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IMPACT OF JUST-IN-TIME

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Just-In-Time philosophy and techniques are commonly applied to the operations planning and control area. Master production scheduling, material requirement planning, distribution requirement planning and capacity requirement planning all require re-thinking, as continuous improvements such as setup reduction, lead-time shortening, shop floor restructuring, total quality management, total productive maintenance, etc. have been introduced. The various impacts of JIT on operations planning and control are discussed in this chapter.

Reducing Setups

- *Advantage of Small Lot Size*

  Small lot size reduces inventory, hence reducing costs. In terms of financial benchmarks, the return on inventory assets, return on total assets, and turnover rate generally increase with smaller lot size while break-even volume and inventory decreases. Using small lot sizes also limits the potential losses due to quality problems. Even if an entire lot is defective, the absolute financial costs of scrap and rework will be relatively low.

  Manufacturing using smaller lot sizes also provides more timely feedback from quality problems, allowing engineering changes to be made more rapidly and quality problems to be resolved earlier. Thus, the use of small lot sizes improves quality.

  Smaller lot size also shortens manufacturing lead times, decreases delivery times and improves customer responses. Small lot size results from the shorter setup times required for each lot. When setup times are reduced, machine utilization increases and manufacturing lead times decrease. In small lot size manufacturing, products are switched more easily, and the product-mix is more flexible. This flexibility also improves delivery responsiveness.

- *Method to Reducing Setups*

The steps involved in setup reduction are:

1. *Define the setup operation.* Setup operations include mold change, fixture change, tool change, material change, etc. In changing a mold or fixture, aligning and adjustment are required. These activities are also part of setup operations.
2. *Record the entire process of the setup operation.* Operations process charts as shown in Figure 1 can be used to record setup operation processes. In operations process charts, operations and inspections are sequenced by time. Videotaping is also frequently applied to record the setup operations.

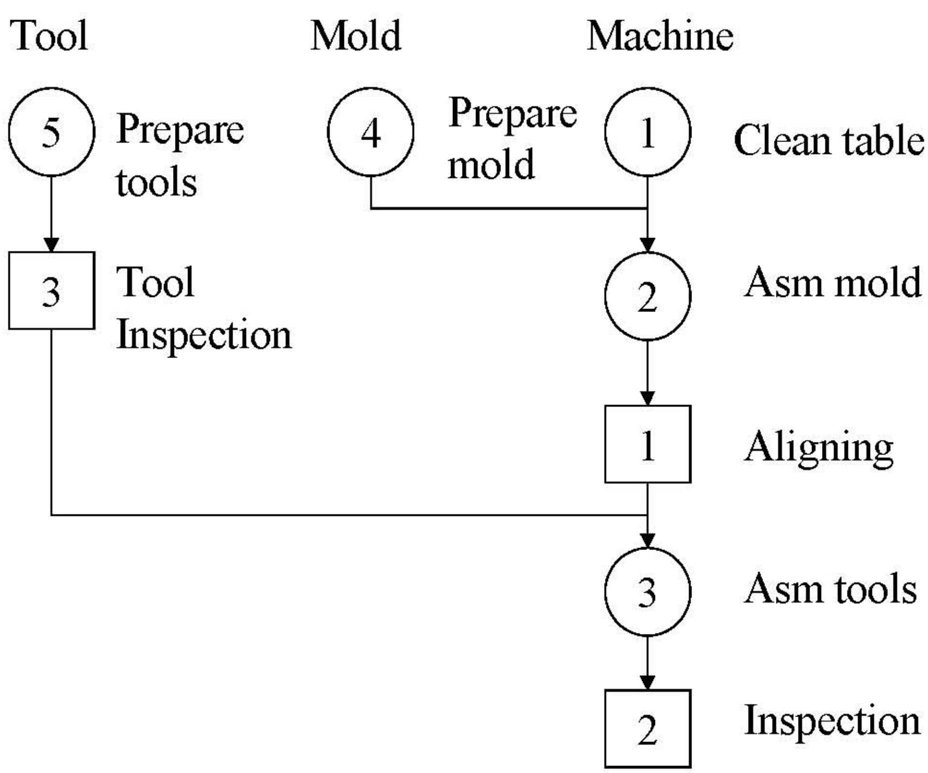

Figure 1: Operations Process Chart

step #	Description of Activity	Actvities op ◯	insp ☐	trans ⇨	store ▽	time	cum. time	dis-tance
1	Clean table					5	5	
2	Prep mold					3	8	
3	Move mold					2	10	8m
4	Asm mold					10	20	
5	Aligning					5	25	
6	Prep tool					2	27	
7	Insp tool					5	32	

Figure 2: Process Flow Chart

3. *Analyze the setup process.* The records of the setup operation are analyzed, and the operations are broken down into more detailed elements. Process flow charts, as shown in Figure 2, are used to analyze the setup operations. Process flow charts map four activities: operation, inspection, transportation, and storage.
4. *Improve the setup operations with ECRS approach.* The ECRS approach includes elimination, combination, rearrangement, and simplification. The goal of ECRS is to, first, reduce the number of operations as much as possible. Operations that cannot be eliminated are then combined, if possible, to further reduce the number of operations. The operations are then rearranged in an optimal sequence.
5. *Separate the setup operation into internal and external operations.* Internal setup is the setup operation done within a machine. The machine stops during the internal setup. External setup is the portion of the setup operation done outside of the machine.
6. *Convert internal to external setups.* Reduce the number of internal setup operations as much as possible.
7. *Reduce the time to perform each step of setup.* Speed up the setup operations by using automation or tools.

- *Group Technology*

Group Technology (GT) is the engineering and manufacturing philosophy that identifies physical similarities in products and processes and establishes effective product design and manufacturing.

Nancy Hyer and Urban Wemmerlov stated in an article in the Harvard Business Review that the aim of Group Technology is to capitalize on similarities in recurring tasks. They believe this can be accomplished in three ways:

1. Performing similar activities together,
2. Standardizing closely related activities,
3. Efficiently storing and retrieving information related to recurring problems.

An example of an activity that can benefit from the application of GT is product design. Similar parts are designed by rapidly retrieving existing design data. If possible, existing parts should be used in new products instead of creating new parts. In other words, standardize parts so that they can be used in various products. Design of a part similar to existing ones is a recurring problem. Therefore, GT simplifies the designing process.

In a plant, like machines are traditionally grouped together. There is no common sequence of machines for the jobs passing through different routings. Group technology analyzes different processes, finds their similarities, and standardizes them so that the machines can be arranged into a manufacturing cell. Machines are arranged in a cell in the sequence common to all products. Various products flow through the machines in a cell with minimal distance and throughput time. Setups are not required for producing different products in a cell.

Restructuring the Shop Floor

Just-in-time restructures the shop floor by demanding a new philosophy and approach to plant layout, machine selection, storage arrangement, etc.

- *Plant Layout*

The principles for JIT plant layout includes:

1. *Minimize movement.* Operations or work centers should be close to each other.
2. *Maximize visibility.* Storage areas, kanban boxes, materials, and containers should be visible to workers.
4. *Facilitate supplier/customer communications.* Where there are two consecutive work centers, the preceding one is the supplier and the following one is the customer. Plant layout should make it easy for suppliers to know the status of their customer's inventory and supply materials to the point of use.
4. *Maximize kanban discipline.* JIT plant layout makes it easy to see if there is a kanban on any material. Therefore, it is difficult for a worker to produce an item not authorized by a kanban.
5. *Be simple, flexible and safe.* The layout design should be simple. The production line should basically be of an "I" shape. The work centers in the production line should arrange their machines in a "U" shape cell. The layout should be flexible in case the product mix changes. Safety is also a consideration in designing plant layout.
6. *Be orderly.* Everything should have a place and be in its place. In the philosophy of JIT, nothing is arbitrarily placed on the shop floor. Everything should be located at its indicated place.

- *Material Flow*

In the JIT environment, material flow can be *disconnected* or *connected.* In a *connected* flow, routings are fixed and each machine has equal time to process a material. The production lines are balanced. Work stations use dedicated machines and operations are linked, i.e., materials flow through operations with minimal waiting time. A connected flow production line with dedicated machines is designed for each product family. These production lines can only produce one product family and have less flexibility. Setups are few and the lot sizes are small. The flow of material is simple and rapid, and the throughput time is short. Figure 3 shows a connected flow for final product assembly, and two connected flows for component fabrications.

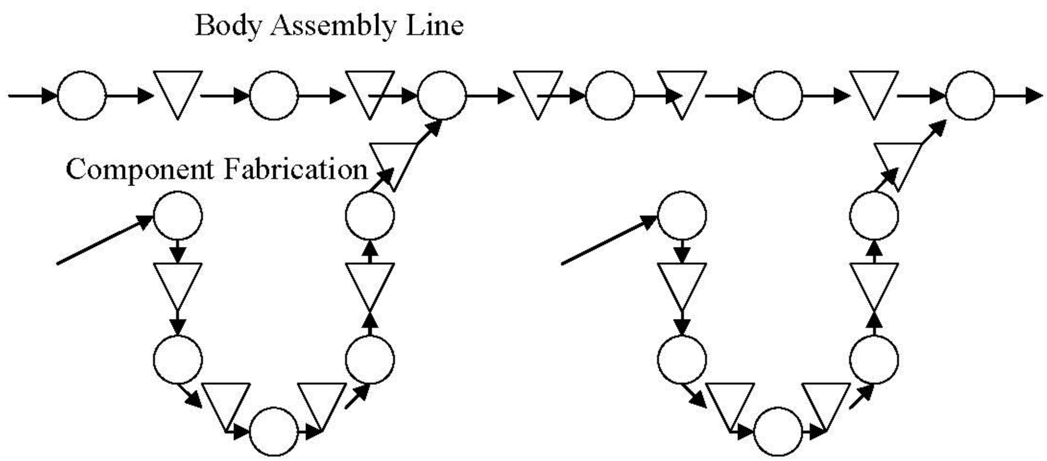

Figure 3: Connected flow for component fabrication and body assembly

In a *disconnected* flow, routings are variable and each machine has a different amount of time to process different materials. Workstations use general-purpose machines that can be set up to produce different products. Operations are de-coupled instead of linked. Materials flow through operations with some waiting times. A disconnected flow production line with generic machines is designed to produce multiple products. The system has more flexibility than connected flow systems. There are more setups and lot sizes are relatively large. The flow of material is complex and unclear, and throughput times are longer. Figure 4 shows a disconnected flow for producing three product families. There are six types of machines. Each type of machine can be set up to produce all products. The first product family goes through all six of the machines, and the second and third go through five of them.

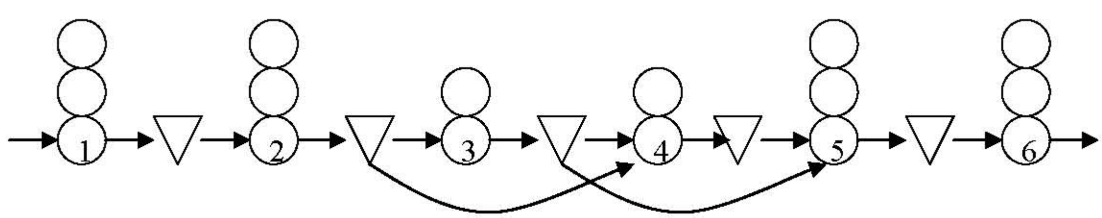

Figure 4: Disconnected flow for Three Product Families

The machines in each work center are generic machines and can be set up to produce various products. In this case, the process times in work centers are not equal, and the line is not balanced. If each product is produced in special lines with dedicated machines, set up operations will not be needed. The production line can be balanced and the materials flow through the operations without waiting in storage. These are connected flows as shown in Figure 5.

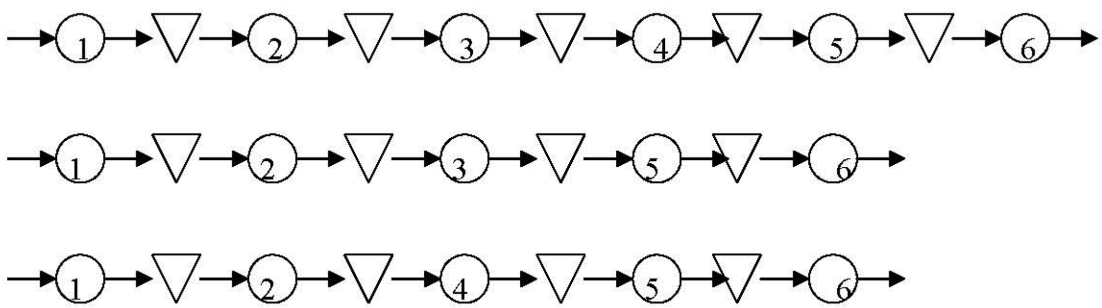

Figure 5: Connected Flow for Three Product Families

Connected flow and disconnected flow are both repetitive productions -- repeat processes rather than repeatedly build identical products. Connected flow is for high volume/low mix products; disconnected flow is for low volume/high mix products. JIT can be applied to both connected flow and disconnected flow. In the beginning stage of implementing JIT, we should start with a disconnected flow. JIT will take you toward a connected flow process. Every time the disconnected flow is simplified, i.e., every time one kanban is removed, you move closer to a connected flow.

- *Equipment Selection*

In connected flow, dedicated equipment should be used. Since there are multiple connected flow lines in the factory, smaller machines of the same function and different setups should be chosen and placed in each line. Large machines with a wide range of applications are selected in the disconnected flow lines. General purpose machines are used in disconnected flow lines, but the setups should be simple. In selecting the machines, faster setups and the flexibility to adjust for line balancing should be considered in addition to evaluating technological features.

- *Storage at Point of Use*

In a JIT environment, materials are stocked on the shop floor. Putting materials at the point of use minimizes material handling and reduces response time. In connected flow, there are few types of materials stocked at each storage. Putting the materials at the point of use is reasonable. In disconnected flow, stocking materials for all product families at the point of use may not be economical. If all required materials cannot be stocked at the point of use, they should be stored as close to the point of use as possible, and a material handling approach should be designed to enable the operators to retrieve the materials quickly. Materials can be sorted by product families and put in trays or carts near the work center so that the operators can exchange the materials rapidly.

- *Automation*

As the number of kanbans is reduced, the speed of the material flow gradually increases. Eventually, the reduction of kanbans becomes harder and harder without mechanical assistance. From the formula of kanban calculation discussed in the last chapter, we know that when the kanban volume decreases, the replenishment time also decreases. Manual handling may not be quick enough to feed the materials. Automatic facilities such as robots can be applied to move the materials from the preceding work center to the following work center. Automation need not be costly. For example, in the rolling kanban case, materials and kanbans on a slanted roller conveyor are automatically moved to the next workstation. When the following workstation removes the first material from the conveyor, a space is created at the end of the conveyor. This is the signal for the preceding workstation to start working on the next item.

- *Autonomation*

In a JIT environment, no defects are passed on to the next workstation. If a quality problem occurs in a workstation, work at other workstations should be put on hold until the problem is eliminated. Autonomation is the mechanism by which any workstation is allowed to shut down the production line when a defect or abnormality is detected.

JIT Impact on Operations planning

- *Time bucket*

Time buckets in MPS and MRP are shortened with a JIT approach. Traditionally, the interval for a time bucket is a week. In a JIT environment, the length of time buckets is shortened to a day, half a day, or an hour.

- *Rate-Based Planning*

Rate-based demand data are used in MPS procedures instead of discrete customer orders or shop orders. Rate-based MPS specifies the production rate for each product in a period of time. The numbers of kanbans to be issued is decided based on the production rate and the replenishment time. Table 1 shows a traditional MPS which levels the capacity required in each period. The rate based MPS shown in Table 2 levels both the capacity and the materials.

Table 1: Traditional MPS

Period	1	2	3	4	5	6
Product 1	800		800		400	400
Product 2	400	600	400		400	600
Product 3		600		1200	400	200
Total	1200	1200	1200	1200	1200	1200

Table 2: Rated Based MPS

Period	1	2	3	4	5	6
Product 1	400	400	400	400	400	400
Product 2	400	400	400	400	400	400
Product 3	400	400	400	400	400	400
Total	1200	1200	1200	1200	1200	1200

The master scheduler monitors MPS and communicates rate change information to the suppliers and the shop floor. This information is important for them to prepare the production in advance.

- *Bill Of Material*

Bills of materials are flattened. The required quantity of components is made at the time at which they are actually needed. Therefore, they are moved to the next work center rather than stocked in the warehouse. The BOM for the middle level items are defined as phantoms. The effective BOM contains only two levels – end products and raw materials. The flattening of BOM is shown in Figure 6.

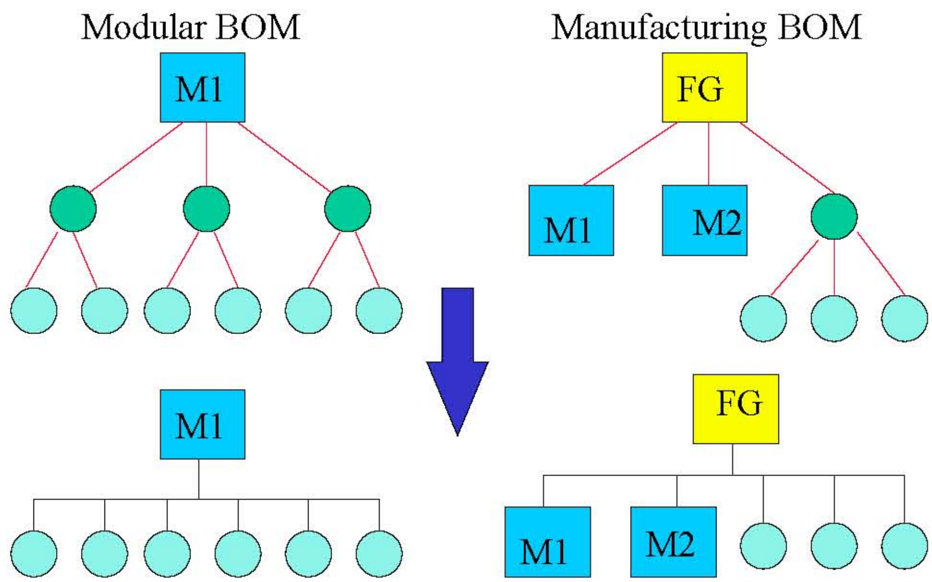

Figure 6: Flattening of BOM

In Figure 6, bills of material for both module and finished goods are single level BOM. The modular production line feeds modules into the finished goods line. All the middle level items are built-on-the-line parts.

- *Material Requirement Planning*

Because of the stability of the JIT environment, the MRP is not executed frequently. Since the suppliers deliver the materials in a regular way, MRP need not be used to generate purchase orders. Since the work center produces items according to circulated kanbans, it is not necessary to run MRP to generate shop orders. Because of the flattened BOM and the negligible setup costs, the lot-sizing rule used in MRP is lot-for-lot (LFL). Since production rates of products may change in the planning horizon, MRP is required to predict the change in material requirement. The prediction of change in material requirements enables the shop floor and suppliers to take necessary actions in advance. An example of changing rates is shown in the MPS in Table 3.

Table 3: MPS with Changing Rates

Period	1	2	3	4	5	6
Product 1	600	550	500	450	400	350
Product 2	400	400	400	400	400	400
Product 3	200	250	300	350	400	450
Total	1200	1200	1200	1200	1200	1200

- *Capacity Planning*

The work centers are arranged in the sequence of the fixed routing, and the machine loads are balanced. As long as production is performed smoothly, the manufacturing activities repeat over and over, and capacity requirement planning is not required. As various products are produced in one production line, product mix may affect the stability of the loading. The capacity requirements by the projected production rates in MPS are evaluated with rough-cut-capacity-planning (RCCP). Although the production is triggered by actual demand instead of MPS, the MPS still influences the preparation of materials and tools as well as the purchase and manufacturing of the critical parts. RCCP is crucial in JIT environment. In RCCP, key resources are structured into planning the BOM.

JIT Impact on Operations Control

In a JIT environment, MRP is used for planning, and kanbans, rather than manufacturing orders, are used for execution. The traditional approach uses input/output control to keep a constant level of work in process. Traditional I/O control uses work orders, planner/schedulers, and on-line real time computers to maintain timely control. JIT control uses kanban related tools.

- *Outbound and Inbound Queue Control*

Kanban uses visual controls and the operators instead of the plans and the planners. Kanban sets an upper limit on work in process in the manufacturing area, and only what has been consumed can be replaced. This is called outbound-queue control, i.e., produce only when the outbound queue is consumed. When many operations feed a bottleneck cell, in-bound queue control of the bottleneck work center may be more effective. In this system, when the inbound queue declines, the material release rate at the gateway workstation is increased. This is a control approach drawing from the theory of constraints (TOC).

- *Refill and Rolling Kanban Control*

A refill kanban tells us when and what to build. Whenever the operator sees a kanban, he or she replenishes the indicated materials. Refill kanban is a complete authorization of production. A rolling kanban and a customer order or a schedule makes up a full authorization. The customer order in the gateway workstation and the rolling kanban in the inbound queue of the other workstations authorize what to produce. The kanban space emerging when a kanban is removed from the outbound queue triggers the production of the kanban in the inbound queue. In the initial stages of JIT, the build plan drives production. Later on, the actual customer order will be used to initiate the production.

- *Material Checking*

If there are many materials involved, material checking before production may be necessary. When we are ready to start producing a given quantity of a particular product, denoted by a kanban authorization, the system (computer simulation) checks the on-hand balances in the work center and in the factory. The system either indicates that all materials are available, or specifies what items are expected to be in short supply.

JIT Implementation Stages

There are three stages in implementing a JIT project. The first order switched from push to pull is the customer order. In the second stage, shop orders and pick orders are switched into the pull system. In the last stage, purchase orders are eliminated and the pull system of the supply chain from suppliers to customers is accomplished by applying kanbans. The implementation stages are shown in Table 4.

Table 4: JIT Implementation Stage

Stages	Orders from Customers	Orders on Shop floor	Orders to Suppliers
Stage 1	Pull	Push	Push
Stage 2	Pull	Pull	Push
Stage 3	Pull	Pull	Pull

- *Stage One*

In the traditional environment, the MPS is based on customer orders and forecasts. The production of the end products and components and the procurement of the materials from the suppliers are all triggered by the MRP. This is a pure push system as shown in Figure 7.

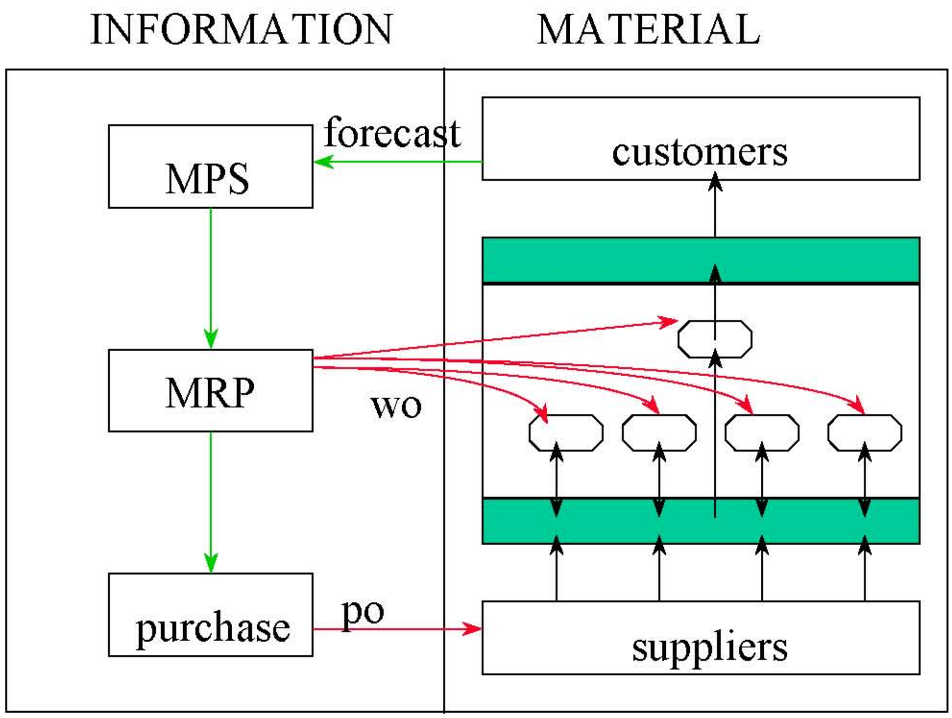

Figure 7: Push System

In the beginning of implementing a JIT system, the production of finished goods is switched into a pull system. The production of end products is triggered by the actual delivery of customer orders, as shown in Figure 8. The setup cost of producing the end product is normally lower. Therefore, it is reasonable to remove the shop orders for the end product first. When the setup operations are eliminated or simplified to an extent, the shop orders for the manufactured items are eliminated, and the manufacturing activities are included in the pull system, as shown in Figure 9. When the supplier relationship is improved and the frequent material delivery is accepted to both sides, the purchase activities are included in the pull system. The final stage of JIT is shown in Figure 10. The highest-level materials not manufactured to the actual consumption are defined as the push-pull boundary. In stage 1, the push-pull boundary is the components fed into the finished goods assembly line. In stage 2, the push-pull boundary is the raw materials. In stage 3, the push-pull boundary is the suppliers' components fed into their end product lines.

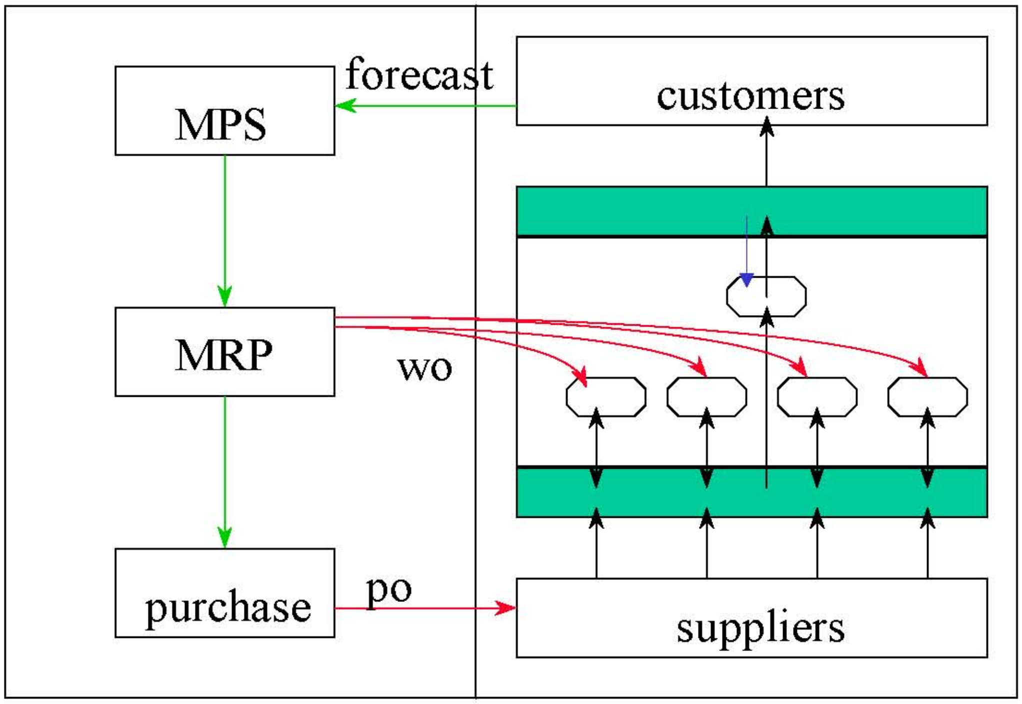

Figure 8: JIT System in Stage 1

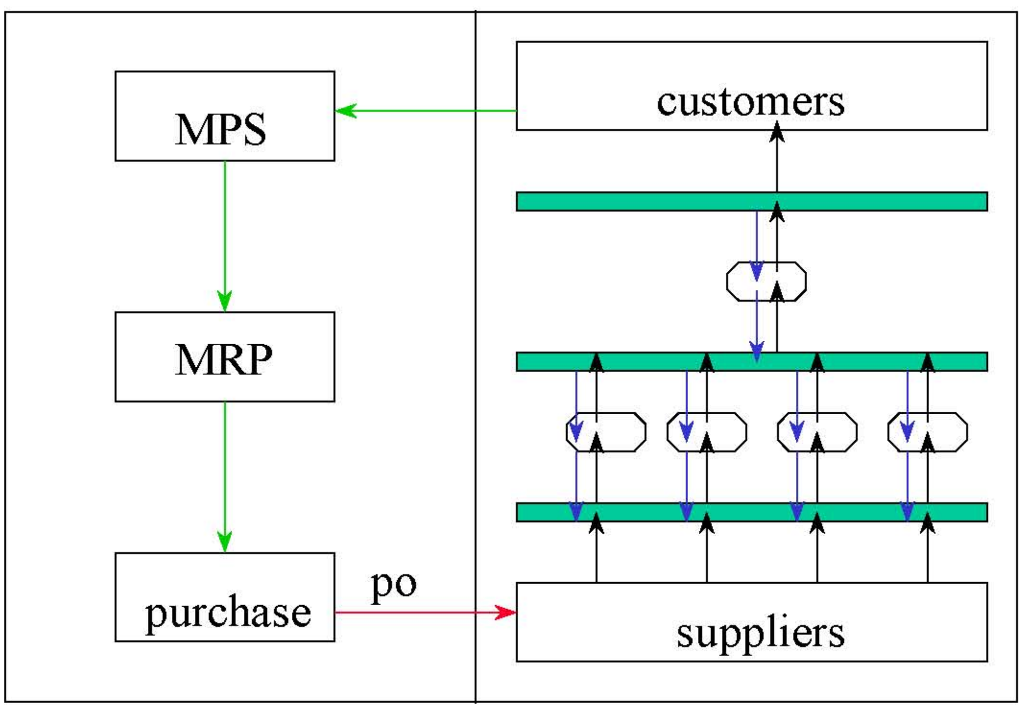

Figure 9: JIT System in Stage 2

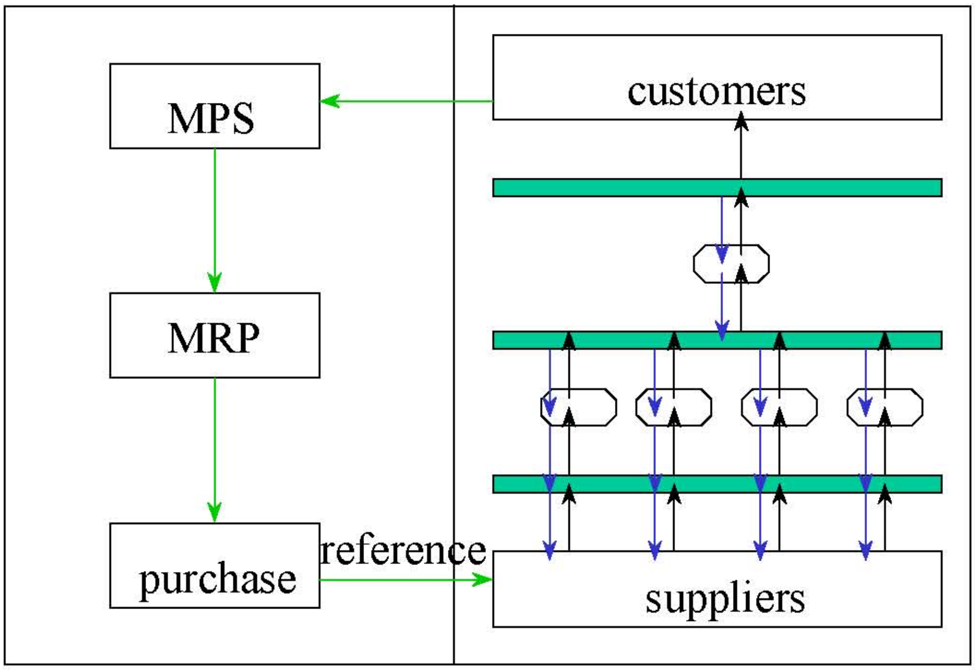

Figure 10: JIT System in Stage 3

JIT Impact on Inventory Management

- *Primary and Secondary Stockroom*

In a JIT system, inventories are stored at the points of use (POU) rather than issued to them from the warehouse. The POU storage is called the primary stockroom. The materials stored at the primary stockroom are those immediately needed by the work center. The secondary stockroom, or overflow storage, stores the materials due to lower delivery frequency and are not immediately required by the work centers. In a JIT system, overflow storage will eventually be eliminated. Kanbans are re-circulated between POU and overflow storage to replenish the materials. Eventually, the materials in POU are replenished directly from the suppliers. The re-circulation of kanbans between POU storage and the secondary storage is shown in Figure 11.

The inventory records are updated when the materials are moved from the overflow storage to the POU storage. When the finished goods are shipped from the last work center, the inventory records of all the related materials at POU are updated. This procedure is known as the "back-flush".

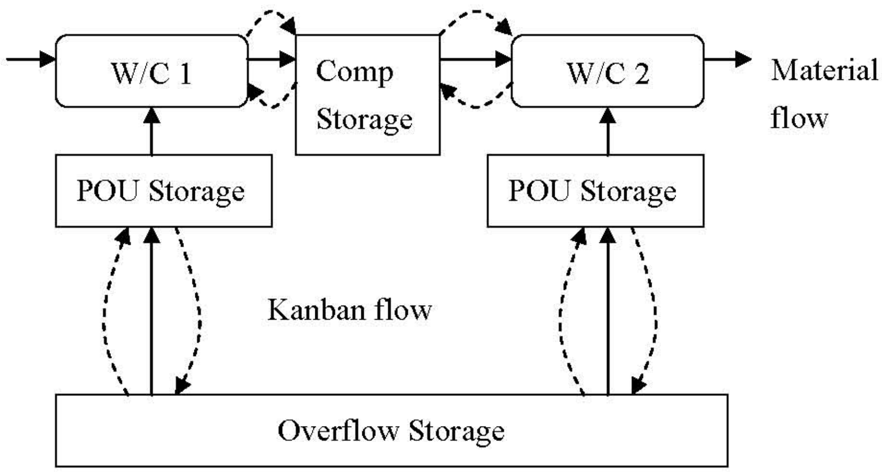

Figure 11: Re-circulation of Kanbans

- *Cycle Counting*

Traditionally, cycle counting is the responsibility of material control people. In a JIT environment, operators in the production area should be responsible for the cycle counting of their own materials. In doing cycle counting, each person should record the counts for each of the part numbers in his assigned areas. The computer should sort the entries and develop the total for each part in the entire work center or cell. If an item is within reasonable tolerance, the count will be accepted. If it is not, the system should produce an exception notice that tells which part is out of tolerance.

- *Responsibility for Inventory Accuracy*

Production people must take ownership for accuracy and reconciliation of their own inventory. Reconciling inventory means comparing the physical inventory figures with the perpetual inventory record and making any necessary corrections. (Apics) Low priority should be put on the minor items and the operators should concentrate their efforts on the twenty percent of materials that represent most of the value stored at the point of use. Parts that have been issued to the shop floor are not part of the cycle-count process in the overflow stockroom. Materials in the stock rooms and at each point of use work center are counted independently. Inventory accuracy is verified for each part number and location combination rather than part number alone.

- *Causes for Inventory Inaccuracy*

Inventory inaccuracy comes from BOM errors, count errors, and inadequate training of people both in counting and reconciliation. Other causes of inaccuracy include inadequate reporting of scrap, improper use of substitutions, and poor processing of engineering changes. Lack of adequate process control also causes inventory inaccuracy. Inventory counting does not necessarily guarantee inventory accuracy. Too frequent counting increases the chance for errors. By storing the materials at the point of use rather than issuing them frequently we can eliminate some of the handling and counting. The root cause of the inventory inaccuracy should be determined and corrected.

JIT Impact on Information Systems

Decentralization is a JIT impact on information systems. In a JIT environment, each work center is responsible for more than just manufacturing. In addition to manufacturing, a work center takes on responsibility for inventory management, tool management, maintenance, and information processing.

- *Client and Server Computer*

Each JIT work center has its own personal computer system with spread-sheet and word-processing software performing rate-based planning, RCCP, quality analysis and reporting, inventory control, production reporting, and report writing. These computers are called clients and are linked to a central computer called a server. The data files required by the clients such as MPS and BOM are down-loaded from the server computer to the client computer. The client periodically sends production and inventory information to the server. The client should have read-only access to the other relevant information on the server.

- *Decentralization of Information Process*

The client computer at each work center performs the local information processing such as production reporting, quality analysis and reporting, inventory counting, production rate planning, capacity analysis, and general report writing. Software tools are ready and training is provided so that the people at each work center are capable of designing their own applications as well as filling the information requests made by the server. This is the practice of so-called end-user-computing (EUC). The formal information systems department of the future will be responsible for providing the facilities and standards to process information, but the users will be responsible for its applications.

JIT Impact on Engineering Change

- *Engineering Change*

Engineering change consists of the activities engaged in to modify or correct the design of a part. It is triggered by a request from a customer, quality control, marketing, or other departments. In a JIT environment, parts are manufactured in a continuous mode. Engineering change should specify the timing of change. When a kanban for the part to be changed is returned for replenishment, it must be intercepted so that the instructions for incorporating the engineering change can be attached.

- *Kanban Reaction*

When refill kanbans are used, the location can be flagged or blocked, so that when the customer goes to the kanban location to retrieve the next part, or when the supplier initiates production to replenish it, he is alerted that a change is being initiated. When rolling kanbans are used, the engineering change information is attached to the associated kanbans at the gateway work center. Color-coded kanbans can be used to indicate a revision. Once all cards are of the new color, the pipeline has been purged of previous versions of the product. A note in the storage location can also trigger a change once that material has been consumed.

JIT Impact on Marketing

- *Long Term Contract and Kanban Delivery*

Sales and order processing are based on long term contracts and are out of the day-to-day loop. Sales is involved only in making certain that the customer is satisfied and in determining the appropriate times to re-negotiate a contract. Some re-circulated kanbans are issued to the customers, in accordance with the amount specified in the contract. The customers do not place purchase orders any more. All deliveries are triggered by kanbans. Many expensive activities associated with selling, purchasing, order taking, order entry, warehousing, etc. are therefore eliminated.

- *Market Promotion*

Factory tours have become a selling tool. With JIT, manufacturing capabilities become a key factor in closing the sale. The customers should be able to tell from our processes, both in the factory and in the office, that costs are going to remain competitive in the future. Marketing incentives that promote unevenness at the end of month, quarter, and year should be avoided. Sales promotion should encourage orders to come in on a long-term, steady basis instead of stimulating a large amount of purchases in one period and having no sales in the next. Sales are promoted by continuous price reduction and quality improvement. Inadequate sales promotion may cause fluctuations in requirements known as the “bull whip effect”.

- *Manufacturing Lead Time and Forecast Horizon*

In a JIT environment, manufacturing lead times are shortened by the short lead-time at the last workstation to replenish an end product. Shrunken manufacturing lead times improve our ability to respond to customer needs. As a result, with its short manufacturing lead times, JIT will improve forecasting by shortening the forecast horizon, the time span in which the detailed forecast needs to be made.

- *Customers' Participation*

In a JIT environment, customers participate in the design process, which results in very competitive costs. With the customers' participation, the quality and quantity they require is determined much more accurately and efficiently. In order to produce to the customers' demands, electronic data interchange (EDI) with the customers' computer systems is applied to read their on-hand balance. This enables us to build what was consumed. The contract gives a standing authorization to replace an item up to a certain level.

JIT Impact on Purchasing

- *Long Term Contract*

JIT demands a strong relationship between customers and suppliers, based on mutual trust. A lack of trust produces wasteful operations, from increased handling and inspection to increased accounting and purchasing. Instead of ordering in fixed long lead times, the company works together with the suppliers to establish long-term contracts. Therefore, the supplier feels secure, and can make the capital investment and other long-term decisions necessary to ensure an optimal manufacturing process.

In negotiating long term purchase contracts, the following points should be considered:

1. The effective date of the contract and how it can be canceled or re-negotiated
2. Legal information about the participants involved
3. Total quantities and price of parts covered by the contract
4. Part variations that will be allowed within the lead time and price range
5. The maximum amount of inventory in the supplier's place that the customer will be responsible for
6. How quality is going to be measured
7. Delivery frequency, delivery authorization, and invoicing procedure
8. MRP report as well as knowledge of future products that customer needs to provide their key suppliers
9. Direct problem-solving channels to key suppliers
10. Confidential information that the customer and supplier need to maintain

- *Centralized and Decentralized Purchasing*

JIT uses a strategy of combining centralized and decentralized purchasing. A centralized purchasing function is responsible for contract negotiation while day-to-day delivery is carried on with decentralized kanban releases. Kanbans are circulated between the supplier and the primary stockroom at the POU. In addition to negotiating the contract, the centralized purchase department also helps the suppliers with improving processes, communicating product information, informing material requirement plans, etc. The evaluation of suppliers is also a responsibility of the centralized purchasing function.

- *Reducing the Supplier Base*

Traditionally, an item is sourced from multiple suppliers in order to diversify the risks of material supplying. Multiple sourcing is an easy solution, but it avoids the problem instead of solving it competitively. With JIT, we must maintain a more manageable number of suppliers. JIT emphasizes the establishment of supplier partnerships, i.e., the working relationship in which customer and supplier act as one organization.

Is sourcing from a single supplier risky? Certainly not. Competitive prices can still be easily monitored. Long-term purchase agreements are likely to encourage a supplier to continually improve his process, lower his cost, and improve his quality. Under the protection of a long-term purchase agreement, suppliers are willing to make capital investments that will improve their manufacturing processes. Therefore, a supplier would lose all of his business by being unethical. There is not much motivation for the suppliers to be greedy.

For a multinational company with factories located in many countries, each factory could have a single local supplier, and could serve as backups when something happens to other suppliers.

- *Total Cost Consideration*

In a JIT environment, price is only one of the factors used in evaluating the cost of purchasing an item from a supplier. The total cost consideration should include other factors such as:

1. Is the product packaged in such a way that it can be delivered directly to the point of use?
2. Can inspection be eliminated?

3. Can the very few defects simply be exchanged for good products?
4. Can frequent deliveries be accomplished economically?
5. Will kanban be used to minimize the paper work and reduce the transaction expense?

- *Purchasing Evolution*

In the pre-MRP stage, there was no computer system providing material requirement information. A planner broke down the production schedule into various component requirement plans with a manual spreadsheet. The buyers then used this to negotiate orders with suppliers.

When the MRP system was installed, the buyers or planners used the computerized MRP output to perform their own purchasing functions. In applying manufacturing resources planning systems (MRP II), a professional supplier-manager would negotiate the major contracts, but a semi-professional supplier-scheduler would perform the detailed order release process with the MRPII output.

When the environment progresses to JIT, the supplier-scheduler's responsibilities can be transferred to a direct labor person in the work center. Replenishment is ordered via kanban, and execution is handled between the customer's shop floor and the supplier's shop floor. In a JIT environment, traditional purchase orders and detailed supplier delivery schedules are eliminated. The output from MRPII system is provided to the supplier for macro planning purposes. Activity on the shop floor is initiated by kanban.

- *Eliminating Wastes in Purchasing*

By using circulated kanbans between the supplier and customer, day-to-day routines can be handled by the kanbans and the people in the work centers. The waste in purchasing activities such as ordering, packaging, inspection, damage, material handling, invoicing, and accounting can be eliminated. The purchasing department can devote itself to establishing sound supplier partnerships.

JIT Impact on Transportation

- *One Person for Multiple Functions*

In a JIT environment, the truck driver of the supplier, receiving person, material handling person, and inspection person of the customer are all one person. The same person drives the truck day in and day out and brings the material right onto the shop floor, stores it where it belongs, and then enters the receiving information into the computer system.

- *Customized Route*

More customized routes will be developed. Instead of one supplier shipping to many customers, we may have one customer picking up from many suppliers. A contract carrier may service his customers according to a regular, prescribed route. The traditional approach and regular route approach are compared as in Figure 12.

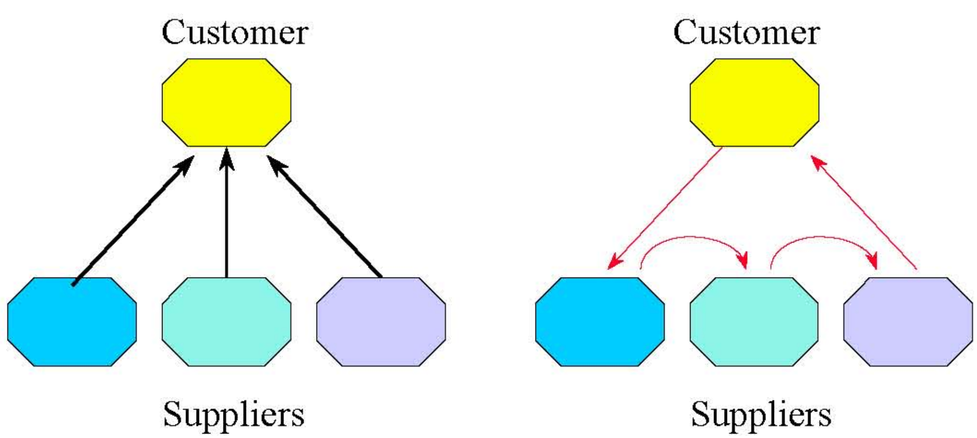

Figure 12: Traditional (left) and Customized Route (right) Transportation

Figure 13 also shows traditional approach and a regular customized route approach for transportation. In the traditional approach, a supplier, S1, ships the materials to all its customers. In customized route approach, a customer, C1, collects the materials from its suppliers through a predetermined route on a regular schedule. The carrier may make a circuit on a fixed schedule. Material is picked up from the supplier at a specific time and delivered directly by the trucker to the point of use according to a dependable schedule.

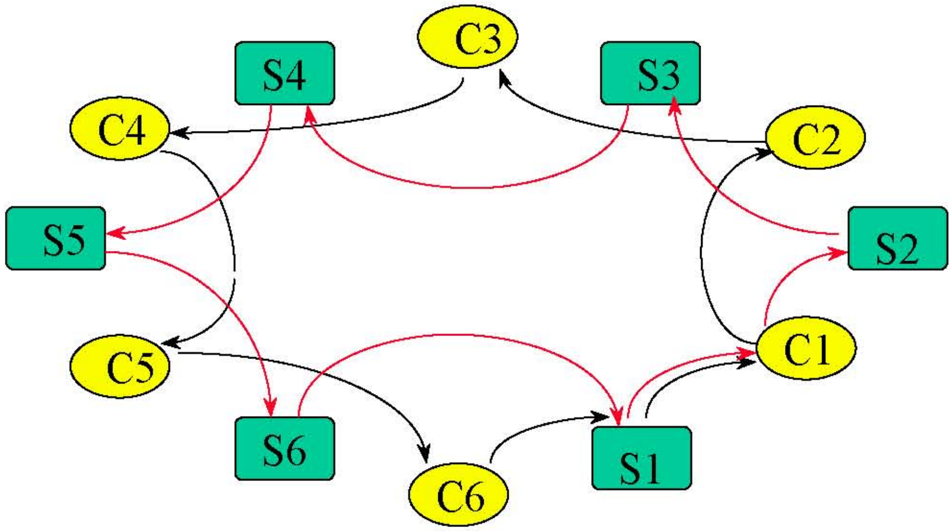

Figure 13: Supplier Shipment and Customer Collection

- *Consolidated Freight*

A customer that receives multiple deliveries from several suppliers may adopt another transportation alternative, having its suppliers feed a centralized hub where freight can be consolidated, as shown in Figure 14.

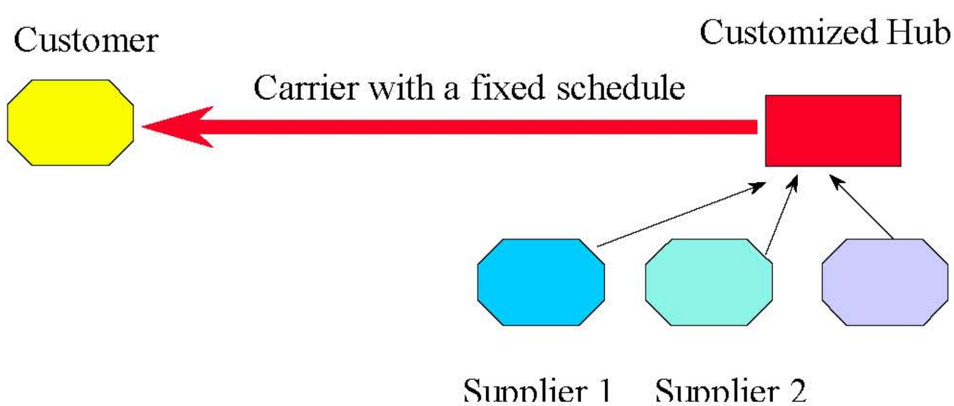

Figure 14: Customized Hub and Consolidated Freight

- *Other Changes in Transportation*

Packaging under JIT will require more standardized, returnable, collapsible and reusable containers, as well as cartridges that plug directly into production lines at the customer's point of use.

JIT requires the use of more side-load vehicles to load and unload the materials from the suppliers and to the points of use in a more efficient, time-saving manner.

More bar codes for efficient material tracing will be used. Transportation companies can inform customers whether a shipment was made or picked up, as well as state the current location of the shipment and the estimated time of delivery.

Supply Chain Management (SCM)

- *JIT and SCM*

JIT has been emerging as an effective approach to manufacturing for two decades. It is a customer-oriented philosophy, environment, and technique. The purpose of JIT is to provide customers with quality products or services at the lowest possible cost and with the shortest possible lead-time. Various JIT techniques link not only work centers in a factory, but also its suppliers and customers. A company facilitates the material flow up from the raw material supply, down to the ultimate consumption of end products. This function has recently come to be known as "supply chain management" as JIT techniques have been enriched by new information technologies.

- *Kanban and Internet*

Ubiquitous Internet applications make pull signal transmission efficient and at very low cost. When a customer purchases an end product from the retailer, the inventory at the retailer is updated and a kanban signal is transmitted through the Internet to the distribution center. When the distribution center delivers the consumed end product to the retailer, via the Internet, a kanban signal is prompted on the terminal of the final assembly line in the factory. As the end product is assembled, the kanbans of the consumed materials trigger the production or purchase of new materials. The kanban signals are then transmitted through the Internet to the suppliers and the materials are replenished.