Intelligent Order Management Systems

White Paper
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Introduction

For many industrial organizations in the USA, post World-War II, life used to be simple. You made a large quantity of a few standard products and stocked them in a warehouse. You then shipped these products from the warehouse in response to customer orders and made more products when inventory ran low.

Then, in the 1970's and 1980's the world changed. Most long-run manufacturing was moved offshore to take advantage of lower labor costs and more business-friendly regulations. As a result, the surviving manufacturing plants in the USA had to become experts in how to make products in small batches with a turn-around time shorter than the 6 weeks or so that it was economical to ship these products from Asia.

Then in the 1990's came the concept of a "Market of One" with the need to ship a wide-range of custom products, tailored to the individual needs of each customer. And finally, or so we thought, in the new Millenia, along came Amazon, with its promise of overnight delivery for consumer products, which quickly led to the demand for rapid delivery of customized industrial products.

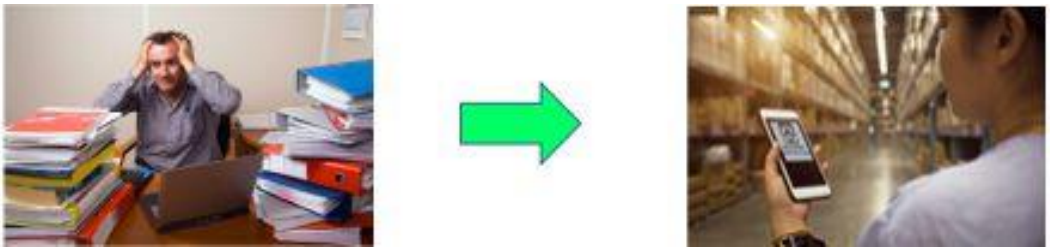
Then came Covid and the war in Eastern Europe, which has precipitated the collapse of Global Supply Chains, shortages of materials, and the reshoring of manufacturing in the USA. But this did not take away the demand for rapid delivery of semi-custom products. In fact, with a necessary change from supply chains to supply networks, this trend has been exacerbated.

As one Production Manager lamented, I use to make 5 products at a time, with each product running for many weeks, and was able to plan my raw materials purchasing and manufacturing schedule weeks ahead of time. Now I have several hundred jobs at a time, each with a few-days delivery time, running through 25 work centers. As a result, job scheduling and materials planning has become a nightmare, especially with sudden and unexpected disruptions to my supply chains.

In most manufacturing plants, this has resulted in far more people needed to monitor, plan, and schedule manufacturing operations and related materials purchases than are required to run the automated machinery that actually make the products.

In this White Paper we examine how KnarrTek's Intelligent-Agent technology can assist a small number of people to manage and control the flow of orders through one or more manufacturing plants and their associated warehouses, to ensure rapid on-time delivery of semi-custom products.

Technology Evolution



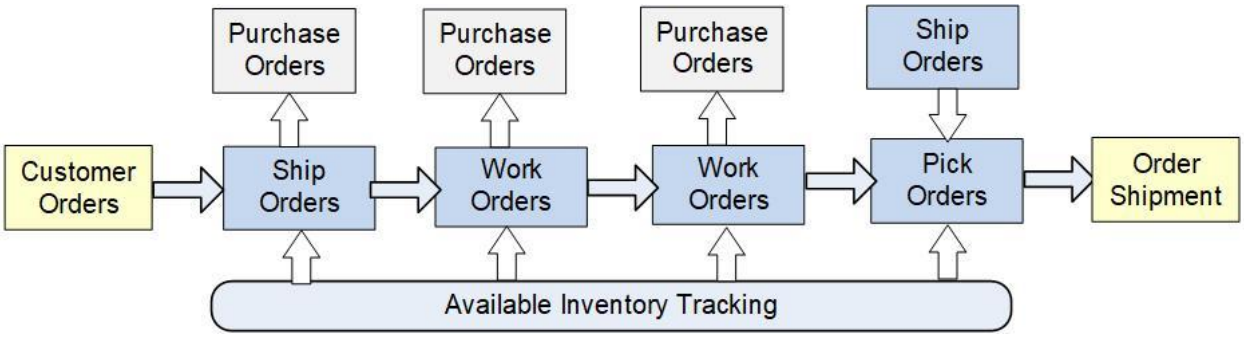
Materials Requirements Planning (MRP) algorithms were developed in the last century to automate the planning of what intermediate materials and finished products to make and what materials needed to be purchased. These MRP algorithms were based on the Bills of Materials (BOMs) for parts and a schedule of finished products to be made, which were typically based on sales forecasts.

These algorithms started with a planned baseline inventory for the start of the planning period (next week, next month) and then generated a schedule of parts to make and parts to buy (over the next few weeks or months), assuming nothing else was going on in the manufacturing plant. They were further refined in MRP II to incorporate scheduling information, such as the predicted resource availability (machines, people), and were expanded to work over a set of linked plants and warehouses, in EPR or Enterprise Resource Planning systems.

These systems, which were pioneered by Toyota, worked very well for long-run manufacturing, such as in automobile manufacturing, where there were weeks or months of predictable demand for their products. But they have failed to work in today's situation, for most Manufacturers in the USA, where customer orders arrive daily, at random times, with expected delivery times of a few days. Also, work cannot be scheduled weeks ahead of time, as people may suddenly be unavailable due to Covid 19, and supplies may not arrive on time due to supply chain problems.

As a result, manufacturers in the USA have been forced to adopt a dynamic order Management process.

Dynamic Order Management Processes



In a dynamic order management process, customer orders can be received from a variety of sources, such as from:

- An E-Commerce website

- Orders entered manually into a Sales Order or CRM System based on FAX, Phone, and Sales Person Orders.
- Orders received from an ERP or Accounting System
- Orders received directly from Customer Systems, such as by EDI.

As each order arrives, it is compared with in-stock inventory and required safety stock levels. Then one or more of the following orders are generated:

1. A Ship Order to ship parts from stock.
2. A Work Order to make products
3. A Purchase Order/Requisition to buy more materials and a corresponding Receiving Order to receive those materials into Stock
4. A Pick/Move Order to move materials from one location to another.

These orders are based on the available inventory, which is the quantity of available material in stock, less the materials needed for already issued Work Orders and Ship Orders, plus the quantity for materials planned to be made, based on issued Work Orders, and the quantity of materials planned to be received.

Predicted available inventory is a time varying function that is continuously changing with the arrival of new orders and materials, shipment of existing orders, and the running of jobs. This gets even more complicated when multiple plants and warehouses are involved.

As Ship Orders are generated, Work Orders may be issued as a result, based on the BOMs of parts to be made. These may then lead to the generation of other Work Orders and Purchase Orders/Requisitions.

The benefit of this dynamic demand-based planning is that it happens in real-time without the need to need to totally replan operations each time an MRP algorithm is run. It eliminates the need to stop production, and replan everything whenever a shipment is late, a machine goes down, or a critical employee is absent. Instead, Orders are created, adjusted, and shipped dynamically as they flow through one or more warehouses and manufacturing plants.

Instead of having a fixed schedule, Orders are scheduled dynamically, in real-time, according to wanted dates and the availability of needed material, people, and equipment. This leads to making the best use of resources, available at the time, to process customer orders through plants and warehouses.

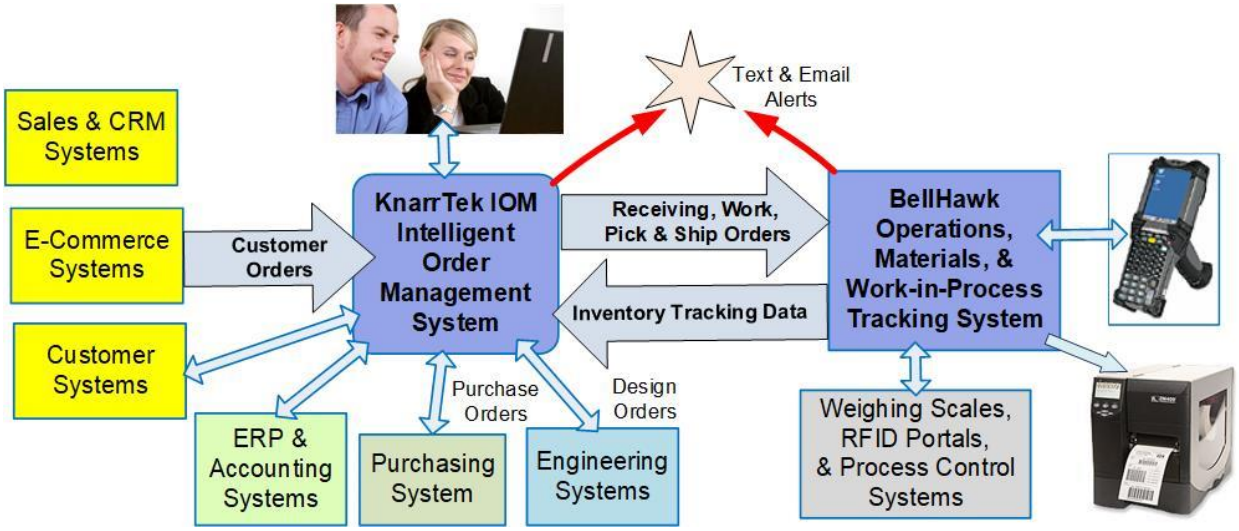
Many industrial organizations attempt to manually follow this process, out of necessity, using an inventory tracking system combined with Excel spread sheets, E-Mail, and a lot of time wasted in daily planning, scheduling and coordination meetings. This consumes an enormous amount of time of operations, materials, and supply chain managers, and their staff.

KnarrTek Intelligent Order Management System

While the functions performed in the dynamic order management process are straight forward to state, in reality there are an enormous number of situations that can arise in this process, such as:

- "What do we do if the delivery truck runs into a ditch?
- "Can we substitute an alternate part?
- Should we Make or Buy this component?
- Should we run this on Machine A which is slower but available or wait for the availability of Machine B, which is faster?

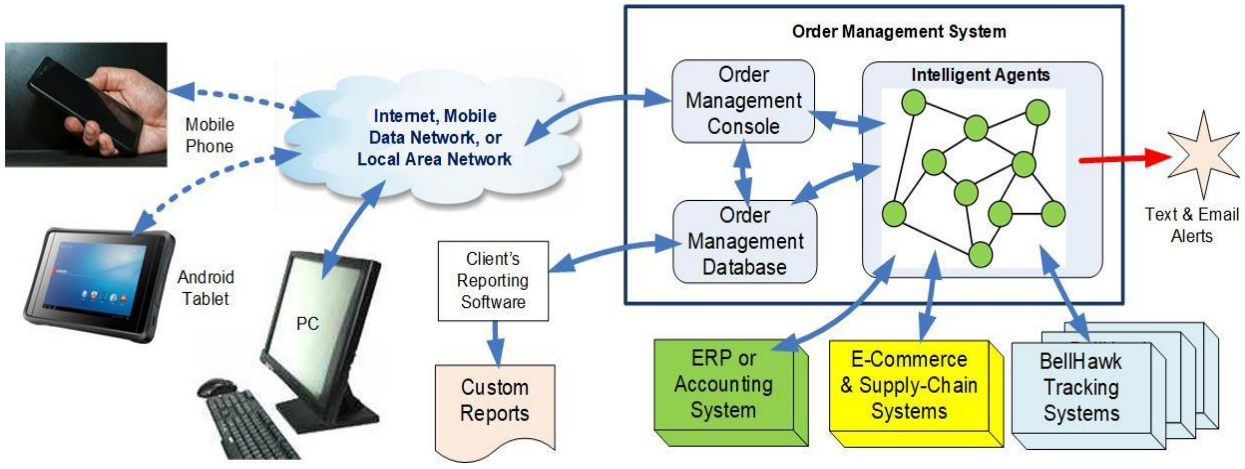
The answers to these questions typically depend on the specific organization, its current order flow, and the need to make decisions quickly, i.e.in near real-time. This is why it takes a small army of people to monitor what is happening, decide when a problem has occurred, make the appropriate decisions, and then take the appropriate decisions. It is also why these same people spend a lot of time in "coordination" meetings.



In the Intelligent Order Management (IOM) systems implemented by KnarrTek, we deconstruct the problem into two parts:

1. Tracking and monitoring the status of inventory, operations and work-in-process within each manufacturing plant or warehouse. This is done using our BellHawk software
2. The conversion of Customer Orders into a sequence of Design, Purchase, Receiving, Manufacturing, Picking and Ship orders, which are sent to one or more BellHawk Systems for action, and or are sent to other systems for information or action.

Within a KnarrTek IOM system there are a number of components:



1. An Order Management Database which tracks the current status of orders, including customer and purchase orders as well as the status of ship, work, and pick orders at each of the locations served by a BellHawk tracking System. This database also tracks the available inventory at each geographic location.
2. An order management console, through which users can enter customer orders and track the status of all the related orders at different locations. This interface can also be used to run custom reports when needed.
3. Interfaces to other systems within the Enterprise's IT infrastructure as well as possibly with customer and supplier systems. These are used to automatically exchange data which is related to order management.
4. A set of Intelligent Agents whose role is to:
    a. Convert customer orders into ship orders
    b. Convert ship orders into work orders and purchase orders
    c. Convert ship and work orders into pick/move orders
    d. Track the status of materials and operations and Alert managers and their staff when actions need to be taken. This is done by means of Email or Text messages.

The orders that are generated, can be automatically sent to multiple BellHawk systems in different geographic locations, with the results of these actions tracked in one central IOM system.

Intelligent agents are scripts, written in Python, that monitor a database table for changes and then update other database tables as a result and/or send alert messages.

Each agent carries out a small part of the decision making, such as:

- Converting new customer orders into ship orders
- Converting new ship orders into pick orders for warehouses and/or work orders to make finished products
- Converting work orders into purchase orders for needed raw materials and other work orders for making intermediate materials.
- Issuing pick orders to move materials from a warehouse to the shop floor

By breaking down each of these actions into an Intelligent Agent script, we can limit the decision making incorporated into each individual agent, thus simplifying code development and especially testing.

Each Intelligent Agent is independently scheduled through the IOM console interface to run periodically, which avoids the need to write one large body of code that integrates all the decision making that has to take place within the IOM.

Instead, Agent scripts can be added dynamically to an already running system or an updated Agent script substituted for a previous version in a running IOM system. This enables the use of Agile development methods where the decision-making capability of the IOM can be progressively extended over time, without going back and retesting the system as a whole, as would be needed if one large body of code were used for the decision making.

This results in quicker and less costly deployment of Intelligent Order Management Systems.

Operational Aspects of Intelligent Order Management Systems

Much of the work of incrementally converting customer orders to ship orders, ship orders to work orders and the like can be automated by Intelligent Agents that run continuously to monitor events and carry out the needed actions. This can automate a large amount of the work involved in routine materials and operations management, in response to customer orders, of which we have just scratched the surface in this paper.

Also, real-time scheduling of the actions needed to carry out orders can be done automatically by each BellHawk system to make sure that these actions occur in a reasonably optimal sequence. This does not ensure that all customer orders get delivered when promised but that the most important orders will be worked on and shipped first, within the limitations of the resources available.

But there are also situations where things are not going according to plan and intervention by experienced managers and their staff are required. In this case, both the IOM and BellHawk can use Intelligent Agents to monitor the situation and send Email or Text message alerts to managers and their staff when intervention is required.

While converting the day-to-day routine monitoring, analysis, and decision making work of operations and materials managers, and their staff, into Intelligent Agent scripts is a lot of work,

in its self, once it is done then a tremendous amount of “busy work” currently done by these people is replaced by Intelligent Agents that work tirelessly around the clock.

Does this mean that these people are no longer needed? No, we still need managers to manage the people and relationships involved, and their staff to work on analyzing results and implementing process improvements. But these people, will no longer have to waste a large amount of time doing routine scheduling and planning using Excel spreadsheets or in every day coordination meetings.

Commentary

With the reshoring of manufacturing to the United States, manufacturers and distributors are finding great difficulty in recruiting or keeping experienced materials and operations managers, many of whom are approaching retirement age. With a system, such as a KnarrTek Intelligent Order Management (IOM) system, industrial organizations can enable their existing managers to manage much higher throughput, with far fewer support staff, by automating many of their routine management tasks.

Such a system can also help staff retention by reducing the stress level for managers by taking away the need to try to spot troubles before they occur. Instead, the IOM can do much of the monitoring for them, automatically, 24x7, and only alerting them when actions are needed.

What about the cost of implementing an IOM system, tailored to the specific needs of each organization? While it is hard to generalize, the cost of writing all the needed scripts or customizing individual scripts for an individual manufacturing plant may typically cost between $50,000 and $150,000. This cost is recouped, in most cases, within one year by the savings in the cost of staff people who would otherwise be needed to perform these tasks manually.

This does not count, the increase in sales, resulting from quicker on-time deliveries of customer orders and improvement in overall operational efficiency resulting from efficient scheduling of production and warehouse operations.

Author

This white paper was written by Dr. Peter Green, who serves as the Technical Director of KnarrTek Inc. and Milramco LLC. Dr Green obtained his BSC (Hons) in Electrical Engineering and his Ph.D. Degrees in Electronics and Computer Science from Leeds University in England. Subsequently Dr. Green was a senior member of technical staff at Massachusetts Institute of Technology and a Professor of Computer Engineering at Worcester Polytechnic Institute. He has also been a member of the senior management team of eight high-technology start-ups or early-stage companies.

Dr Green is an expert in implementing real-time Decision Support Systems for operations management and materials tracking within manufacturing and industrial distribution organizations. He is a systems architect and led the team which developed the BellHawk materials tracking software and MilramX decision support software. Over the past decade Dr Green has also led the implementation of over 100 systems, based on BellHawk and MilramX, which use Decision Support Systems to assist manufacturers and other industrial organizations to improve the efficiency of their operations and to increase sales through improved customer satisfaction.

For further discussion, or to send comments, please contact the Author at peter.green@Milramco.com.

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