RETAIL WAREHOUSE MANAGEMENT WITH SAP® SOFTWARE
BENEFIT FROM PROOF OF TECHNOLOGY AND PERFORMANCE
Overview

Many leading retail companies create value by leveraging a highly efficient, high-performing retail warehouse as the backbone of their commercial success. Thus, to help you make good business decisions about your retail warehousing, SAP provides a comprehensive proof of technology and performance for the latest version of the SAP® Extended Warehouse Management (SAP EWM) application.

To manage today’s challenges, your retail organization requires extreme performance, stability, and scalability of your warehouse management solutions as well as your IT infrastructure. This document provides comprehensive, up-to-date performance information to help you optimize your IT investments.

The information is designed for:
- Decision makers responsible for IT investments
- Customers implementing SAP EWM
- Partners providing implementation services

SAP built a dedicated test environment to:
- Optimize SAP EWM application support for processes for food and hard goods retailers, combined with guidance for detailed sizing and configuration
- Prove the high performance and scalability of SAP EWM
- Support and accelerate implementation projects for SAP EWM

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Completed in early 2010, the performance test project for the SAP® Extended Warehouse Management (SAP EWM) application offered comprehensive proof of performance and scalability in a real-world environment simulating a typical retail distribution center. The test focused on:

- Support for actual warehouse business processes and achievement of key performance indicators (KPIs)
- Retail-typical logistical volumes in hard goods and food assortments
- An increasing number of parallel users in warehouse processes for large retailers

In the performance test results, SAP EWM demonstrated the ability to handle:

- Live warehouse business processes, with the test covering 39 processes in 4 scenarios for:
  - Inbound goods receipt, including the material flow system with a programmable logic controller (PLC) emulation
  - Outbound goods issue, with 10 large picking waves for 42,000 delivery items each
  - Flow-through
  - Cross-docking
- Daily mass volumes of transactions and a secured flow of information between SAP EWM, automated PLC, and mobile devices and user interfaces (UIs), as proved within the required KPIs:
  - Receipt of and wave creation for 420,000 delivery items per day in about 1 hour
  - Release of picking waves within 15 to 20 minutes
  - Response time below 1 second for every process step performed in the mobile UI

We tested SAP EWM with industry-typical hardware resources and normal, measured resource utilization. The test evidenced a high scalability and efficiency of SAP EWM. In one of the most critical process steps, picking by a warehouse worker, SAP EWM enabled 180,000 delivery items to be picked within 60 minutes.

Note that the results surpassed the requirements of the KPIs.

One of the most important results pertains to time-critical daily processing of information on the SKU level and in a parallel-user environment. The test results showed that activities for complex and simultaneous warehouse processes were processed without issues, in the necessary time frames.

We tested SAP EWM with industry-typical hardware resources and normal, measured resource utilization. The test evidenced a high scalability and efficiency of SAP EWM. In one of the most critical process steps, picking by a warehouse worker, SAP EWM enabled 180,000 delivery items to be picked within 60 minutes in the outbound scenario.

All of the performance test results are applicable to every customer and partner because of detailed process descriptions that enable fast implementation and support for high-performing warehouse business processes.
The overall focus was on a very big grocery distribution center with more than 400,000 items per day of goods issue. In addition, we tested goods receipt and merchandise distribution. The warehouse included automated high-rack storage as well as mobile device integration. Thus, we examined all main performance-critical activities of a distribution center, both as single units and as simultaneous events.

The most important KPIs were as follows:
- Relevant mobile device transactions have a response time below 1 second.
- The time for distributing store orders from a central merchandise system is sufficiently short so that the data is available early enough in SAP EWM for planning purposes.

**Inbound Goods Receipt**

We tested the following scenario: obtaining goods from reliable vendors, with the warehouse already having been notified of all arriving physical deliveries via electronic data interchange or a similar notification method, such as fax.

The performance-measurement schemes differentiated between a big number of deliveries with only a few items each and a small number of deliveries with a lot of items. The scenario involved the following steps:
1. The full freight vehicle arrived with palletized goods.
2. The driver contacted the goods receipt office.
3. The office clerk posted the goods receipt.
4. Workers unloaded pallets from the freight vehicle.
5. Workers put away pallets, according to system-guided strategies, using a material flow system.

**Outbound Goods Issue**

The outbound goods issue scenario tested goods issue for stores, planned as distributed workload over the working hours by grouping deliveries according to their planned time of leaving the distribution center.

The measurement schemes tested a working period of either one shift or one of two shifts. We grouped the outgoing deliveries of one day in picking waves. For every wave, the following work was done:
1. After the internal replenishment from the high rack to the picking zone, warehouse workers picked products for each store per store order using material-handling trucks. The picking strategy was man-to-goods, and workers confirmed every pick.
2. At the same time, the empty freight vehicles arrived and docked at the doors.
3. After picking, workers transported the material-handling trucks to the goods issue staging area and then loaded every material-handling truck into a freight vehicle and printed the delivery note.
4. Workers closed the freight vehicle, and the vehicle left the distribution center.

**Flow-Through**

The flow-through focused on the following task: a planned distribution of products from vendor pallets to store material-handling trucks in the distribution center; this is called “product-driven flow-through.” This activity took place after a goods receipt, more or less without any storage time. As in the first scenarios, the assumption was that planning data was already in SAP EWM. The detailed steps were as follows:
1. The full freight vehicle arrived with palletized goods. (Every pallet contained only one product.)
2. Warehouse workers unloaded the pallets from the freight vehicle and transported them to the distribution area.
3. There, workers distributed the products as planned from the pallets to material-handling trucks for different stores. At the same time, empty freight vehicles arrived and docked at the doors.
4. After picking, workers transported the material-handling trucks to the goods issue staging area and then loaded every material-handling truck in a freight vehicle and printed the delivery note.
5. Workers closed the freight vehicle, and the vehicle left the distribution center.
4. After picking and staging, the workers loaded every material-handling truck into a freight vehicle and printed the delivery note.

5. Workers closed the freight vehicle, and the vehicle left the distribution center.

Simultaneous Scenarios

In addition to testing the scenarios individually, we tested them simultaneously, because this simultaneous processing occurs in real-life warehouses (see Figure 1). For example, outbound processes of subsequent picking waves could overlap in time. Outbound processes took place throughout the whole day, while most of the inbound processes took place in the morning.

The test scenarios covered a realistic set of business activities that are relevant for a large grocery distribution center. For efficiency, the implementation optimized support for processes and minimized the interaction of office workers with the software system. Mobile devices enabled system-guided, validated execution of the warehouse labor. To test potential performance-relevant characteristics of the scenarios, we examined extreme occurrences of the characteristics.
The test scenarios covered a realistic set of business activities that are relevant for a large grocery distribution center. For efficiency, the implementation optimized support for processes and minimized interaction of office workers with the software system. Mobile devices enabled system-guided, validated execution of the warehouse labor. To test potential performance-relevant characteristics of the scenarios, we examined extreme occurrences of the characteristics. However, the scenarios were still within the borders of expected business processes in retail.

Test Methodology

We conducted the test on a software system that we created by merely customizing a standard SAP EWM 7.0 application. The technical details of the test setup – such as the server hardware and the approach of consecutive test phases – are described in the appendix section of this document.

Master Data Setup and Warehouse Layout

The master data setup described here, together with the material flow depicted in Figure 2, gives a brief but informative overview of the implementation of SAP EWM. The layout in Figure 2 shows the material flow of all four scenarios in scope, abstracting from the real implemented warehouse layout. The left side was reserved for goods receipt, the right side for goods issue. The material flow started with unloading (inbound, flow-through, and cross-docking). In the inbound scenario, handling units were stored in high-rack storage that was fully automated by the material flow system. That means that the movement from the staging area to high-rack storage – that is, put-away – ended at the identification point of the high-rack storage area. SAP EWM controlled the material flow within the high-rack storage area by sending telegrams to the PLC.

The same situation existed for the replenishment step, which was the starting point of the outbound scenario. Here, workers moved pallets from high-rack storage picking points to the picking area. The pickers collected items from the replenished pallets and put them into material-handling trucks, which were then moved to the staging area (picking and staging). In the flow-through scenario, workers removed the received pallets (put-away) to the distribution area, and there the workers distributed items to material-handling trucks (picking), which were then transported to the outbound staging area. In the cross-docking scenario, workers directly moved pallets from the inbound staging area to the outbound staging area, a process that is also called “picking.” Finally, in outbound, flow-through, and cross-docking, workers loaded the staged handling units onto freight vehicles.

![Figure 2: Warehouse Layout for Performance-Testing Scenarios](image)
The master-data setup supported the intended throughput (see the table). The number of vendors, products, and stores reflected the quantity structure of inbound deliveries and outbound deliveries. In the first testing of the inbound scenario, for example, detailed in the section titled “The Inbound Scenario,” 1,000 items of 1 product each were delivered in 40 deliveries. The number of doors, in contrast, depended on the intended parallelization of the unloading and loading processes. In this test, for instance, 20 mobile users unloaded the 40 deliveries. In addition, because mobile users had to log in to unique resources of SAP EWM, these resources exactly mirrored the parallelization of the related mobile-based processes.

<table>
<thead>
<tr>
<th>Master Data</th>
<th>Inbound</th>
<th>Outbound</th>
<th>Flow-Through</th>
<th>Cross-Docking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vendors</td>
<td>40</td>
<td>-</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Stores</td>
<td>-</td>
<td>420</td>
<td>400</td>
<td>230</td>
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<td>1,000</td>
<td>24</td>
<td>24</td>
</tr>
<tr>
<td>Doors – In</td>
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<td>-</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Doors – Out</td>
<td>-</td>
<td>42</td>
<td>40</td>
<td>23</td>
</tr>
<tr>
<td>High-rack storage (material flow system)</td>
<td>4 identification points</td>
<td>4 picking points</td>
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<tr>
<td>Resources (RF) unloading</td>
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<td>-</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Replenishment</td>
<td>-</td>
<td>4</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Put-away</td>
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<td>-</td>
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<tr>
<td>Loading</td>
<td>-</td>
<td>42</td>
<td>40</td>
<td>23</td>
</tr>
</tbody>
</table>
The inbound scenario comprised the following steps.

The software received an advanced shipping notification (ASN) electronically and created a planned inbound delivery. SAP EWM received the ASN message via an interface between the SAP ERP application and SAP EWM. This standard interface distributed data of inbound deliveries from SAP ERP to SAP EWM. In this scenario, the ASN contained the planned data on arrival date and time, quantity and packaging information for materials, and so on. On creation of the inbound delivery in SAP EWM, the application performed the rough process planning, which defined the warehouse internal sequence of process steps.

The office clerk prepared for goods receipt. When the freight vehicle driver arrived, the receiving office clerk prepared the execution process by first checking and comparing the delivery papers with the inbound delivery data available in SAP EWM. The application provided a transaction, which enabled workers to select inbound deliveries by the external ASN document number and to display and change the inbound delivery data.

The office clerk posted the goods receipt and prepared for unloading. After validating the correctness of the inbound delivery data, the office clerk navigated from the delivery document screen to an unloading preparation screen, which provided an overview of the relevant unloading data. (The screen displayed the packaging information.) The office clerk posted the goods receipt for the whole delivery with a button available on this screen and then created unloading tasks for all the packages. Behind the scenes, the application determined the final put-away storage bin and created a planned put-away task. Thus, the application managed the warehouse planning process for the whole put-away process throughout the various warehouse storage types, including sophisticated put-away strategies. To enable software system-guided execution of the warehouse labor, the application created unloading tasks with an assignment to a work list, to which only the unload workers were subscribed.

Warehouse workers unloaded the freight vehicles. As soon as the unloading tasks were created in the software, SAP EWM enabled the unload workers to unload the freight vehicles using mobile devices. To start unloading for a freight vehicle, they entered the ASN document number into their mobile-device UI and then scanned the bar-code label of any pallet or package that was located on the freight vehicle. After the workers scanned the pallet label, the software provided information about the planned staging area where the unloaded pallet was to be dropped to await follow-up put-away processing. When dropping the pallet onto this staging area, the worker confirmed the unloading via the mobile device. This was facilitated by a mobile device enabled with a bar-code reader and a staging area that was labeled with a bar code. The workers unloaded all pallets on the freight vehicle. After the last pallet was unloaded, the software asked the unloading worker to enter the next ASN document number and then start unloading the next freight vehicle. After the worker confirmed the unloading of a pallet by the mobile device, the software immediately populated the work list of the warehouse workers who were in charge of put-away.

Workers performed put-away. The put-away worker saw the physical work to be done by looking at the pallets, which were in the staging area. The worker then scanned the bar-code label of a pallet with a mobile device, and the software guided the worker to move and drop the pallet onto the identification point of an automated high-rack storage section. For SAP EWM, this high rack could be any legacy material flow system. After dropping the pallet onto the identification point, the worker confirmed this by scanning the bar-code label of the identification point. Then the mobile device was ready for scanning any other pallet on any staging area.

An automated high-rack storage system moved goods to the final storage. Independent of any action of human workers, the put-away to the final storage bin was done by an integrated, automated process flow. This flow occurred between SAP EWM and the legacy material flow system (for example, a high-rack system) by means of the interface of SAP EWM to the material flow system. Immediately after the identification-point confirmation of the pallet, SAP EWM sent a request telegram to the legacy material flow system about the need for moving the pallet from the identification point to the final storage bin. The sending of the request telegram was based on a move task from SAP EWM for the pallet. Using
the move task, SAP EWM enabled full-process and real-time stocking, including the movements within the automated high rack. When the material flow system finished the movement, this move task was confirmed by a telegram message that SAP EWM received from the material flow system.

Values of Performance Characteristics (Inbound)

We used the following two scenarios for testing:
- Many supplier shipments with a small number of products each – The test assumed a time window of a maximum of 6 warehouse working hours for the inbound process, testing 40 inbound deliveries with 25 products each. The supplier packed every product onto 2 pallets, resulting in 50 pallets per delivery. Twenty unload workers and 4 put-away workers worked simultaneously.
- Few supplier shipments with a large number of products each – The test assumed a time window of a maximum of 6 warehouse working hours for the inbound process, testing 5 inbound deliveries with 200 products each. The supplier packed every product delivered into 2 packages, resulting in 400 packages per delivery. Five unload workers and 4 put-away workers worked simultaneously.

Using the move task, SAP EWM enabled full-process and real-time stocking, including the movements within the automated high rack. When the material flow system finished the movement, this move task was confirmed by a telegram message that SAP EWM received from the material flow system.
The outbound scenario comprised the following steps.

The software created the planned outbound delivery and picking wave. Via the standard interface, the SAP ERP application electronically passed the data of planned outbound delivery to SAP EWM, which created the planned outbound delivery in itself accordingly. This planned outbound delivery served as a request for warehouse processing and contained the planned and required data of outbound processes that had to be fulfilled and accomplished by the warehouse. In the preplanned outbound scenario, which is typical in the retail distribution center, this delivery distribution took place in a timely decoupled manner well before warehouse execution had to be started. Due to the high throughput nature of large retail distribution centers, retailers must limit manual user interactions. SAP EWM supports this by automated picking-wave creation, based on heuristics and rules. In the test, the picking-wave creation took place as an automated background job right after the creation of the planned outbound delivery. This automated wave creation took place before the morning shift of the warehouse started.

Workers planned and performed replenishment. The office manager planned for the picking to take place in a picking area, based on fixed bin assignments for the various products. SAP EWM supported this by guiding dedicated replenishment from high-rack storage to the picking area bins of the stock needed for picking waves. The shipping-office clerk used an operational warehouse-monitoring transaction to get an overview of the scheduled picking waves. The clerk could then trigger the replenishment process for these waves by creating all the product move tasks that were needed. The replenishment was a complex process. It involved an automated high-rack storage system that received a request telegram from SAP EWM for each replenishment task. The request was to move the required pallet from a high-rack storage bin to an identification point of the high-rack storage bin. Once the legacy material flow system moved the pallet to the identification point, the underlying move task of SAP EWM was confirmed. Confirmation occurred through an automatically created interface telegram from the material flow system of the automated high-rack system. Immediately afterward, SAP EWM activated a move task to the picking area and assigned the task to a work list. Warehouse workers who subscribed to this work list could use software system-guided work procedures with their mobile devices. SAP EWM advised them to pick up the pallet from the identification point and place it into the picking bin of the product. Pickup and drop-off were facilitated by bar-code labels of the identification bin and the pick bin, along with bar-code-labeled pallets.

The office clerk triggered the picking-wave execution by releasing the wave. When a picking wave was due to execute, the shipping-office clerk displayed and inspected the planned picking wave using an operational warehouse-monitoring transaction. The clerk also could apply manual changes to the automatically created picking wave, but this happened very rarely. Then the clerk released the picking wave. After a few minutes, the picking tasks were created and assigned to a work list, which was the basis of the software-guided picking process.

Workers picked items. The pickers of the warehouse who were subscribed to the picking work list followed software-guided work procedures using their mobile devices. They started the picking process by fetching two material-handling trucks from a truck buffer area and then began the software-guided picking. SAP EWM guided a picker to the first pick bin and displayed on the mobile device the picking information, which included the material to be picked, the required quantity, and the pick material-handling truck, where the item had to be placed. SAP EWM supports several units of measures in the picking process, such as boxes of 6 or 12 pieces. This box size was displayed to the picker, who then picked boxes instead of picking single pieces. Bar-code-labeled picking bins, bar-code-labeled boxes, and bar-code-labeled material-handling trucks facilitated this picking step.

Workers staged the material-handling trucks. After each worker finished picking and confirmed picks for the two trucks, the software guided the picker to move the material-handling trucks to a certain staging area by displaying the area in the mobile device. The picker moved the two material-handling trucks to the staging area and confirmed this via the mobile device. Bar-code-labeled staging areas facilitated this step. After staging confirmation, the software automatically created loading tasks for the material-handling trucks. It assigned
the tasks to the work list of the loaders, who could immediately start loading the material-handling trucks onto the freight vehicles. After having finished this picking round, the picker iterated this picking procedure by once again fetching two material-handling trucks and reentering the software-guided picking information on the mobile device.

A freight vehicle arrived and docked at a door. For each planned outbound freight vehicle in SAP EWM, the shipping-office clerks created the data about the planned freight vehicle arrival and departure. They assigned the deliveries that had to be loaded to this freight vehicle. They also planned a warehouse door for the freight vehicle and acknowledged this in the software system. This planning part could be accomplished either prior to the physical freight vehicle arrival or on arrival of the freight vehicle. The driver entered the office, and the office clerk registered the check-in of the freight vehicle at the warehouse site or yard. The office clerk told the driver at which specific door to dock the freight vehicle, and the clerk executed in SAP EWM the arrival of the freight vehicle at the door. Then the warehouse loaders could start the loading.

Workers loaded material-handling trucks onto freight vehicles. The loaders started the loading process by entering the identifier of the freight vehicle into their mobile devices. Then they scanned the label of any material-handling truck from the staging area near the door, and the software validated that this material-handling truck should be loaded onto this freight vehicle. They loaded the material-handling trucks and confirmed the loading in the software by scanning the door bar code with their mobile device. They continued until all planned material-handling trucks were loaded onto the freight vehicle. Then the application asked the loader for confirmation that there was no additional (unplanned) loading onto this freight vehicle. Such confirmation set a "loading finished" status for the freight vehicle in the software, which enabled the office clerk to be notified that the freight vehicle was ready to depart.

The freight vehicle departed, and the office clerk posted the goods issue. The office clerk started the desktop transaction, which displayed the current system data for one or several freight vehicles. The clerk recognized that loading was finished for a freight vehicle and triggered the printing of the needed paperwork, such as the creation of the delivery note. These printed documents were handed over to the driver, who then left the office and started the transport journey. While the driver walked to the freight vehicle, the shipping-office clerk posted goods issue for the whole truckload, executed the freight vehicle departure from the door, and executed check-out from the warehouse site or yard in SAP EWM.

Values of Performance Characteristics (Outbound)

In both scenarios of the outbound process, we tested the processing of 420,000 planned outbound delivery items in SAP EWM, which corresponded to the planned throughput of one day. We used the following two scenarios for testing:

- **Supply to a high number of midsize stores:** We assumed 420 outbound freight vehicles per day within a time window of about 16 warehouse working hours. Each freight vehicle had a load for five midsize stores. Each store had 200 products delivered in eight material-handling trucks, for a total distribution of 2,100 stores per day. The load of each freight vehicle was five deliveries, with 1,000 items in total. The load consisted of 40 material-handling trucks, each containing 25 different products. Each product was packed into one or several small boxes – for example, three boxes of six pieces of a product. Workers picked these boxes by means of 14 picking waves throughout the day, each wave having a size of 30,000 items and being dedicated for 30 truckloads. Three hundred pickers and 30 loaders worked simultaneously.

- **Supply to large stores:** We assumed 420 outbound freight vehicles per day within a time window of about 10 warehouse working hours. Each freight vehicle had a load of 1,000 products for a single large store. The load consisted of 40 material-handling trucks, each containing 25 different products. Each product was packed into one or several small boxes – for example, three boxes of six pieces of a product. Workers picked these boxes by means of 10 picking waves throughout the day, each wave having a size of 42,000 items and being dedicated for 42 truckloads. Four-hundred-twenty pickers and 42 loaders worked simultaneously.
FLOW-THROUGH PROCESS
RETAIL WAREHOUSE ACTIVITIES USING SAP EWM

The flow-through scenario comprised the following steps.

The software created planned outbound delivery and inbound delivery. Similar to the inbound and outbound scenarios, SAP EWM received the delivery data from SAP ERP via the standard interface between SAP ERP and SAP EWM. SAP EWM created deliveries according to the planned data. The flow-through was a preplanned process.

The office clerk prepared for goods receipt. This was done as in the inbound scenario.

The office clerk posted the goods receipt and prepared for unloading. This was done similarly to the process for the inbound scenario except that, for the sake of spanning a broader test space, the clerk posted the goods receipt after preparing for unloading.

Workers provided material-handling trucks for picking. One or several workers were in charge of providing material-handling trucks for picking in the outbound areas of the flow-through work centers. Because of the preplanned nature of the process, they had to do this prior to the flow-through picking and distribution and could accomplish it in parallel to unloading and put-away. When a worker placed a material-handling truck in the outbound area, the worker acknowledged in the software the existence of the material-handling truck for picking.

Workers unloaded the freight vehicles. This was done as in the inbound scenario.

Warehouse workers performed put-away. This was done similarly to the inbound scenario except that the put-away drop bin was not the high-rack identification point but the input area of a work center where the flow-through goods would be distributed. The software guided the put-away workers to the preplanned work.

In both scenarios of the outbound process, we tested the processing of 420,000 planned outbound delivery items in SAP EWM, which corresponded to the planned throughput of 1 day.

Workers picked items by distributing an inbound pallet to several outbound material-handling trucks, each being delivered to a separate store. The workers of the work center started their work by a logon to the work center. Then the workers started the picking by scanning an inbound pallet in the inbound
area of the work center. The application guided each worker via the worker’s mobile device. The software informed the worker about which product and quantity had to be fetched from this inbound pallet and placed into which outbound material-handling truck. The worker acknowledged in the software the fetch and placement by scanning the bar code of the inbound pallet and the outbound material-handling truck. The software continued to guide the work to be done until the inbound pallet was empty. Then the worker scanned another inbound pallet and picked items from this pallet. The worker iterated work on several inbound pallets. When all inbound pallets were empty, the worker acknowledged the completion in the software system by scanning all the outbound material-handling truck bar-code labels and marking them as finished.

Workers finished staging. As soon as an outbound material-handling truck was marked as finished, the staging worker started the staging by using the mobile device to scan the material-handling truck’s bar-code label at the outbound area of the work center. The software guided the worker by displaying the planned staging area. The worker acknowledged the accomplished staging by scanning the bar code of the staging area.

A freight vehicle arrived and docked at a door. This was done as in the outbound scenario.

Workers loaded material-handling trucks onto freight vehicles. This was done as in the outbound scenario.

The freight vehicle departed, and the office clerk posted the goods issue. This was done as in the outbound scenario.

Values of Performance Characteristics (Flow-Through)

We conducted the test with one scenario: a single supplier shipment with few products for 400 separate store deliveries. The test assumed a time window of a maximum of 4 warehouse working hours for the flow-through process. It used 1 inbound delivery with 24 products, each having a quantity of 2,400 pieces, packed in boxes of 6 pieces. Each product was on a single inbound pallet. On the inbound pallet were 400 boxes. The 24 inbound pallets were distributed to 400 outbound material-handling trucks, which were related to 400 store deliveries. The store deliveries were made by 40 freight vehicles, each containing the deliveries for 10 stores. Each freight vehicle contained 10 material-handling trucks, each of which contained the boxes of 24 different products. One unload worker, 1 put-away worker, 1 worker for providing the empty material-handling trucks for picking, 24 pickers, 40 workers for staging, and 40 loaders worked simultaneously.
The cross-docking scenario comprised the following steps.

The software created planned outbound delivery and inbound delivery. Similar to the inbound and outbound scenarios, SAP EWM received the delivery data from SAP ERP via the standard interface between SAP ERP and SAP EWM. SAP EWM created deliveries according to the planned data. Cross-docking was a preplanned process.

The office clerk prepared for goods receipt. This was done as in the flow-through scenario.

The office clerk posted the goods receipt and prepared for unloading. This also was done as in the flow-through scenario.

Workers unloaded the freight vehicles. This was also done as in the flow-through scenario.

Workers performed cross-docking (picking). Each warehouse worker started a software system-guided putaway, which used the cross-docking work list. The system guided the worker to a specific inbound staging area and pallet. When the worker scanned the bar code of this pallet, the software displayed the planned destination outbound staging area. The worker moved and dropped the pallet to this area and acknowledged the drop by scanning the bar code of the area. Then the system guided the worker to the next inbound pallet. The system-guided work iterated as long as there were inbound pallets existing in the inbound staging area.

A freight vehicle arrived and docked at a door. This was done as in the flow-through scenario.

Workers loaded material-handling trucks onto freight vehicles. This was also done as in the flow-through scenario.

The freight vehicle departed, and the office clerk posted the goods issue. This was also done as in the flow-through scenario.

Values of Performance Characteristics (Cross-Docking)

The test was conducted with one scenario: many supplier shipments cross-docked to many separate store deliveries. The test assumed a time window of a maximum of 4 warehouse working hours for the cross-docking process, as well as 230 inbound deliveries, each having 24 products. Each inbound delivery consisted of 3 pallets, with each pallet containing 8 products. The goods were delivered by 230 deliveries to 230 stores, each having 24 different products in 3 pallets, which were received by several inbound deliveries. The transport to the stores was made by 23 freight vehicles, each having the load of 10 deliveries for 10 stores and thus containing 30 pallets. One unload worker, 3 pickers, and 23 loaders worked simultaneously.

The performance tests revealed that SAP EWM could achieve or surpass all KPIs derived from the business requirements of a big grocery warehouse. The tests proved the scalability and robustness of SAP EWM and showed the ability of SAP EWM to fully process 420,000 outbound delivery items in a 10-hour business day. Stress tests on the crucial outbound picking transaction showed that even 180,000 items per hour could be picked. All heavily used mobile UI transaction steps had average response times below 900 ms.
The performance tests revealed that SAP EWM could achieve or surpass all KPIs derived from the business requirements of a big grocery warehouse. The tests proved the scalability and robustness of SAP EWM and showed the ability of SAP EWM to fully process 420,000 outbound delivery items in a 10-hour business day. Stress tests on the crucial outbound picking transaction showed that even 180,000 items per hour could be picked. All heavily used mobile UI transaction steps had average response times below 900 ms. Moreover, the creation of 420,000 delivery items and their assignment to 10 created picking waves took less than 1.5 hours. The simultaneous inbound and outbound scenario mix successfully simulated a productive system.

Overall Results

We intensively and systematically tested the performance of SAP EWM 7.0 in more than 500 test runs that resulted in a wealth of performance measurements (see Figure 3). For the sake of being comprehensive, we focus here on the most important transactions. Transactions consisted of a series of dialog steps. All response times given here refer to the average of the most complex and resource-intensive dialog steps of the respective transaction. It does not refer to the average response time of all dialog steps within a transaction (which was well below 100 ms).

All results are related to the scenario that posted the greater challenge, which is the inbound goods receipt from few suppliers and the outbound goods issue to large stores. The latter was more challenging than the former in terms of transactional performance issues and resource consumption requirements. All performance optimizations related to SAP EWM are included in the support pack SP06 of SAP EWM 7.0.

SAP EWM created 420,000 outbound delivery items assigned to 10 waves in 1 hour and 25 minutes.

One outbound wave could be fully processed in less than one hour. This includes docking of a freight vehicle to a door, picking, staging, loading, goods issue, creation of the delivery note, undocking from the door, and checkout from the yard.

A stress test on the outbound picking and staging process revealed that retailers can achieve a throughput of 180,000 picked items per hour – far beyond the original KPIs. In these tests, SAP EWM demonstrated its robustness and stability. A scalability test proved that the system resource consumption of this crucial process is linear.

The most complex and resource-intensive dialog steps of all important mobile (RF) transactions of all four scenarios had an average response time of less than 900 ms. In our scenario the response time of PLC-related telegrams showed that SAP EWM is no bottleneck for the PLC.
The throughputs of selected transactions are given in the table. Note that these values were not from stress tests, which would target a maximum throughput. Instead, the throughputs were dependent on the number of users and the average think times chosen for the tests. These parameters were derived from the analysis of the required throughput of a real customer’s warehouse. Further, the hourly throughputs were extrapolated from runs that usually take below one hour (see the “Measured Throughput” column).

### System Throughput

The throughputs of selected transactions are given in the table. Note that these values were not from stress tests, which would target a maximum throughput. Instead, the throughputs were dependent on the number of users and the average think times chosen for the tests. These parameters were derived from the analysis of the required throughput of a real customer’s warehouse. Further, the hourly throughputs were extrapolated from runs that usually take below one hour (see the “Measured Throughput” column).
The high load in the first 15 minutes was due to the release of the next wave running in parallel to the 420 pickers of the current wave (among other processes). The remaining time was dedicated to loading, creation of delivery notes, goods issue, and shipping transactions. The numbers in the circles refer to the related steps in Figure 2.

In the performance test, the load created by the smaller scenarios of cross-docking and flow-through is negligible compared with the related load for the outbound and inbound.

The most complex and resource-intensive dialog steps of all important mobile (RF) transactions of all four scenarios had an average response time of less than 900 ms. In our scenario the response time of PLC-related telegrams showed that SAP EWM is no bottleneck for the PLC.

**Find Out More**


**CPU Utilization in Simultaneous Scenario**

In the online scenario, the hardware underlying the software system under test was at no point a bottleneck, as can be seen in Figure 4. The figure shows the CPU utilization during the full processing of one picking wave run simultaneously for all inbound processes. During this run, we configured the server for 20 CPUs (40 cores).
Data Setup
We created the master data and initial transactional data setup on the basis of the goal of the KPIs. We used standard functionality in SAP and the legacy system migration workbench that is part of the SAP NetWeaver® technology platform. The master data quantity structure is described in the section of this document titled “master-data Setup and Warehouse Layout.”

Single-User Testing
In the subsequent phase, we tested the implementation of SAP EWM for single-user performance, using SAP GUI scripting. We ran RF transactions in SAP GUI.

Load Test
Finally, we developed a series of complex scripts from SAP LoadRunner to automate the test and simulate online users. We focused on scalability and throughput, again driven by the KPIs defined in the first phase. We extrapolated the technical layout and hardware footprint (described in the section in this Appendix titled “Technical Setup: System Landscape and Test Environment”) from the resource consumption measured in the single-user test phase. We tested three kinds of load:

Test Setup
The standard SAP EWM 7.0 application was deployed on a server of 117,000 SAPS, with 21 dual-core CPUs. SAP Application Performance Standard (SAPS) is a hardware-independent unit of measure. SAPS values are the yardstick with which partners show how well their hardware works with SAP software. The SAPS unit of measure was established in 1995, and 100 SAPS is defined as the computing power to handle 2,000 fully business-processed order line items per hour.

In addition, we emulated a legacy material flow system and connected it to SAP EWM via the plant connectivity functionality of the SAP Manufacturing Integration and Intelligence (SAP MII) application. We tested all relevant desktop and handheld transactions with the SAP LoadRunner application by HP – in isolation as well as in a scenario mix in which all inbound and outbound processes were running simultaneously. The handheld transactions used RF devices.

Test Approach
We structured this performance test in consecutive phases, starting with a thorough analysis of the scenarios in scope and the KPIs to be met. As a result of this assessment, we implemented SAP EWM as part of a system running SAP SCM 7.0. Only standard customizing was allowed; no additional modifications or programs were permitted. The only exception was a series of programs in the ABAP® programming language, which simulated the interface of the SAP ERP application, which usually feeds SAP EWM with delivery documents. This simulation made it possible to focus on the back end of SAP EWM and to simplify the test landscape. Further, the implementation included an emulation of a PLC that was connected via the plant connectivity functionality. The PLC, along with the material flow system, was responsible for controlling automated high-rack storage.

Data Setup
We created the master data and initial transactional data setup on the basis of the goal of the KPIs. We used standard functionality in SAP EWM (such as stock upload) and the legacy system migration workbench that is part of the SAP NetWeaver® technology platform. The master data quantity structure is described in the section of this document titled “Master-Data Setup and Warehouse Layout.”

APPENDIX
TECHNICAL DETAILS
The technical setup of a performance lab environment is a representation of the targeted production environment (see Figure 5). To understand the former, we had to sketch out the latter. The production landscape – simplified and without technical details – is depicted below.

In the center stood the back-end application, SAP® EWM, which was a supply chain management software system. It exchanged business documents (for example, delivery notifications) with SAP® ERP. SAP Extended Warehouse Management (SAP EWM) exchanged telegrams with the PLC for control of the high-rack storage. The PLC was connected to the back end via the plant connectivity functionality.

We broadly grouped end users into two classes. The first users worked in the office with the front end of the SAP software (SAP GUI) running on desktop PCs. The second worked at the handling units (pallets, material-handling trucks, and so on) with mobile devices that were wirelessly connected to the back end. These devices were connected via Internet transaction server (ITS) mobile technology over HTTP.

The layout of the test environment is depicted in Figure 6. The system under test consisted of SAP EWM installed on an IBM pSeries P595 server with IBM System Storage DS8000 and the material flow system emulation. SAP EWM ran as part of SAP SCM 7.0 SP04, with IBM DB2 9.5.004 as the underlying relational database management system (RDBMS).
SAP SCM, as well as the RDBMS software, ran on a single logical partition (LPAR) with up to 21 dual-core POWER6 5.0-GHz CPUs, with simultaneous multithreading (SMT) enabled.

The Java-based material flow system emulation was deployed on VMWare Server running Windows 2003, connected to SAP SCM via the plant connectivity functionality of SAP MII.

The load from HTTP and SAP GUI was generated with SAP LoadRunner 9.1 running on Windows 2003.