

ON THE STRATEGY OF SUPPLY HUBS FOR COST REDUCTION AND RESPONSIVENESS¹

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Abstract

A supply hub is a location generally close to a manufacturer's facility where all or some of its supplies are warehoused with the agreement that the materials will be paid for only when consumed. Supply hub is an innovative strategy employed by especially the electronics industry to achieve cost reduction and improved responsiveness. After first tracing the developments leading to the establishment of supply hubs, the paper then describes the dynamics of the operation of supply hubs. Case examples are provided to highlight the current practices. Finally, some research issues are identified.

Keywords: *Supplier Owned Inventory, Vendor Managed Inventory, Postponement of procurement, Responsiveness*

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Contents

1	Introduction	1
2	Supply Hubs - An Overview	2
2.1	Developments leading to Supply Hubs	2
2.2	Traditional arguments for using supply hubs	4
2.3	Traditional arguments against using supply hubs	5
2.4	Prerequisites in establishing supply hubs	6
2.5	Major players and initiatives	7
2.6	Current Industry Development in Asia	7
3	Supply hubs - Dynamics	7
3.1	Current typical mode of operations for supply hub	8
4	Supply hubs - Case examples	9
4.1	Circle's Hub operations	10
4.2	Company <i>A</i> and its 3PL provider <i>B</i>	11
4.2.1	Company <i>A</i> 's logistics partners in Asia	12
4.2.2	Company <i>B</i> , the 3PL partner of <i>A</i>	13
4.3	Solectron and Burnham	16
5	Supply Hubs - IT Aspects	19
5.1	Generic Model	19
5.2	Circle	20
5.3	Company <i>A</i> /Company <i>B</i> Model in Singapore	20
5.4	Burnham/Solectron Model	21
5.4.1	Burnham's IT Strategy	21
5.4.2	Burnham's Information Systems	21
5.4.3	IT infrastructure between Burnham and Solectron	21
5.4.4	IT infrastructure between Burnham and Suppliers	21
6	Supply hubs - Industry issues and possible research issues	22
6.1	Transfer of title of goods	22
6.2	Price negotiation	22
6.3	Inventory storage model	23
6.4	Power relationship and conflict	23

6.5	Supply Hub management - key supplier, 3PL or contract manufacturer?	24
6.6	Migration of EDI to Web-Based Systems	24
7	Conclusion	25
8	Acknowledgments	26

1 Introduction

The rapidly developing global market place has made the industrial environment more competitive. As a result, the last decade has seen a growing interest in logistics and supply chain management in order to reduce cost and improve responsiveness to customer demands across the supply chain. A key question that needs to be addressed in improving supply chain efficiency is managing the interaction or relationship among the supply chain partners. Erengüç et al. [8] point out that though a dominant firm in a supply chain usually tends to optimize locally with no regard for its impact on the other members of the chain, there are cases of such firms capable of fostering more cooperative agreements in the chain. Wal-Mart and the Vendor Managed Inventory (VMI) program is a case in point. Under Wal-Mart's retail link program, suppliers like Johnson and Johnson, and Levers Brothers get the on-line summary of point-of-sales data [10]. Erengüç et al. further highlight that firms in a supply chain with no clear competitive advantage may still form alliances in order to compete in the global market place. For example, to support just-in-time (JIT) production, suppliers are required to deliver frequently in small quantities. Some suppliers of Toyota deliver as frequently as four times a day. However, it is a known fact that many of Toyota's suppliers are single-source suppliers located close to points of delivery [1, 2]. Thus, it is relatively easy for these suppliers to synchronize their operations with those of Toyota. Unfortunately, suppliers for companies outside Japan are usually located far from points of delivery. The long haul, plus problems involving multiple suppliers, makes logistics management a complex problem for the suppliers [13, 3]. Yet, Weiser Lock (see [8]) was able to successfully implement JIT by working closely with their Canadian suppliers, and thwart the increasing competition from East Asian manufacturers. Thus, it is very clear that irrespective of the competitive positions of the companies in the supply chain, cooperative decision making is advantageous. But when one wades through the documented literature on industry practices in relationships among the supply chain partners especially in the area of inbound logistics, one will find a spectrum of relationship ranging from the Manufac-

turer Owned Inventory (MOI) through Vendor Managed Inventory (VMI) to Supplier Owned Inventory (SOI). The supply chain is constantly evolving and the supply chain a la mode as far as the electronics sector is concerned is that of using supply hubs (or materials hubs or vendor hubs) to provide both leanness and agility for players in the supply chain.

In this paper, we treat the study of supply hubs from the perspective of suppliers, 3PLs and key customers. In this case, we note that global PC (Personal computers) players like Compaq, Hewlett Packard, Apple and Dell have supply hubs or another and in one geographical region or another. Typically the use of supply hubs also comes with an increase in VMI arrangements [11]. Indeed, many companies in the high tech and electronics industry have set up hubs or VMI facilities to house many of the components, parts, and raw materials, necessary for the assembling or manufacture of a product.

2 Supply Hubs - An Overview

A supply hub is typically a location physically close to a manufacturer's facility where all or some of its supplies are warehoused with the agreement that the materials will be paid for only when consumed [15].

Indeed there are variations in the instant at which the payment for the material becomes effective but in the sequel we will use the above definition for all practical purposes. The location referred to here is usually the premises of a 3PL but it may also be on-site, i.e., sited next to the manufacturing facility and within the manufacturer's premises. Thus there are different implementations of the same concept.

To put matters in perspective, we now give an overview of the developments leading to the establishment of supply hubs.

2.1 Developments leading to Supply Hubs

Supply hubs as defined above can be thought of as yet another model of supplier-buyer relationships that have grown after the highly successful arrangement between Wal-Mart and its suppliers Procter and Gamble (P&G) and

Rubbermaid [9]. P&G set out to manage replenishment of pampers at Wal-Mart in exchange for daily sales information. The result of this quid pro quo is legendary. Wal-Mart's costs came down significantly and thus was born what is now called 'VMI'. Basically, VMI is an arrangement under which the supplier manages the customer's inventory at the customer's distribution center or at a retail outlet [7]. The program provides higher visibility of a supply chain, facilitating better control of the supply chain.

The success story of the Wal-Mart and P&G association spread to the grocery industry in the form of Efficient Consumer Response (ECR). Panduit Corporation, an electrical component manufacturer and Graybar of St. Louis spearheaded the drive to bring VMI to the electronics industry. In December 1995, the National Association of Electrical distributors made VMI the standard program for the industry [7].

Despite the successes with VMI, there have also been companies withdrawing from the VMI programs [7]. One of the reasons forwarded is that there was no real sharing of data as is required under VMI. The supply chain visibility promised by VMI was not achieved because the vendors were not able to use the point-of-sales (POS) data but were dependent on using the quantity dropped at distribution centers. Some industry experts claim that VMI is best suited when there is not much variation in demand including seasonal variation. In the retail industry, manufacturers have a perception that the retailers stand to benefit more than the manufacturers. Some examples are Spartan Stores and K-Mart(see [9]). Spartan Stores, a grocery wholesaler, discontinued the VMI program after about one year due to poor results while K-Mart scaled down its VMI program because some manufacturers were not so good at forecasting. Collaborative Planning and Forecasting Replenishment (CPFR) is another program, which has been started in retail and grocery industry to avoid the disadvantages of VMI.

Electronics product manufacturers have to deal with other issues besides the ones noted above. Product life cycles have been shrinking drastically over the years and so the risk of obsolescence is very high in the field. Faster cycle time is the order of the day. Manufacturers are now forced to keep no inventory or low inventory. Despite VMI's advantages, inventory needs to be managed at

the manufacturer's site. For some of the suppliers, managing inventory may not be their core activity. Furthermore, under VMI, some manufacturers were at the mercy of the suppliers. A missed supply may become very critical to a manufacturer. The electronics industry has discovered SOI to be a solution to both obsolescence and stock outs.

2.2 Traditional arguments for using supply hubs

The reason for a firm to consider moving to a supply hub is typically to get rid of the high margin of error in forecasting and the uncertainty imposed on suppliers to keep excessive safety stock throughout the supply chain. Today, supply hubs have become a streamlined approach to managing inventory by suppliers for customers. The purpose of these facilities is to basically have a ready supply of the parts available to support assembly or manufacturing operations undertaken either by a client or a contract manufacturer. The twist here is that the end manufacturer (who can be the customer) only takes ownership when the parts are used or received. Thus, the manufacturers have access to a ready supply of inventory at little or no inventory carrying cost to them.

Under the current circumstances supply chain successes depend on acquiring new skills by the partners in a supply chain. OEMs today try to achieve a turnaround time of less than five days. Suppliers of semiconductor, for example, who have a cycle time ranging between 6 to 18 weeks, need to react to this new challenge of meeting the demand of the OEMs. Suppliers now can no longer wait for the purchase order signals from their customers. This requires enhancement of communication between supply chain partners. Clearly OEMs now argue that creation of supply hubs with investment in information technology is the way to go to improve replenishment efforts. Thus, some of the arguments put forth are as follows:

(a) Customer's Perspective:

1. Fill rates have improved due to better management of inventory and estimation of safety stock. Generally, the literature has re-

ported improved service levels with no residual impact on suppliers.

2. Slower moving inventory have reduced significantly due to better observation of inventory levels sku policies.
3. Increased inventory turns due to better planning and coordination at the hub level.
4. Buyers (from customer side) now spend less time doing basic stock replenishment. They can concentrate on planning (sourcing globally from new vendors), and focus on product management issues such as incoming product quality accreditation.
5. Order cycle times have reduced significantly from the customer's perspective.
6. Return on Investment (ROI) increases as a result of holding no or low inventories, thereby enhancing shareholder value.

(b) Supplier's Perspective:

1. For a supplier, there is now only one (or at most fewer) location(s) to send materials to, even if customer has many manufacturing locations. This avoids duplication of resources on the part of the supplier.
2. Most importantly, suppliers need not implement JIT in their facilities as is required under JIT. This eliminates the consequent strain on suppliers' resources.
3. Facilitates better inventory management in view of the inventory visibility offered by the SOI arrangement.

2.3 Traditional arguments against using supply hubs

Although the industry trend is towards the use of supply hubs, either in its pure form as a Supplier Owned Inventory or as a variation thereof, there are

some misgivings expressed by some of the players, especially the suppliers. For example, Solectron is driven to the use of supplier hubs by its customers and so is in a situation to push their own suppliers to subscribe to the concept of SOI. But it has to entice with free warehouse space to rope in their suppliers. So far they have about only 15 (out of about 150) of their suppliers who have joined the program. Some of the reasons put forth against supplier hubs are:

1. Sharing of information exposes suppliers to the mercy of other suppliers and the Hub manager.
2. Cost of setting up information system for inventory visibility is not easy to come by for smaller suppliers.
3. Creation of another intermediation point in the supply chain.

2.4 Prerequisites in establishing supply hubs

Given the above arguments against supply hubs, we present some well established prerequisites for establishing supply hubs:

1. Economy of scale in either production or supply
This is an obvious and necessary condition; otherwise the project becomes not viable.
2. At least some, if not all, of the suppliers are located sufficiently far away from the manufacturing site
Proximity to customer locations is one of the factors for the success of JIT implementation. As the trend now is for global sourcing of materials, many of the suppliers of companies are now globally located. To meet the JIT requirements of a manufacturer, its global suppliers now need to set up warehouses close to the manufacturer. This is an expensive proposition to the suppliers. One way to solve this problem is to organize a supplier hub close to the location of the manufacturer.

3. Need EDI or Internet in place between suppliers and hub, hub and customer, and suppliers and customer to achieve total information visibility and integration with inventory flow.

2.5 Major players and initiatives

Compaq has laid claim to the fact that they were the first to establish a supply hub for their operations (see [15] for full details). However, our initial research has found that other computer giants have also established their supply hubs albeit in different forms. For instance, BAX Global currently handles the supply hubs for Apple, Dell and IBM in Southeast Asia. However, Bax is unwilling to release information to the authors as they consider the information proprietary to their clients.

2.6 Current Industry Development in Asia

Several key logistics players are involved in promoting the supply hub concept. Amongst them are Circle International, BAX Global and YCH. MNCs, particularly finished goods manufacturers located in Asia are turning to vendor hubs to ward off the effects of economic instability. Using the hub can serve to reduce their exposure to high inventory costs (for storage and ordering at diverse points in Asia), component obsolescence and non-fixed asset sheet costs.

3 Supply hubs - Dynamics

Lou Pritchett, the Vice President of Sales of P&G is reported to have said, "today, if a supplier wants to achieve preferred supplier status, it will have to do more than just sell products. It will have to become part of the customer-supplier team". This appears to be the driving force again in the formation of supply hubs. Buyer-supplier relationship is a well researched topic. But most of these studies usually focus on one-to-one relationships. The concept of supply hub is a one-many relationship and that makes it interesting to

study the dynamics of supply hubs. In what follows, we briefly describe this.

3.1 Current typical mode of operations for supply hub

It is noted that not all suppliers participate in the supply hub. For example, Intel does not subscribe to this concept, even though it has VMI arrangements with companies like Dell. Further, the concept is still in its infancy and so needs some promotional efforts on the part of the OEM or EMS provider (see Solectron case example below).

As supply hub is a place where all the participating suppliers place their materials, the management of the hub requires expertise. The operation and management of a supply hub is generally handed over to a 3PL.

The 3PL is required to locate the supply hub very near the OEM or an EMS provider in order to support JIT production. The responsibility for ownership of the inventory and inventory management in a hub resides with the supplier at present (though there exist variants thereof). Suppliers continue to feed their clients' manufacturing forecasts. Usually, change of ownership is recognized only at the point where the goods enter the physical production line or out of the hub. There is an interesting variation in the ownership of materials. Some vendors have apprehensions that they may ultimately own the inventory for too long and so are reluctant to join the supply hub. In order to lure such vendors, some customers have installed a "freshness clause" in their agreements according to which, the customer assumes ownership of materials that have been in the warehouse beyond a specified period.

The client provides bounds for the inventory levels to be maintained at supplier hubs, which are usually agreed upon at the moment of signing the contracts. We learn that though the policy is a two-number min-max policy, the customers are more insistent on the minimum level to be maintained. The minimum level insisted upon is two weeks' requirement. The supply hub operator has the responsibility to oversee this arrangement. The information system is to trigger messages to the vendors whenever the minimum level is crossed. From our meetings with the 3PLs, it is revealed that this event is rare.

Outbound transportation from the 3PL to the customer's production site

is managed by the 3PL itself. But inbound transportation into the 3PL's warehouse is either the responsibility of the suppliers or in some cases the 3PL manages this also.

Though the 3PLs are basically facilitators and managers of inventories of the vendors, they also perform some value adding services. Kitting is a common service expected of the 3PLs. Some 3PLs even handle procurement, purchase order management and invoicing of supplier goods for the customer. In addition the 3PLs also provide services to suppliers. For example, some suppliers may expect the 3PL to perform quality inspections and checks that are required by governments [15]. This may further require capabilities of handling reverse logistics by the 3PL.

The 3PLs need to use sophisticated Warehouse Management Systems (WMS) in order to be transparent to both the customer and its vendors. EDI and Internet technologies are put to the best use possible to achieve the transparency and communication capabilities required.

From the dynamics described above, it is clear that the underlying principle in the supply hub concept is "postponement of procurement" [15] which comes after the now famous "postponement strategies" in the final configuration of products. Like the postponement of the final configuration, postponed procurement is going to stay. For the success of this concept, information flow is as important as is the flow of materials. Companies need to possess the necessary technologies to participate and benefit from this arrangement.

4 Supply hubs - Case examples

The description and the observations given above came out of a series of visits we had in Singapore and Atlanta, USA and also from the available literature. In what follows, for the sake of proper documentation we present three case examples.

4.1 Circle's Hub operations

This is a well-documented case [4]. We highlight to show that supply hubs are well advocated by 3PLs, both foreign and local.

Circle is a global logistics services provider of over a hundred years standing. Based in San Francisco, Circle has operations spread over 100 countries providing comprehensive supply chain management services. Circle's version of a supply hub is called a 'vendor hub'. It provides vendor hub services for clients around the world. Circle operates a supply hub for her Asian clients out of Subic Bay in the Philippines and recently launched a similar facility in Singapore. In the North American region, Circle offers vendor hub concept from its facilities at New York and Laredo, Texas. These are strategic locations to serve customers whose competitive advantage is response time.

One customer who uses Circle's vendor hub concept is Ford Visteon [6]. Visteon, which was originally a division of Ford, is a global supplier of specialist components for the automotive industry. It has a line of manufacturing operations in Brazil, which receives parts from about 500 suppliers in the US. Originally, it operated its own supply hub in Hatfield, Pennsylvania. The supply hub also performed some assembly operations prior to shipping to Brazil. Wanting to cut down on the long cycle time to and fro Brazil and also on the inventory costs, it approached Circle. Circle successfully sold its vendor hub concept to Visteon. It operates the vendor hub for Visteon from its New York facility with much less manpower Visteon employed. Parts from about 500 suppliers of Visteon arrive by truck. Parts are then entered into Visteon's inventory system. Within hours, parts are consolidated into pallets and are flown overnight from JFK airport to Brazil. In order to ensure continuous production in the plant in Brazil, Circle have special arrangements with airlines according to which air lines will be paid if it does not use the allocated space on the flights. Likewise, the airlines too have agreements to compensate Circle, if the cargo is not air lifted. Circle's operations save Visteon's cycle time by about 50%. In addition, Circle also shows savings on the return leg. The success of this vendor hub arrangement has led Visteon to applying this concept to its other businesses in Europe.

By using Circle's vendor hub, its customers are guaranteed savings on in-

ventory cost with simultaneous high improvement in productivity. Generally, Circle operates its vendor hubs under the following conditions:

1. Responsibility for inventory management shifts to the MNC's supplier.
2. The suppliers conceptually maintain ownership of the production materials destined for finished goods manufacture.
3. The suppliers continue to supply their clients based on the MNC's manufacturing forecast; however, change of ownership is only recognized at the point where the goods enter physical production line assembly
4. The vendor hub operator serves as the catalyst, manager and facilitator of inventory levels, managing multiple suppliers for the MNC

On its part, Circle offers the following services:

1. Manages the supplier's inbound traffic.
2. Works with the MNC to expedite production materials so they arrive at "line-side" stocking points at precise times for production schedules.
3. Offers insurance and customs brokerage to streamline the supply chain. This guarantees on time delivery, minimizes delays, avoids excessive duties and ensures product meets the MNC's lead-time requirements.
4. Handles procurement, purchase order management and invoicing of supplier goods for the manufacturer.
5. It can also "pick and kit" production materials to be sent to manufacturing according to the production schedule.

4.2 Company A and its 3PL provider B

Company A is a Fortune Global 100 company and one of the key proponents of the concept of SOI in Singapore. It is claimed that with this model, this company was able to slash millions of dollars from working capital needs. Company A is one of the largest global computer companies and is also one

of the largest global supplier of computer systems. Besides producing commercial desktop and portable products and desktop PCs, it develops and markets hardware and software solutions for businesses. Company *A*'s products are sold and supported in more than 100 countries through a network of authorized partners.

4.2.1 Company *A*'s logistics partners in Asia

This has its primary Asian manufacturing site in Singapore. Established in the 1980s, this is one of its largest manufacturing sites. In addition it has regional configuration centers in India, China, Australia and Japan. It also outsources the manufacturing of its basic models in Taiwan and China. The Singapore plant has 5 major OEM suppliers and a total of about 150 suppliers in Asia.

Its logistics decisions are usually handled by the global logistics team in its corporate head quarters located in the USA. Its in-house warehousing needs are met partially through in-house resources and partially through outsourcing to other major logistics services providers. In Singapore, it outsources to three key partners, one of which is company *B*. Company *B* manages *A*'s supplier hubs in Singapore and Australia. All parts required by *A*, except items like screws and microprocessors, are inventoried at *B*'s warehouse. Its outbound logistics is handled by another major 3PL. Company *B* also performs some sub-assembly operations for Company *A*. Company *A* also outsources some of its logistics operations in China to this 3PL.

Company *A* has been using the SOI policy since mid 1990s. To maintain high quality levels the suppliers are required to buy parts from companies that have already been approved by it. It employs multi-sourcing for materials. It also shares the risk with the suppliers. For example, if the forecasts are too high and supplier is left with excess inventory it absorbs some of the losses.

The Singapore plant outsources the manufacture of certain computer products like monitors, memory modules and modems to companies in Malaysia, China and Taiwan. The trend is towards more outsourcing in the future. For manufacturing in Singapore, Company *A* gets kits assembled in the supply

hub which are then assembled into products at the plant. A kit can be assembled at the supply hub and can be shipped to the assembly line within 2 hours of receipt of the request. The production in Singapore is geared towards the high-end user, and 80% of it is shipped to the U.S. and Europe.

We now give an overview of Company *B*, the company which pioneers the concept of SOI with company *A*.

4.2.2 Company *B*, the 3PL partner of *A*

Company *A* was established in the 1950s. Through the employment of innovative business strategies, it has raised itself from a local logistics operator to an award winning premier supply chain solution specialist. It develops and provides a full spectrum of supply chain functions for world class MNCs. Services provided by this company are logistics value-added solutions, warehouse management, inventory management, international freight forwarding (Air and Sea), bonded trucking, third party repair/materials recovery operations and supply chain consultancy, design, implementation and operations.

It was no wonder that Company *B* was officially appointed to manage Company *A*'s Materials Hub for Asia Pacific. It then embarked on this back-end logistics function to better manage *A*'s material supply. Through this, *B* created visibility of the materials held in the supplier hub for both *A* and its suppliers. Instead of producing to stock, *A* is now well placed to build to order. Some of the key features of *B* are:

- A fleet of more than 250 transportation equipment.
- Freight forwarding agents worldwide.
- Global supply chain network.
- In-house developed, award-winning logistics management system comprising of warehouse, traffic and freight management system modules.
- Fully automated storage and retrieval system.
- EDI link-up capabilities with Portnet and Tradenet.

- A fleet scheduling system based on Artificial intelligence (AI).
- Air-conditioned warehouses.
- Bonded/licensed facilities.

Company *B* is growing and expanding throughout the Asia Pacific with operations in Singapore, Malaysia, Taiwan, Hong Kong, Australia and China. It is currently building a facility in Mexico.

The SOI hub for *A* is a leased site in Singapore. This hub serves *A* and is only 10-15 minutes away from its manufacturing facility in Singapore.

The area of the warehouse is about 100K square feet. The warehouse holds inventory for about 150 of *A*'s suppliers. The suppliers own the materials held until it is pulled by *A* for production. *B* manages the inventory on behalf of Company *A* and its suppliers. Company *B* operates the hub on a 24 hours a day, 7 days a week schedule. It handles also the transportation of the materials from the SOI hub to *A*'s manufacturing site. Inbound transportation into the hub is the respective supplier's responsibility. All the parts required for *A*'s PC assembly, with the exception of microprocessors and the screws, are stored in this warehouse. Company *A* expects every supplier to keep a minimum of two week's supply in the hub. In fact, *A* spells out, what is called a Min-Max policy to its supplier. The min (or minimum) and the max (or maximum) numbers are based on quantitative analysis but details were not forthcoming.

Kitting by carton and kitting to exact

Once a normal order from *A* is received by *B*, all the required materials for the order are kitted by the carton level at the *B*'s warehouse. At *A* the cartons go into inventory and the exact number of parts required are pulled from this inventory. Only at this point in time, ownership of the material pulled changes to *A*. Recently, as per *A*'s request, the onsite inventory is being moved to the hub itself so that kitting can be done to the exact requirements.

Service guarantee

Company *B* guarantees the delivery of kits to *A*'s manufacturing facility every 4 hours. For a short order, which usually consists of a few parts, it takes *B* only an hour to complete the kitting and the delivery of kits.

Company *A* follows two different policies for pulling materials from two competing suppliers. Under the FIFO policy, material is pulled according to the date on which it entered the hub. The other policy is based on percentages agreed upon with the competing suppliers. For example, if suppliers S_1 and S_2 supply material X then *A* might decide to pull at every instance of a requirement of X , a certain percentage from the supply of S_1 and the remaining from the supply of S_2 .

Reports by B

Company *B* sends *A* a 2-hourly inventory report. Weekly inventory reports are also sent to suppliers. A fringe benefit to *A* by using *B* as a SOI hub operator is that *A* could consolidate its billing and invoicing process.

Other services

Company *B* provides services on information systems such as offering interfaces for its customers, ie. for both *A* and *A*'s suppliers; to access *B*'s information system to create system visibility for all concerned.

Other processes

Company *B* also performs distribution operations for multinational companies. To capitalize on the trend towards strategy of "postponement" employed by manufacturers, *B* has built value added activities in their facility to perform such functions as re-labelling, re-packaging etc. It has also systems built for reverse logistics.

Recently, *B* has web-enabled their award winning Management system so that its customers can have round-the-clock access and control over their inventory on their mobile phones and other handheld devices.

Company *B* is currently looking at alternative viable business models. For instance, it is experimenting with the practice of owning inventories for some suppliers.

The last two sections dealt on vendor hubs serving OEMs. The drive initiated by OEMs for SOI has passed up the supply chain forcing some of the suppliers of these OEMs to establish supply hubs of their suppliers. For example, Seagate, one of the major suppliers of hard disks, participating in its customers' supply hubs, has(d) itself a supply hub for its vendors in its

premises in Singapore.

A North American example is Solectron and it has relationship with a regional 3PL called Burnham to operate its supply hub. We now document this case, which is in itself interesting because Solectron identifies itself as a Supply Chain Facilitator rather than an EMS provider. The case includes detailing the set of drivers prompting Solectron to work with Burnham (a traditionally non-VMI logistics service provider) and the set of suppliers towards a full-fledged VMI program. Specifically, we seek to examine this transformation and its underlying principles.

4.3 Solectron and Burnham

Solectron (see also [14] for more details) is one of the leading providers of electronics manufacturing services in the world. Its customer base includes big players like Cisco Systems, HP, IBM and Sun Microsystems who design and sell manufacturing equipments, workstations, computers and computer peripherals, telecommunication and other electronic equipments.

Solectron prefers to call itself an integrated supply chain solutions provider as its array of services covers the entire product life cycle. Starting from product design, it can help in the management of new product introduction, prototyping, printed circuit board assembly and system assembly, purchasing and materials management, distribution, product repair and warranty services. System assembly for example includes building complete systems like mobile phones and testing them for their full functionality.

Solectron has excellent performance record. Its service capability and performance frees much of the time of its customers and enables them to concentrate on their competencies of sales, marketing and research and development. It has a such a wide network of global manufacturing facilities in the Americas, Europe and Asia that all its customers have easy and ready access to manufacturing facilities closer to their changing markets. As such, this is one motivational factor, which moved Solectron towards a full-fledged VMI hub operation managed by a third party vendor. The other driving factors are described below.

Solectron's gross margin depends on several factors. Besides the usual fac-

tors like product mix, production efficiencies and manufacturing capacity utilization, the gross margin depends on the start-up and integration costs of new acquired businesses. This is because Solectron has been going through buying spree recently. It also depends on exogenous factors like the pricing within the electronics industry and the cost structure at the individual manufacturing sites.

Solectron expects threat to its gross margin may come from increased sales derived from systems-build projects, additional costs associated with new projects and price erosion within the electronics industry. Another issue of concern is component shortages. Component availability is constrained by lead time and other factors and this could also impact on its revenue growth. Further, Solectron's major sales is from a small set of big customers. This means that a loss of even a single customer will have a greater effect on the net sales. Indeed, according to the recent statistics from the company (<http://biz.yahoo.com/e/1/s/slr.html>), the sales from the ten largest customers formed 72% of net sales for the year 2000 while it was 74% in fiscal year 1999. Some of these customers individually account for more than 10% of Solectron's net sales. Given this scenario, it becomes important for Solectron to retain these large accounts as losing even a single customer would drastically affect the bottom line. Solectron's contracts do not include clauses that bind the customers to make minimum purchases. So, with growing competition in contract manufacturing, the customers might even reduce the level of services ordered at any time. Further, technological changes and rapid product obsolescence force the electronics industry to perpetually innovate in terms of their product offerings, lest their bottom lines will be affected drastically. With the majority of the customers from the electronics segment, Solectron's range of services could decline significantly if any of its customer's products become obsolete with the customer not coming out with an alternative product. Thus, Solectron has to be constantly on its toes to retain these big customers. It also needs to keep abreast of the new technology in order to provide advanced services and at the same time be also cost-effective and responsive to its customers.

The BTO/CTO process, especially for the low-volume, high-mix, quick-

turn requirements, has gained momentum in the past year because users want more say in how their systems will be configured. Given this trend, systems makers cannot afford to stock more inventory than is necessary to fill orders. Direct-sales PC makers started the trend, and others were forced to follow to avoid losing market share. Participants in the PC supply chain are adopting strategies to cope with hard-to-forecast demand associated with the new “a la carte” environment. These methods include co-location with component suppliers, assemblers, and even logistics partners; the creation of supplier hubs to warehouse components; drop-shipping components directly to assemblers or configuration centers; as well as an increasing reliance on electronic systems for automated communications and process management. Solectron’s solution is the co-location of supply-chain partners which in this case is the suppliers. The idea is to have all the value in one place, rather than trying to maintain control of inventory across 10 or more different locations. Co-location also brings the component suppliers closer to the manufacturing plants to reduce cycle times, with the purpose of keeping the conveyor belt moving.

As a specific example on hand, we look at the relationship between NCR and Solectron. The facilities of Solectron build NCR’s servers, scanners, and point-of-sale terminals. These products are highly customer specific, with varying volumes (from 1 to 500 units of POS) and product mix (up to five different types of POS for a supermarket location). Given that Solectron’s strategy is to take on a larger share of the lucrative systems-build business and persuading customers to turn to Solectron to become their virtual manufacturing partner, Solectron has decided to make more investments in logistics infrastructure and supplier base management. Solectron’s percentage of box-build business is growing from about 10%-12% of revenue in 1998 to between 30%-50% by the year 2000 (<http://www.manufacturing.net/magazine/purchasing/archives/1998/pur0328.98/032mfg.htm>).

It is clear that the Internet will be a key part of a CM’s supplier management and supply hub strategies. It is becoming the tie that binds CMs to their suppliers. It will result in closer alliances between CMs and their key suppliers, and it will be a useful tool as more CMs handle procurement for

OEMs.

E-commerce will be incorporated into other supplier management programs. Take the case of SCI System's supplier-managed inventory program. Under the program, suppliers ship parts not to a facility of SCI, but to a nearby hub operated by a third-party logistics provider. When SCI receives customer orders, it notifies the hub via EDI and the parts are shipped. SCI does not own the parts until they are shipped; the only inventory it has is on the production line. The program reduces inventory costs and increases inventory turns, says Bill Quinn, vice president of purchasing for SCI. To SCI, this program is useful because it supports BTO strategies, which many of SCI's customer use [5].

Having considered three industry cases, we now briefly look into the Information Technology aspects of operating a supply hub successfully.

5 Supply Hubs - IT Aspects

5.1 Generic Model

Figure (1) shows a typically information flow model among the Suppliers, the Buyer (OEM/EMS) and the Supply Hub. Demand forecast is sent from the Buyer to the Suppliers on regular intervals (e.g. weekly). The actual demand is pulled from the Buyer out of the Supply Hub. This information is usually sent via EDI/Internet directly to the Supply Hub information system. The latter system will generate information needed for picking from the warehouse, and updates of the inventory levels. In case of exceptional demands, the Supply Hub system will trigger the Suppliers for replenishment. The updated inventory and consumption levels are reported back to the Suppliers on regular intervals (e.g. daily) electronically. At the same time, the Supply Hub provides inventory visibility to the Buyer.

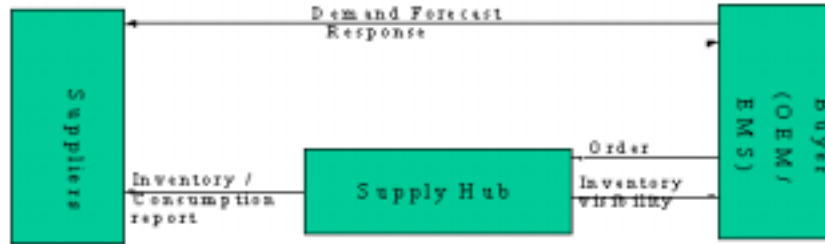


Figure 1: Generic Model of a Supply Hub

5.2 Circle

The success of a vendor hub operation clearly depends on the extent of cost savings and the flexibility that it can provide. This can only be achieved through the use of a good information management system. Circle's inventory management system can provide visibility to both the supplier and the manufacturer on the status of the inventory. It has its own sophisticated Warehouse Management System (WMS). Circle uses system interfaces that facilitate the use of client-developed programs. It also provides internet access to the suppliers and the clients. They can generate reports through Circle's web site or by linking to Circle via a common Internet Service Provider (ISP).

Thus, Circle considers itself as creating value and benefits to its clients who use its vendor hub concept. By being a bridge connecting the suppliers and the manufacturer, it helps reduce inventory costs, other administrative costs and distribution and material handling costs. Further, the clients can now focus on their core competencies thereby achieving overall efficiencies.

5.3 Company A/Company B Model in Singapore

Company B maintains its proprietary information system developed inhouse. It maintains EDI links with both its suppliers and Company A, as well as Singapore government systems such as PortNet and TradeNet. Suppliers

receive daily and weekly inventory reports from *B*, while *A* receives 2-hourly inventory reports from *B*, all through EDI.

5.4 Burnham/Solectron Model

5.4.1 Burnham's IT Strategy

Burnham has an in-house IT department of 35 professionals, headed by a CIO. System design and maintenance are performed internally, while system implementation is sometimes a joint effort, utilizing software vendor and third party contractors.

IT continues to be a core competence of Burnham, with an eye towards the changing e-Commerce scenes, and the attractiveness of IT outsourcing (through Application Service Providers).

5.4.2 Burnham's Information Systems

The Warehouse Management System, PKMS, was developed by Manhattan Associates. It has an open systems architecture, and utilizes RS/6000 and AS/400 (RISC). A mirror image of PKMS is maintained on a Web-enabled warehouse (BLIS) which aggregates information and provides it to both suppliers and Solectron.

Burnham's ERP system is a JD Edwards system.

5.4.3 IT infrastructure between Burnham and Solectron

Burnham maintains EDI links with Solectron. Orders from Solectron arrive via EDI, and are checked by an operator on 30-minute intervals. From the orders, an outbound manifest is printed, which also serves as the pick list. The manifest contains the storage location of the item(s), extracted from PKMS. Inventory visibility is available via the web.

5.4.4 IT infrastructure between Burnham and Suppliers

Burnham emails inventory levels to suppliers, based on suppliers' requests. They are usually sent daily in the morning, and contain information of every

item and its inventory count and shipped quantity as of 2AM the day before.

Burnham also provides a web-based protected system to allow suppliers to check vendor-specific live inventory levels and the weekly demand forecast. The inventory figures are updated automatically when items have been scanned to reflect the movement in the warehouse.

6 Supply hubs - Industry issues and possible research issues

In this section, we present some pertinent industry issues arising from our visits and discussions thus far. Alongside this, we will also highlight possible research areas of potential interest to academia and industry.

6.1 Transfer of title of goods

As noted earlier, there appears to be a variety of models practiced for the transfer of title of goods. But manufacturers of electronic products are eager to postpone the transfer of title of the materials they buy. Manufacturers want to guard themselves against the detrimental effects of short product lives. But in the industry there appears to be two points in time at which the title transfer takes place. In the first case, the transfer is effected only at the instance when an individual part is pulled for production, even though a carton might have been extracted from the supplier hub earlier. In the second case (example Solectron), the title transfer takes place at the instance when the carton is delivered at the designated drop zone. Further, Solectron has a "freshness clause" in the contract for standard parts according to which the title is automatically transferred to Solectron when the parts have not been pulled before a stipulated time.

6.2 Price negotiation

Though the industry trend is towards establishment of supply hubs, we find examples of lukewarm response (see the case of Solectron) from suppliers.

Further, if a supplier is a monopolist (for example Intel) it cannot be lured into joining the supply hub. So, there is a need to design strategies to sell the concept of supply hub to the suppliers. Note that Solectron's strategy of free warehouse space is to entice its suppliers. Obviously there is a need for proper pricing strategy to be worked out to the benefit of all parties concerned. One key area of research lies in contract price negotiation in the light of technological obsolescence.

6.3 Inventory storage model

The current industry model is to have a 3PL to manage the supply hub. The customer specifies a Min-Max policy according to which any supplier has to maintain an inventory between the minimum and the maximum levels specified by the customer in the contract. Although a maximum is specified, the customer is not concerned about the maximum. It is the minimum level against which the supplier's stock is monitored. Two weeks stock requirement is the minimum level practiced across the industry. There is no documented evidence of how this magic number of two weeks has been arrived at. So, there appears to be a need for a systematic quantitative analysis of finding the minimum requirement expected of the suppliers. Further, there are other questions that are interesting to be studied. Some questions are:

1. Should it be 2 weeks uniformly for all parts?
2. Is this the optimal policy for each supplier?

6.4 Power relationship and conflict

1. Relationship between customer and supplier: The traditional adversarial relationship between a customer and supplier is vanishing. There is greater awareness that cooperation and coordination are necessary for supply chain efficiency. Even then there are examples of companies, which cannot be forced into the supply hub. Companies like Intel, which are monopolists in nature, use their own clout to dictate terms.

2. Relationship between customer and customer: How can the 3PL/CM ensure that each customer can obtain the correct allocation of parts in the event of component shortages (e.g. chips)?
3. Relationship between supplier and supplier: Likewise, how can the 3PL/CM ensure that each supplier can still supply the appropriate allocation of parts in the event of component without compromising price?

6.5 Supply Hub management - key supplier, 3PL or contract manufacturer?

If the decision to create a supply hub has been made, then a question that naturally arises is who should manage it. The current industry practice is to let a 3PL handle the management of the suppliers. This appears to be the popular decision in view of the many potential advantages. If an OEM or an EMS provider operates the hub, then that would involve overheads shooting up to the total cost. Though there would be much control over the operations, it might also need the time of their high level executives. Thus the top management team might be spending some of its time on their non-core activities.

6.6 Migration of EDI to Web-Based Systems

The most advanced form of information dissemination is web-based (i.e. users access information through a web-browser). For example, suppliers can access their current inventory levels at the Supply Hub dynamically and continually via HTTP. To date however, this mode of communication is not as pervasive as the conventional EDI, emails (SMTP) or FTP.

In the near future, we foresee that procurement would be primarily web-enabled, but the inventory level updates would still be primarily EDI-based.

Increasingly, we see the emergence of e-Market places and exchanges that link buyers and suppliers in real-time to seamlessly conduct e-commerce on a global basis. While the current implementation of EDI processes are char-

acterized as static flat file transfers over VPN networks, XML enables interactive application-to-application interoperability over the Internet.

The migration to XML is going to take time because companies have invested heavily on their existing EDI systems. The good news, however, is that traditional EDI users can cost-effectively extend to XML in the short term by installing XML-EDI translators on their web servers.

7 Conclusion

Asia has been traditionally a base for contract manufacturing. Although, this has been changing with massive localization taking place in Guadalajara in Mexico, Asia will continue to enjoy its prime status in view of the emerging markets in India and China. Similar to the postponement strategies in product differentiation employed by companies, postponement of procurement in the form of supply hubs is gaining ground. This is quite evident from the statement of Bringi Dev, Director of Marketing services at Compaq India [12]. Soon after the announcement of duty cuts by Government of India on processors, memories etc., Bringi Dev said, “This (Supply Hub) is the next step for manufacturers in India”. Supply Hubs are here to stay. So the impact of supply hubs and the attendant practices, on the supply chain becomes an important topic for research.

To this end, in our paper we have attempted to trace the developments leading to the establishment of Supply Hubs. We have highlighted how companies, especially computer manufacturers, perceive supply or vendor hubs to be a strategic tool to reduce cost and also to improve responsiveness to customer demands. We then described the dynamics of supply hubs drawing largely from the observations we made during our visits to these supply hubs and also from some recent literature. We have also provided some case examples. We then followed with a section, which dwelling on the interesting and important Information Technology (IT) aspects of operating a supply hub. Finally, the general industry issues and possible research questions have been identified.

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