.

While this final information loop is vital, it is the weakest link in most systems.

From the lowest form of communication (paper and pencil) to more advanced wireless bar-code scanners, technology used on the warehouse floor has been the most inefficient. Every mode of communications has its limitations. Paper pick tickets provide no real-time visibility and are error prone. Hand-held terminals force workers to continually stop to read the screen (usually in a cryptic DOS / character mode presentation) and key in information before scanning. Speech computers, while offering hands-free operations, are limited to only a few warehouse operations such as picking and cycle-counting. They are typically expensive, proprietary computers dedicated to speech-only with no screens, scanners or keyboards. And the Speech computer will only have as much information as was provided through the interface from the host.

The advent of ruggedized Windows mobile computers opens up new opportunities for improvement in remote worker efficiency and accuracy which improves the overall effectiveness of warehouse operations.

These devices offer multiple input and output technologies that allow workers to receive and enter information in the most effective manner. Communication modes include browsers, touch-screens, bar-code scanners, speech recognition, RFID readers and keyboards, all on single, integrated, wireless devices. These overlapping, often redundant, modalities enhance the human-computer interaction by presenting the choice of output and input best suited for any single task.

At the same time, warehouse systems are being designed to serve up better information which is consistent for all modes of communication. This eliminates the need for specialized interfaces for specific devices, such as a proprietary speech system. Information is dispatched to multi-modal devices in interactive format rather than batches of work orders. This helps maintain a persistent series of updates and confirmations between the host WMS and the worker, which enhances the value and accuracy of real-time transactions visibility. A wireless computer in the hands of workers enables multiple modes data capture and communications.

There are many different types of devices needed, based on physical and environmental diversity from warehouse to warehouse. This includes: sub-zero freezer operations; variable range scanning; voice capable circuitry; RFID scanners and wearable vs. hand-held vs. truck-mounted applications. Manufacturers including Motorola, LXE and Intermec have been on an aggressive product development path to deliver Windows-based devices to address these and other issues.

This paper explores the factors and benefits of multi-modal mobile computers in real-time warehouse settings and how both workers and managers benefit by completing the information loop.

The mobile worker's role in inventory transactions

Warehouse management systems (WMS) provide a critical, centralized facility for managing transactions including orders, locations, inventory and operations. From their workstations, managers can view receipts, prioritize order picking and schedule work to meet a dynamic set of requirements and expectations. And yet all of this information is only as good as its availability to the people who execute the transactions on the warehouse floor.

The WMS prepares work for the mobile worker. It helps the warehouse manager evaluate and categorize orders, expected receipts, available inventory and send instructions to the worker including where to go and what to do.

When a warehouse worker makes a pick it initiates a physical transfer from the warehouse operator (or his client in a 3PL warehouse) to the customer. While a pick is a seemingly routine activity, it a transactional event that fulfills a customer-initiated demand order. The event affects inventory counts, inventory value, shipping transactions and ultimately payment. When the right product is picked and shipped to the right customer, everything is working as expected.

But in warehouses, as most other places of business, there are exceptions, mistakes and failure of communications. Many things can go wrong.

- A worker is dispatched to a location to pick a certain quantity of product but the location is empty or contains a different product. The worker needs to report back to the manager, directly or through the system.
- A worker is sent to a location via a hand-held bar-code scanner to pick product. He reads the quantity on the scanner's DOS (character mode) display, scans the location, and then looks away to holster the scanner. The worker then inadvertently picks from a different location which is immediately adjacent to the proper location. The wrong product is picked because it's necessary for the worker free his hands to physically pick the product.
- A worker equipped with a speech-based system enters a zone where persistent noise makes it impossible to hear the instructions. The system does not have a screen allow him to read the instructions.

Every time a worker has to wait for information, seek out an answer, or report a problem work is not getting done. The sooner exceptions are detected the sooner they are resolved, and the more productive the warehouse. When a mistake is made, it takes more than twice the original effort and cost to correct it. The worse case is when a customer receives the wrong product which results in a return, replacement shipment and an unhappy customer.

In a multi-modal environment, a worker can request a location check (via speech command, "check location") to verify expected inventory identity, description and quantity. The system responds back with a speech command to scan the location. Once the worker scans the location bar code, the wireless computer speaks the description, SKU number and expected quantity. The same information is also visible on the browser, complete with a photo of the product. If a variance is discovered, the worker can order a cycle count for the location and then ask the system for another location for the product.

The work flow is flexible as is the information flow. But the main objective for the worker is to accurately complete orders on time.

Modes of human-computer interaction

Warehouse workers and computers exchange information in a variety of ways.

Printed Reports: Reports, in the form of pick-tickets and other work orders are created by the warehouse manager. Workers equipped with their paper orders, clipboard and pencil work their way down the list until work is completed. Then the manager or someone else must enter back into the system confirmation of picks that were made along with any exceptions. This is a batch system in the truest sense.

Hand-Held Terminal: Work is dispatched to the worker via a wireless network to a “brick-on-a-stick” or other mobile computer. These terminals have largely been DOS based, with proprietary networks. Technology has been catching up, however, with Windows CE and Windows Mobile systems which operate over a standard 802.11 network. These terminals primarily execute bar-code scanning but also display information on a DOS or Windows screen which allows the worker to view work orders, locations, and specific instructions for each task. The biggest problem is the worker must continually start and stop work to read the monitor and perform data entry tasks.

Pick-To-Light: Pick-to-light systems offer total hands-and-eyes-free operations for warehouse workers. While these systems increase productivity and accuracy, they are single process focused, stationary, expensive and inflexible.

Dedicated Speech Computer: Voice has gained popularity throughout the warehouse industry over the past 10 years. Through speech recognition and speech synthesis, mobile workers can communicate verbally with the system which frees their hands and eyes to increase productivity, accuracy and safety. Most speech systems are interfaced to warehouse management systems and require continual integration and interface maintenance. Speech systems are best suited for specific operations such as order picking, cycle counting and replenishment. Most speech systems utilize proprietary worker devices which are expensive and only useful for speech applications. These devices typically do not have screens, scanners or keypads for alternative data input/output.

RFID: RFID has succeeded in advancing operations in consumer product based warehousing, primarily to retailers. RFID is very effective on docks for receiving and shipping, handling inbound and outbound shipments, mostly at the pallet level. It has yet to become effective as an operational tool at the pick-face or less than pallet/carton level.

Multi-Modal Interaction: In human-computer interaction, a modality is 1) a sense through which the human can receive the output of the computer, and 2) a sensor or device through which the computer can receive the input from the human. In less formal terms, a modality is a path of communication between the human and the computer. When multiple modalities are available for some tasks or parts of tasks, the system has overlapping modalities. When multiple modalities are available for all tasks, the system has redundant modalities.

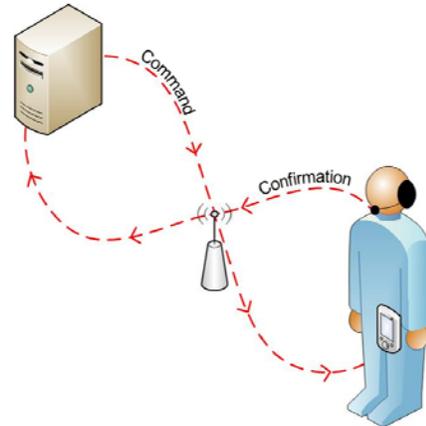
For our purposes in the warehouse, multi-modality is the combination of messages exchanged between the WMS and worker with speech commands, browser text, bar-code scanning, keypad input, touch screen, RFID and even pick-to-light. Some or all modes are used in an overlapping manner, depending on the nature of the work (picking, receiving, putaway, etc.) and warehouse environment factors (freezer, long-range scanning, etc.).

The Multi-Modal Warehouse | Getting the Mobile Worker in the Loop

A multi-modal environment allows workers to capture data and communicate on the same device in multiple ways interchangeably, without preplanning workflow configuration or communication method. Instructions are delivered via speech and on the screen at the same time. If the worker didn't hear the voice instructions, he can ask the system to repeat it, or simply look at the screen to read the text-to-speech string. In picking, the computer is likely to tell the worker to go to a specific location and speak back a check digit. This confirms the proper location back to the WMS. The worker could also scan the bar code on the location if the check digit is unavailable. Failing that, the worker could key in the check digit or bar-code number. Because the solution is a native part of the WMS system, information is interchangeable, so the most convenient, fastest, and safest mode can be utilized at will.

Each computer/worker instruction and confirmation is a loop of communication. It might sound/read as the following two loops:

- 1) Computer dispatches worker to specific location and worker confirms the proper location: *Computer speech and browser text: "Go to location XYZ and read the check digit"*
Worker reads or keys in: "Three Four" (Or scans the location)
- 2) Computer instructs worker to pick product quantity, worker confirms the pick:
Computer: "Pick 10"
Worker: "Got It"



The process of completing work throughout the day is a continuous string of command and confirmation loops which sets up a natural, rhythmic pace. There are fewer interruptions to the flow of work. Starting and stopping to read instructions, scan, holster the scanner, check off the pick ticket, etc. is greatly reduced. When there are exceptions, the worker and computer interact to report the situation for corrective action later so that the worker can continue with the set of tasks. Any mid-task adjustment due to an exception or process change becomes part of the work flow, rather than an interruption to the momentum.

A worker can get an overview of work assignments beyond the next location or next single task. A verbal and visual report on how much work there is left to do, how much is accomplished, pick rate and other productivity reports are available, based on system rules and individual user permissions.

Some modes are better suited for certain operations than others. For example speech is very adaptable to picking, receiving, cycle-counting, replenishment and putaway. It provides hands and eyes free operations, enhancing accuracy and productivity. But other operations may require a bar-code scan, especially in areas where product numbers, serial numbers, or lot numbers need to be captured. Speech is not as suitable for input of long strings of numbers as is a bar-code scan.

Information display and data capture takes on new dimensions with multi-modal devices. When a worker asks for product details, he can hear the product number, location and product description spoken by the computer and can read it on the screen at the same time. Plus, the screen can display a product photo or image, if it is available in the database. Capturing an image from the warehouse is possible as well. Many

The Multi-Modal Warehouse | Getting the Mobile Worker in the Loop

Windows Mobile computers are available with imagers which can capture a bar-code and take a photo as well. If a worker notices that inventory is damaged, he can take a photograph of the product and send it to the WMS for resolution. This is especially useful as evidence in the receiving operation when damaged goods arrive on the dock.

Native multi-modal vs. interfaced information delivery

How is a multi-modal warehouse system delivered?

It's not as simple as buying Windows mobile devices and configuring them to operate with your WMS. Nor is it a speech system or pick-to-light system interfaced to the WMS. Any system bolted onto a warehouse system makes two systems.

Two or more systems require interfaced access to business rules and the database. If a speech system is interfaced to deliver speech instructions only, redundancy is not possible for reading text, bar-code or other data formats on a single device.

The warehouse system architecture needs to deliver and receive real-time messages that are packaged and sent in the appropriate format for all modes, yet be single, consistent packets of information. This creates a true, interactive dialog between the human and the computer. The continuous series of command and confirmation loops keeps the system and the worker in synch, in real-time. True multi-modal interaction requires that instructions/confirmations involve one system and not be parsed to another system, such as an interfaced speech system.

The solution is part of the core WMS functionality which maintains all of the business rules for locations, inventory, equipment, workers, customers, shippers, etc. as well as maintenance of the database which is available for access and input in real-time.

The database must deliver and receive information packets from these different modes seamlessly. For example, a location check digit and location bar-code, while different in the amount of information, is known to the system as the same entity as an alias.

Instructions which would otherwise be delivered to the worker in a multiple orders at a time (multiple lines, locations, quantities, etc. for each order) are now broken down into granular bits of instructions and confirmations. Warehouse managers still plan the total scope of work for shifts, zones and individual workers. But the system breaks down the work to create a natural flow of transactions and interactive loops as the worker makes his way through the entire assigned wave or series of work orders.

Most WMS systems are not equipped to send and receive information in appropriately packaged messages, even if the worker had a mobile computer capable of multiple input/output. Billions of dollars have been spent on wireless bar-code scanners, RFID, voice systems, Pick-to-Light, spreadsheet print-outs, clipboards and pencils. And even more money has been spent on warehouse systems that organize facilities and their workflow. The problem is all of these technologies have been developed independent of each other.

A multi-modal system design incorporates all phases of the core WMS applications, rules and database, the capacity for delivery to wireless mobile computers and the operational requirements of workers and managers. The IT infrastructure refocuses from centralized intelligence and control to distributed information flow to all users of a system.

One size does not fit all

Mobile automatic identification and data collection (AIDC) technologies have dramatically improved warehouse communications over the past two decades. Since Microsoft launched the Windows CE and Pocket PC operating systems for hand-held devices, more than a decade ago, manufacturers of ruggedized mobile computers have rolled out a wide array of integrated products.

Motorola (Symbol), Intermec, LXE and other manufacturers now offer a vast choice of Windows Mobile devices that accommodate virtually any warehouse environment. The challenge is selecting the best configurations which accomplish the tasks without the need to support more than two or three different types of computers. This is not easy because of the many different operational requirements and the wide choice of options.

It is strongly advised to work with your systems provider on configuration and selection of mobile computers. The software vendor has detailed knowledge of available hardware and tests each one to certify computers for compatibility. Testing includes voice circuitry, battery life, keypad configuration, scanning capabilities and ergonomic considerations.

The other difficulty in selecting the exact configuration is that not all features are available in combination with one another. Manufacturers have sought to minimize the number of individual SKUs in their product lines and only offer pre-set packages. Unless you are purchasing very large quantities of computers expect to select from pre-configured packages.

The following are the more significant factors which will guide your mobile computer selection.

Size/Form: There are many sizes and form factors for warehouse work. The smaller units, such as the Motorola MC70, are small enough to easily fit into a side holster for speech intensive applications. Most others (MC9090x, LXE MX7, etc.) are larger to accommodate extended keypads, long-range scanners and handle grips.

Operating System: The choice between Windows Mobile and Windows CE is usually dependent on the manufacturer due to licensing arrangements they have with Microsoft. This choice is less critical than other form-factors because both operating systems are typically interchangeable for most multi-modal applications.

Memory (RAM/ROM): 64MB/128MB is common with additional memory available in an SD card. Older units were delivered with 32MB of RAM which is not adequate for most applications.

Keyboard: Mobile computers usually offer a choice between a numeric keypad (26 keys) and a QWERTY keypad (44keys). Others have up to 53 keys and variable array of function keys, ESC, and configurable keys.

Monitor: Most monitors are 3.8" QVGA screens, 65K colors, 240 x 320.

Scan Engine: Scanning options range from 1D Linear Scanners and 2D Imagers which are both usually short range. Imagers double as bar-code scanners and cameras to capture images in the warehouse. Long range scan engines are available on only a few models. It is advisable to conduct a warehouse

The Multi-Modal Warehouse | Getting the Mobile Worker in the Loop

audit to detail short-range vs long-range scanning requirements because distances range from less than 12 inches upward to 50 feet.

Freezer: Most standard mobile computers temperature range is -4° to 122° F. Standard temperature for frozen foods is -22°. Many hand-held and vehicle mounted computers are available with heaters which allow them to operate at the freezer temperatures and to tolerate temperature changes and condensation from continually entering and exiting a freezer.

Truck mounted computers: This is an entirely different class of computers from handhelds, but is a requirement for many warehouses. Many truck mounted computers operate with a full version of Windows (Vista and XP) but can still be configured to process speech, bar code scanning (tethered) and other operations such as touch-screen and full keypad. Often monitors are available in full screen and half screen. Half screen computers sometimes are not compatible with warehouse mobile display requirements. One viable option is to use a truck-mounted holster for a hand-held computer.

Handle Grips: For scan-intensive operations, a handle is sometimes more comfortable for warehouse workers. Many units offer detachable handles so that they are interchangeable as scan-intensive vs. speech intensive applications.

Peripherals and Accessories: The choice of computers usually affects the selection of chargers, cradles, spare batteries, holsters and printers. It is advisable to select families of mobile computers which have common batteries to minimize the requirement for different charges. Holsters must accommodate the use of handle grips vs. no handles. Holsters for speech applications are usually specially designed to accommodate securing the headset plug into the computer audio jack.

Headsets: Specialized noise cancelling headsets are an important component of any speech-based system. Each worker should have his own headset for hygiene considerations. Freezer applications require a freezer compatible headset because of condensation and user comfort.

The varying requirements and the diverse availability of configurations make hardware selection a detailed process. Again, the systems provider should be involved with this selection process because of their testing and certifications and their knowledge of the dynamic. It is advisable to make the equipment purchase later in the system implementation process for two reasons: 1) You want to “test-drive” the final candidates to see which is the most acceptable to your situation, and 2) New technology is continually being released to the market.

The payoff of a single platform for multi-modal warehouse communications

Making mobile workers more productive and accurate is the biggest payoff of a multi-modal warehouse system. Eliminating communication issues, interruptions and incompatibility boosts productivity, accuracy and worker safety.

Multi-modal systems will be a recurring theme in warehouse systems of the future. Windows mobile computers are delivering more computing power to workers at a more attractive price-point than any time in history. Delivering the information to capitalize on this distributed, almost ubiquitous mobile technology is a challenge for most warehouse management software vendors.

A single platform incorporating a consistent database, operating system and remote worker technology makes true multi-modal operations possible. Improvements in WMS/worker interaction require a seamless translation of commands and confirmation in real time. Adjustments between modes need to be natural and transparent to the user in order to maintain work flow momentum. The worker is no longer expected to follow complex data input routines to satisfy the WMS. Data interchange is simplified and logical. The worker is truly technology enabled and equipped to execute transactions at the critical loop.

Cadre Technologies, Inc.

This white paper is published by Cadre Technologies, Inc. an independent software vendor, specializing in Microsoft based multi-modal supply chain execution and inventory visibility systems. Cadre's Cadence Warehouse Management System is the first multi-modal product that provides workers with speech, bar-code scanning, keypad and browser interface on a single mobile computer. The system operates in real-time on the Windows Server platform.

For more information about Cadre and its Cadence Warehouse and LogiView systems, please visit www.cadrettech.com or call 1-866-252-2373.

