SETLabs Briefings
VOL 5 NO 3
Jul-Sept 2007

Global Trends in Supply Chain Planning in Semiconductor Industry

By Arnab Banerjee

The global semiconductor industry needs a very high level of planning and collaboration between multiple stakeholders to ensure a smooth supply chain

Over the years, a new world has emerged — an electronic world of computers, the internet, wireless communications, satellite navigation, high-tech machines, newer entertainment styles and hundreds of other pieces of wizardry. For the most part, this world has little contact with the traditional physical realm of earth, water, fire and air; indeed, one of the great appeals of the cyber-world is its ability to transcend time, distance, and material limitations with invisible digital data.

The point of contact between the electronic and physical world is the factory where semiconductors are made – the wafer fabrication facility or better known as "Wafer Fab" and the human minds, which turn the very basic natural material into a cyber world. In essence, wafer fab takes very pure silicon (the basic element in sand) modifies it with phenomenal dexterity, precision and knowledge, and produces integrated circuits — the physical devices that power the cyber-world. Doing this requires leading edge capabilities in optics, chemistry, mechanics, measurement and many other fields. It demands huge amounts of capital — both financial and intellectual. The complex process constantly redefines its own limitations, and somehow manages to move ahead at a blinding rate.

Supply chain planning: Semi-conductor manufacturing industry is ensnared with complicated manufacturing processes. As semiconductor business is rapidly changing with variable demand, obsolescence, capacity concerns, global manufacturing setup, contract manufacturing and multi-tier suppliers playing an important role in the over all supply chain, the planning process has become very dynamic,

complicated and highly sophisticated. This paper attempts to analyze the global trends in supply chain planning and that of factors influencing the global trends in planning such as business models, and product kinds. Semiconductor industry is characterized by extensive networks of supply chains with both in-bound and out-bound partners. Generic supply chain software seldom satisfies all the demands of a complex network of multiple partners and raises various issues concerning reliability.

The paper therefore also dwells on the mechanics of supply chain planning in two scenarios – collaborative planning suite and non-collaborative setup.

SC IN SEMICONDUCTOR INDUSTRY

Semiconductors are a wide variety of products and are used in varied products such as wireless handsets, display and imaging devices, information infrastructure and information access devices such as mobile and cordless phones, flat-panel and conventional CRT displays and monitors, high-speed local area networks, TV set-top boxes, DVD and CD players, internet access devices, and a host of other electronic systems. As result of its wide ranging product portfolio and its labor- and technology-intensive processes, the industry is globalized to exploit the comparative advantages. Typically, the wafer fabs and chip assembly are at different locations and the chain includes warehouses and multi-ranked suppliers spread across the globe to competitively exploit high technology, cheap labor and logistics.

For the semiconductor industry, lack of visibility across the supply chain partners, operation constraints, inability to respond to demand fluctuations, smaller product life cycles and longer lead times perpetuate in supply and demand mismatches.

As a definition of a classical supply chain, three aspects of the overall supply chain are examined — operational supply chain, inbound supply chain, and outbound supply chain.

Operational supply chain: This is the most important part of supply chain modeling especially for a wafer fab. It becomes all the more critical because of complex and resource-intensive manufacturing processes and various other factors such as high lead time, fluctuating demand, complicated BOM and routing structures, variable yield structure, presence of contract manufacturing, short life cycle of the finished goods, and so on.

As operational supply chain plays a major role, its planning is integrated with transactional process packages, which are very often the standard ERP packages in a majority of well-established semiconductor companies.

Inbound/ outbound supply chain: Logistics plays an extremely important role in the industry as it caters to a global customer base and adopts assorted strategies such as global manufacturing, contract manufacturing, shared manufacturing, and multiple sourcing/suppliers.

The Inbound/ Outbound supply chain is of crucial importance to both fab and fab-less semiconductor companies. Inbound logistics consists of raw materials as well as outside processing items. Outbound mainly comprises of distribution to various warehouses across the globe.

GLOBAL TRENDS IMPACTING THE SEMICONDUCTOR SC PLANNING

The underlying purpose of a supply chain is to make products available to customers in the right quantity, at the right time in the best possible

condition in the most cost-effective manner. In classical supply chain term it is called On Time In Full (OTIF).

OTIF is affected by demand fluctuations, manufacturing and supplier constraints and logistics coordination. In addition, a few other factors like prevailing labor conditions, labor efficiency, system comfort of users, weather conditions and so on also have a bearing on OTIF.

As already described above, wafers are lead-time intensive products and therefore sensitivity of the supply chain and availability of finished goods are largely dependent on advanced planning. Though the finished good does not take a long-lead time, the making of wafers does and the decoupling point of supply chain is the wafer and not the finished good.

The main performance measure of supply chain in the semiconductor industry are dependable demand, resource utilization, process yield management, throughput time of wafers, inter organizations transportation facilities and collaboration with contract manufacturing. So demand planning, production planning and scheduling all play a very important role in attaining and retaining business competitiveness. Seamless integration between contract manufacturing and Original Equipment Manufacturer (OEM) is another important aspect of the semiconductor supply chain.

As evident from the above, the supply chain in the semiconductor industry is extremely complex with various factors driving it. Following are a few key factors that predominantly affect the supply chain and its planning processes:

1. **Business profile:** The industry can be classified as fab or fab-less. A foundry or fab is a manufacturing facility where many devices like integrated circuits and chips are made for customers. Fab-less companies on the other hand, specialize in the design and sale of hardware devices that are implemented on semiconductor chips. The planning of supply chain, therefore, is very different for a fab and a fables company.

   While supply chain planning of a fab is dependent on demand fluctuation and resource constraints, that of a fab-less depends on demand fluctuations and supplier constraints. In fab-less business, demand arises out of customers in one part and from self-owned statistical forecast on the other. The planning process is also generally divided into three categories of products:

   1. Low Risk-High Volume products
   2. Medium Risk-Medium Volume
   3. High Risk-Low Volume products.

   The medium risk products are generally those where there is a collaboration existing between supplier, manufacturer and customer. Often, in case of such fab-less businesses the customers also select the suppliers, which adds to the already existing constraints.

2. **Type of product:** The semiconductor product portfolio is broad and is categorized as analog circuits, digital circuits, computer peripherals, microcontrollers, network products and so on. Each category demands a different supply chain (SC) planning strategy. The analog and digital circuit

manufacturers are suppliers to the consumer electronic makers and thus the planning process must address consumer induced demand variations. This calls for a collaborated forecasting technique and an agile material ordering system. It also needs very careful resource constraint modeling in the system, careful lot sizing, cyclic and non-cyclic lot ordering, yield modeling and a flexible scheduling system. The system used for integration should be able to handle large volume of data. The computer peripherals, network products and microcontrollers form a different league of business, which is directly linked to the hardware market conditions. The collaboration among supply chain partners is important in any of these supply chains.

3. **Environmental considerations:** In recent times, environmental considerations are increasingly becoming a major part of the material supply chain process. Several key semiconductor processing materials are currently under scrutiny by the Environmental Protection Agency (EPA) and the European Union (EU). This becomes a major factor in product life cycle, yield consideration and phasing-out the old and phasing-in the new products. Called the 'Green Supply Chain', it plays dominant role in today's globalized supply planning.

4. **Inter/ Intra company level of system integration & hardware:** With global networks of suppliers, vendors and inter-organizational dependencies, the system on which each individual company runs needs to be good but more important is the ability and compatibility to integrate with other systems. A homogenous system may not be available with various customers and vendors but system compatibility is the key.

5. **Level of trust and commitment in supply chain relation:** Successful supply chain performance is based on a high level of trust and a strong commitment among supply chain partners. Effective supply chain planning based on shared information and trust among partners is an essential requirement for successful supply chain management. A lack of trust among trading partners often results in close scrutiny of every transaction thereby increasing the transaction costs, productivity, efficiency and effectiveness. Creating value-added activities with partners becomes almost impossible and supply chain tools used to improve efficiency, effectiveness and productivity —such as vendor managed inventory (VMI), cross-docking (CD), and collaborative forecasting, planning and replenishment (CFPR) — eventually become ineffective.

SC PLANNING IN A NON-COLLABORATIVE SUITE SETUP

Almost every major semiconductor business uses an ERP package for transactional processing and planning software to plan its business. The planning process incorporates various cycles, including a 12-18 months, long-range strategic planning process, an 8-10 months tactical sales and operations planning process, and a short-range 3-4 months execution process. Semiconductor Business

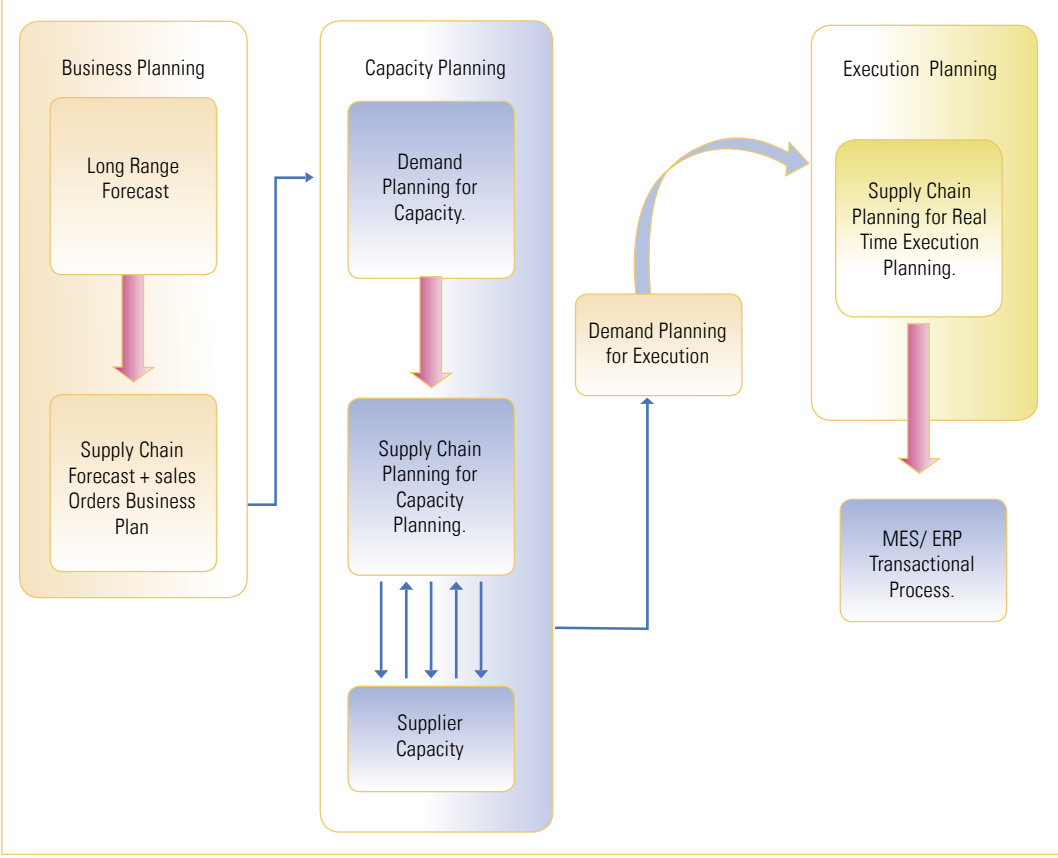

***Figure 1**: SC Planning in a Non-Collaborative Suite Set-up* ***Source:** Infosys Research*

planning can be split into three main parts:

- Strategic
- Capacity
- Execution.

Strategic business planning process is used as an input to both capacity as well as execution planning. All types of planning are driven by demand. Demand planning constitutes an integral part of all three levels of planning. Demand planning, however, is different for strategic, capacity planning and execution planning because of constraints and variations in the outlook of supply that is being planned. Simulation on demands is carried out to arrive at an optimum demand, which in turn is to be put to execution (MRP) in order to minimize lost sales with the finite loading capacity of resources.

Strategic planning: Long-range forecasts, which are used in the strategic plans, are not so much based on mathematical techniques as on knowledge and judgment of various sales/marketing, supply chain and financial organizations. Strategic planning basically spells out how much the company can sell over a long period of time – over the next one to one and half years – based on market behavior, new product launches, and competition.

A demand planning tool in this case is ideally suited to integrate the various inputs obtained from across the company and integrate it with the final aggregated demand plan to be used for supply planning. The long-range strategic demand plan then lays the foundation for sales and operation Plan.

Many items and chips have longer lead times and are required to be procured/ put to manufacturing well before the start of the actual finished goods assembly. This is a key element in defining demands for the strategic plans. The first step in the strategic business plan which is a 12-18 month plan looks at long term forecasts and brings several business groups together in order to help them plan in harmony to achieve the company goals. This plan is generally done at an aggregated product level and is used to calculate the total supply, which is converted to monetary terms (based on cost of items and resources). It calculates projected inventory at the end of each month for finished goods and semi-finished goods and is translated into monetary terms that is used as KPI by management. The plan also calculates inventory turns, planned utilization of resources, gross margins, revenue targets achieved and so on. This plan helps decide the capacity enhancement required at different manufacturing setups, to calculate the percentage of long term demand that can be fulfilled by using the existing capacity (OEM) and to determine which capacity element needs be to expanded within a timeframe so as to meet the projected demand. These plans help the management to carry out cost-benefit analysis for contract manufacturing and to take decisions for capacity enhancements for wafer fabs and for final assembly and hiring framework.

Capacity planning: The finalized long-term strategic plans act as inputs for sales and operations planning. Capacity planning is aimed at maintaining demand as per the KPIs decided at the strategic planning level. It also determines the capacity adjustment or reconfigurations needed at aggregated product level when more accurate demand and capacity information becomes available. The plan helps reduce the lost sales and meet demands to maximum possible extent. For very high demand items this is also used for customer allocations. SOP plans thus give a vivid picture of capacity variability, demands that can be met, manufacturing allocations/ capacity, supplier capacities and customer allocations. All these go as inputs for demand maintenance in Execution planning. Many companies use SOP plan to lot-start wafer and some critical chips that have long lead times while a few others use execution plan.

Execution planning: After SOP plans are finalized, demand is modeled to daily production capacity and to optimize supply and minimize lost sales. Execution plan plays the role of an MRP in the over all manufacturing because it involves the following:

- Inter manufacturing site transfer of raw and semi-finished goods
- Planning/ release of actual manufacturing work orders for execution system
- Planning/ release of requisitions and purchase orders from suppliers
- Planning machine maintenance and resource unavailability
- Maintaining safety stock at different logical stock points in the supply chain.

In effect, it can be termed an MRP plan as it generates work orders, requisitions and also inter-department transfers and firming the generated supplies. Execution planning thus interfaces with transactional modules such as

costing, order entry, inventory control, bill of materials (BOM), purchasing, manufacturing floor control, scheduling and invoicing.

The plan also absorbs the maximum change in demand due to additions and cancellations of orders by customers. It is used to determine the input quantities for each lot at various semi-finished/ finished goods level.

One important characteristic of semiconductor planning is that both product demands and manufacturing capacity are sources of uncertainty. New manufacturing processes create high variability in the yields and consequently uncertainty in the manufacturing throughput, which in turn leads to uncertainty in capacity estimation. So the capacity estimation as done in SOP plan may not remain the same during execution. Due to this variability, manufacturing planning at execution stage also becomes critical to get the desired benefit of SOP and strategic plans.

A majority of the companies use daily and weekly plans for execution purpose as these are also used for finished goods shipment planning. SOP plans determine the lot to be expedited to minimize lost sales and execution plan in effect determines the input quantity as required to meet the desired objective. Projected available balance (inventory) from this plan is used to determine the stock-out situations and prospective lost sales that are then taken care of in future SOP plans for lot expedition.

Demand management in this execution plan is very important as this plan takes forecasts as the input to firm orders. The adjusted demand from SOP plan to execution plans is called as consensus demand. Consensus demand is highly synthesized demand and is in line with the strategic and SOP plans.

As clearly illustrated above, planning cycle in the absence of a collaborative suite is highly complicated and requires very close coordination among many organizations and departments to get the best-of-the-breed plans to gain maximum profitability.

SC PLANNING IN A COLLABORATIVE SUITE SETUP

The semiconductor industry has one of the longest and most complex manufacturing processes in the entire business world, yet semiconductor customers increase pressure on manufacturers to decrease production time while keeping costs low. In turn, manufacturers press their suppliers to have the correct quantity of necessary materials at the exact moment they are needed. Because of technological advances and changes in demand, semiconductor manufacturers — and their suppliers — need to implement multi-organizational planning and real-time collaboration.

Globally, the trend is for a collaborative approach to reduce planning cycle time, improve forecast dependability (as we move for consensus demand planning), and to get product committments from suppliers and contract manufacturing (as we move for consensus supplier/ contract manufacturing capacity).

Collaborative Planning in semiconductor involves the following steps:

- Strategic Capacity Planning
- Collaborative Demand Planning
- Collaborative Capacity Planning
- Execution Planning.

Strategic capacity planning: Strategic planning remains the same with or without collaboration suite. It is a long-term plan for determining the company's objective and business directions. It mainly plans for the two most important characteristics of semiconductor industry:

wafer demands and rough cut manufacturing capacity. It helps companies decide the number of contractual suppliers needed, possible global sourcing allocations, utilize bottleneck resources, monitor start/ completion for each item. This planning cycle serves as an SOP plan as well as a strategic plan. It takes into account long term demand and maps it with existing capacity and forecast the additional capacity/additional contract manufacturing needed to meet the business goals. Once finalized, the plan acts as an input to the collaborative demand and supply planning process.

Collaborative demand and supply planning: Planning starts from demand in a collaborative planning cycle. The initial guidelines are set by the strategic plan, which are used by sales/ customer representatives to generate a consensus forecast along with the manufacturer.

Departments such as sales, marketing and SCM are involved in this process from the manufacturer's side that in turn interact with sales/ customer representatives to firm up demand. Mutual trust and open communication across enterprise holds the key to success at this stage. Once forecasts are finalized, the data is incorporated into the planning cycles for consolidation after which the supply plans are drawn. The plans are shared with contract manufacturers/ suppliers.

At the next level of collaboration planning, suppliers and contract manufacturers commit on the capable supply scenarios. The supply-demand match is done at this stage, mismatches are ironed out. Thus the overall planning cycle is reduced and is more dependable as customer representatives together with the manufacturer draw the consensus forecasts and suppliers/ manufacturers commit on the availability of goods.

Also, the yield variability is catered to as manufacturers and suppliers give the capacity commitment. The process overcomes traditional planning shortcomings and creates faster and more accurate plans. Once the collaborative planning process is completed, demand and supply are finalized and execution plan is run. The frequency of data sharing among representatives, suppliers, contract manufacturers and OEM decides the quality of planning.

As semiconductor product life cycles continue to shrink, managing product transitions and end-of-life events require collaboration within and across enterprises. When products reach full maturity, make or scrap decisions must be made based on inventory availability, market demand, available capacity and profit margins, as well as new product launches. Collaborative planning in all these cases suits really well for this industry.

Execution planning: Once collaborative demand and supply capacities are finalized, demand is modeled to daily production capacity and to generate maximum supply and minimize lost sales. As mentioned earlier, actual execution plan plays the role of an MRP in the overall manufacturing. The plan is used to determine the input quantities for each lot at various semi finished/ finished goods level considering the yield of the various operations. This generates the orders for contract manufacturers and other suppliers. Thus we see that this planning method is fast and compact and is more reliable than the previous traditional planning process using a non-collaborative set up.

Though collaborative planning has been in existence for long now, technological advances and internet communication have now made it more feasible and effective.

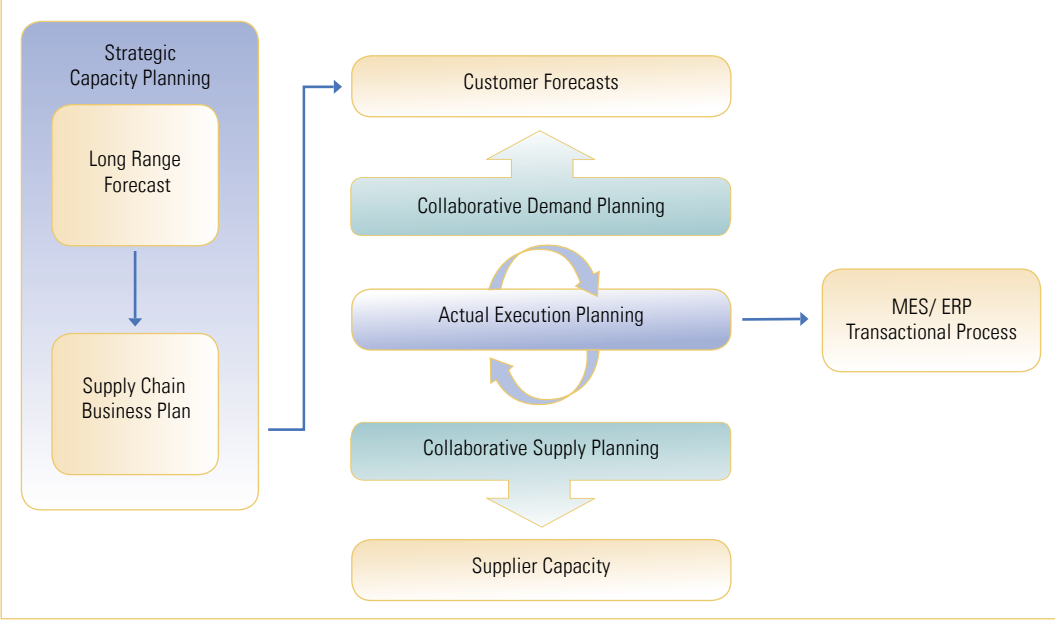

***Figure 2**: Supply Chain Planning with a Collaborative Planning Suite*

***Source:** Infosys Research*

Collaborative planning has the potential to lower working capital, reduce inventory, forecast dependable demand, reduce cycle time and improve responsiveness. Following are a few advantages of collaborative planning:

Phasing out product: In a collaborative planning scenario phasing out a product is easier as all parties involved in the supply chain are constantly communicated of the changes and their plans can be adjusted thereof. The forecast can be reduced or nullified and collaborated with manufacturing division and suppliers about the intended future. Without collaboration, the phasing out will be a tedious and costly process where the manufacturer must use up the product till the supplier stops the scheduled manufacturing in his/her own firm.

New product introduction: With a collaborative planning process new product introductions are smoother. New product forecasts are shared with suppliers and a future supply plan is charted based on their feedback.

Tempering risk: With well-defined planning processes, companies are trying to build a lean and agile supply chain. While currently available software do not cater to 'what-if' analysis, a collaborative approach can help through extensive communication between different stakeholders in a supply chain network to temper risks and make necessary amendments to the plans. The need is to go beyond existing planning domain and react to a potential problem ahead of time.

Some common gaps: A few issues that software of future needs to address are:

1. **Variable yield planning:** Yield is a very important aspect of planning in

semiconductor manufacturing. Issues arise because of variable yield and actual yield being different than what is being planned for future. Balancing maximum throughput with proper yield consideration is a big challenge.

2. **Wrong routing and supplier selection:** Though not a frequently occurring problem, sometimes this software selects wrong routing and supplier which means selecting a lower ranked route or supplier for supply generation.
3. **Optimizing manufacturing capacity:** The challenge is to suggest correct lot sizes to reduce cycle time and operation cost by incorporating demand variability, supplier response and to also maintain high utilization of capacity. Semi-conductor manufacturing is both a resource as well as operation cost-intensive. Hence under utilization is a major concern. At the same time, the industry also battles with fast product obsolescence and volatile demand.
4. **Safety stock calculation and maintenance:** This is required to cushion demand variability. Two most important factors negating it are obsolescence and demand constraint and fluctuating demand. It is difficult ascertain a certain quantity as safety stock and tedious to produce the extra quantity. In reality, inventory is either over stocked or completely starved.

CONCLUSION

While numerous factors affect the supply chain efficiency in the semiconductor industry in both non-collaborative and collaborative planning scenarios, the latter has the ability to manage risk better. Given the highly dynamic nature of the industry, collaborative planning is aptly suited for giving a new supply chain direction to the industry.

REFERENCES

1. S Jain, et al., Criticalit of Detailed Modeling in Semiconductor Supply Chain Simulation, Proceedings of Winter Simulation Conference, 1999.
2. P Dwaraknath, et al., Sales and Operations Planning Practices at Semiconductor Companies, Survey Report, Joint survey by University of Texas at Dallas and Motorola Inc., 2002.
3. M K Sambara, Collaborations for a Hi Tech Contract Manufacturer SME Category, White Paper, Wipro Technologies Limited. Also available at http://www.wipro.com/webpages/insights/contractmanufacturerSME.htm.
4. S Karabuk, David Wu, Coordinating Strategic Capacity Planning in the Semiconductor Industry, Technical Report, Lehigh University, 1999.
5. I G Kwon and T Suh, Factors Affecting the Level of Trust and Commitment in Supply Chain Relationship, The Journal of Supply Chain Management: A Global Review of Purchasing and Supply, May 2004.
6. A Schaller, et.al.Customer Driven Operations Management for Supply Chain, Technical Paper, Motorola Inc., 2007.
7. Achieving Worldclass Fabless Planning, Technical Paper, Inc. Also available at http://www.adexa.com/adexa_library/library.asp.

Author Profile

ARNAB BANERJEE
Arnab Banerjee is a Consultant with Infosys Technologies Limited, Enterprise Solutions. He has considerable experience in large scale IT projects involving ERP and Planning Solutions in Oracle Applications. He can be contacted at Arnab_banerjee01@infosys.com.

For information on obtaining additional copies, reprinting or translating articles, and all other correspondence, please contact:

Telephone : 91-20-39167531

Email: SetlabsBriefings@infosys.com