TECHNICAL NOTES

VASFT001

AWMS™ Adaptive Warehouse Management System

This paper is an introduction to the features and concepts of an Adaptive Warehouse Management System or AWMS™. The features of a non-adaptive system are reviewed and then contrasted with the features of an adaptive system. These concepts are then used in an application example to further demonstrate an AWMS.

Non-adaptive systems more often take the position that reality is represented by the systems internal data and that non-conformant events (or exceptions) should be forced to conform to that internal representation. If conformity cannot be forced, the non-conformant event should be treated as a "logged anomaly" which essentially ignores the event. An inherent design flaw in a non-adaptive WMS is that the "data is reality", and in order to change reality, the system is first changed and it is assumed the real world will follow. This limited view often results in data inconsistencies due to incomplete or non-existent information updates after one of those exceptions.

On the other hand, an Adaptive Warehouse Management System (AWMS) uses the basic design principle that "internal data models reality". An adaptive system recognizes inconsistencies in information, and resolves those inconsistencies. Further, an AWMS may often have features that evaluate events as they occur and determine the individual action to take based on the current conditions. "Real-time dynamic optimization" is the term used by VAS to describe this evaluation and setting of a new course of action.

The following example for the Mandate® AWMS starts with a discussion of warehouse locations and location identifiers. An AWMS will typically have unique location identifiers for any place that may contain items to be managed within the AWMS. Examples include fixed locations such as racks of all types, floor positions, bins, rooms, areas, yards, buildings, facility, workstations, "lost location", stackers, carousels, conveyors, and moveable locations such as trailers, pallets, cartons and totes. Locations in the Mandate® AWMS have an attribute called the "parent location". The "parent location" of a location indicates the "current location" of the item. The parent location of a fixed location is not normally modified. An example of location parentage is a carton has a parent of a pallet, which has a parent of a workstation, which has a parent of an area, which has a parent of a building or facility.

An AWMS example includes a concept of what VAS describes as "believing the last liar". This concept is different from "believing the last lie". A lie is something that is not true, while a liar is a source of information, which is known upon occasion, to provide false information. The notion of believing the last liar implies that new information has intrinsically greater validity than old information. This notion is inherently true because, when evaluating the source of the old information, it too will be discovered to have originated from a liar. Of course, this concept or philosophy cannot be the only basis for making decisions that will establish a current view of reality but it is the basis for adaptiveness. To "adapt" is to "change based on the current environment".

When put into these terms, no WMS provider in his or her right mind would wish to claim to be non-adaptive. Many will claim that the adaptive (or non-adaptive) features are just part of the specification of the system. In certain cases, this may well be true.

The true distinction of an AWMS is that it has an inherent inclination to accept new information to establish its current image of reality.

Now, for the example: Carton 1234, an assumed unique carton license plate number, is believed to have been placed on pallet 1. Pallet 1 is reported to have been placed in rack location XYZ. For this example, assume the carton and pallet are in their respective desired locations so that the AWMS has no inclination to move them.

The wording of these statements of conditions and events in an AWMS is important. All statements need to be understood as the "most likely truth" and in an AWMS are only believed to be true. This is a recognition that any and all statements of fact have, under certain circumstances, been known to be false. In the statement above, cartons have been known to have been mis-labeled as to make their license plate numbers non-unique. Cartons have also been known to be placed on the wrong pallet or even lost. Additionally pallets themselves have been mis-labeled and placed in the wrong location. Locations have even been known to be mis-labeled. For our example however, since this is the only information known to the AWMS, it will report the actual location of carton 1234 as on pallet 1 in rack location XYZ. This is the perception of reality in the AWMS.

Now, a new piece of information is received by the AWMS. A conveyor barcode reader reports an unexpected carton – carton 1234 at a particular zone. The AWMS will inherently adapt to this situation unless specific conditions are set forth to prevent its adaptation. To adapt, an AWMS "knows" that a single carton cannot be in two places at the same time so an AWMS will remove the carton from pallet 1 and automatically update the inventory for both pallet 1 and location XYZ to reflect the loss of the carton and its contents. The AWMS will then automatically update the location of the carton to reflect that it is now in the reported conveyor zone.

With the newly given input, the AWMS will report the actual location of carton 1234 to be on the conveyor. The AWMS will also report of pallet 1 and rack location XYZ as not including carton 1234. This is the newly adapted perception of reality in the AWMS.

As stated before, an AWMS often has features that support real-time dynamic optimization. If it has these features the AWMS will evaluate events as they occur and determine the individual action that should be taken based on the current condition. This is not as complex as it sounds. Recognize that most operational events are not unexpected – most events are exactly what are expected. Additionally, if the planning process includes only decisions that have to be made at that particular time, exceptions will not result in massive re-plans.

In our example, if real-time dynamic optimization is not supported, the AWMS would normally look at the desired location of the carton, and determine it should be on Pallet 1 in rack location XYZ. The AWMS will attempt to route the carton to that location. Typically, this would cause the carton to be routed to a no-read area where the carton is manually rejoined to the pallet.

If real-time dynamic optimization is supported, the AWMS, detecting the unexpected condition would re-evaluate the desired location of carton 1234. The rules for re-evaluation are defined to minimize operational impacts. Examples of existing Mandate AWMS rules for re-evaluation include 1) check if the carton could be used to efficiently fill a current order and if so use the unexpected carton and cancel any less efficient pending actions to fill that same order. 2) If there is no order for use, evaluate the stock levels for various stock areas and determine where it is best to re-stock the carton. Update the desired location of the carton to reflect the results of the re-evaluation. Then route the

carton “toward” this newly optimized desired destination.

To conclude, an adaptive warehouse management system with real-time dynamic optimization is constantly resolving inconsistencies in information and optimizing the best course of action to take based on the current conditions and new information.