Simulation Modeling of Information Flow in a 3-stage efficient Supply Chain Network

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Summary

This paper is the result of the work carried out to simulate information flow in a 3 stage efficient supply chain network. In a supply chain system, an individual member exchanges data with other members to synchronize their business operation, which is a complex process. The problem faced by traditional supply chain is lack of accurate and timely information flow across various stages, which leads to accumulation of inventory resulting in reduced efficiency and effectiveness. The solution to this problem is to reduce the barrier across the output of one stage to the input of succeeding stage by adopting information technology as a tool. Keeping this in mind, the data was collected which included both qualitative data and quantitative data. Qualitative data is related to the processes taking place at various stages of the supply chain with reference to information flow. Quantitative data pertains to annual demand, average information flow processing times of all the processes in the supplier's facility and in the assembly line, demand patterns and sales forecasts at each echelon. The simulation modeling is used as tool to model the supply chain system. ARENA simulation package is used to model the system. The data is obtained from automobile manufacturing company and the models are verified and validated with real time data. Traditional process timings is compared with EDI timings at every stage of supply chain and found % decrease in the information flow timings. The output is tested statistically by running the models under number of replications.

1.0 Information Flow in Supply Chain Network

According to Global Supply Chain Forum (GSCF), Supply Chain Management is ''the integration of key business processes from end user through original suppliers that provide products, services, and information that add value for customer and other stakeholders''. The supply chain encompasses all activities associated with the flow and transformation of goods from the raw materials stage (extraction), through to end users, as well as the associated information flows. Material, finance and information flows both up and down the supply chain. While there is no doubt about the importance of informing in the supply chain and about the fact that information technology can greatly reduce the costs, strategic planning of this process and utilization of information is crucial. Information should be readily available to all companies in the supply chain and the business processes should be structured in a way to make full use of this information. Business process modeling is used to analyze the existing processes and help in renovation and integration of those processes. Sharing and strategic utilization of information in a supply chain can radically improve execution of vital business processes and help integrate processes in different companies resulting in shorter cycle times, lower costs and inventory levels and better quality for the final customer. One of the most common problems in supply chains is the so-called bullwhip effect. Even small fluctuations in the demand or inventory levels of the final company in the chain are propagated and enlarged throughout the chain. Because each company in the chain has incomplete information about the needs of others, it has to respond with the un-proportional increase in inventory levels and consequently even larger fluctuation in its demand to others down the chain. It is also shown that, the production peak could be reduced from by transmitting the information directly from the customer to the manufacturer

Internet and e-business offer many possibilities for effective information sharing that enable seamless flow of transactions in the supply chain. They can also facilitate relationships by their ability to transfer information. Newly developed relationships can drastically change the underlying business processes and different new approaches are emerging, such as vendor managed inventory, computerized point-of-sale systems, material requirements planning, Manufacturing Resource Planning. The efficiency of supply chains can generally be improved by reducing the number of manufacturing stages, reducing

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lead-times, working interactively rather than independently between stages, and speeding up the information flow. It is shown that electronic data interchange could reduce swings in inventory and safety stock.

2.0 Literature Review

A paper on the importance of information flow within the supply chain discusses the importance of information flow within the relatively complex supply chain of a communications company. Analyses the activities within the supply chain and illustrates the importance of the relationship between goods, movement and the exchange of information. The authors Concludes that responsiveness to customer demand, and overall customer satisfaction, cannot be achieved without proper management of both the goods movement and information flow throughout the supply chain. (9)

The main objective of the paper on leverages information sharing to increase supply chain configurability is to achieve collaboration supply chain. Information sharing ensures that right information is available at right place, right time and to right trading partner. The information sharing focuses on information sharing structure, data object and information flow modeling. Information sharing structure is then shown which is of 3 types i.e., sequential information sharing, reciprocal information sharing and hub spoke structure. In the end, the paper tells us to use third party logistics, vendor management inventory as these are used in sequential sharing.(10)

A paper on Information-sharing in supply chains: five proposals on how to proceed aims to focus on supply chain visibility in practice and to suggest ways to improve the supply chain performance through information sharing. On the basis of the case results, five proposals on how to improve visibility were presented. The objective of this paper was to point out improved areas in which original equipment manufacturers can focus in order to benefit from improved visibility. The five propositions are: share only information that improves supply chain performance, simplify, synchronize, and stabilize demand-supply planning processes, use a combination of different demand data sources, benefit from collaborative relationships with customers and understand suppliers' real needs for demand information. This paper suggests a hybrid information-sharing strategy in which demand information is shared in the distribution network and in inventory information in the supply network.(18)

A paper on improving the inter-organizational supply chain through the optimization of information flow discusses about the information flow in the new supply chain and also about the older supply chain. Here the concept is to integrate the purchase, sales, manufacturing and even the logistics activities. An example of hub and spoke is given to show the information and the physical flow but the problem with the hub and spoke is that each level does not get the required information which is very important in a Supply Chain. So a star structure is used as by this each level will get the required information. The IT based hub is placed in between the suppliers and the producers and there is only one store so each will get the required information. This paper has introduced many new IT based technologies but with that the older technologies are also been used and the cost and the distortion in information flow reduces.(8)

Information flow in automotive supply chains- present industrial practice identify the uncertainties experienced in the business as they provide us the focus toward the goal. Here, the problem was divided into three categories they are lack of information, poor performance and lack of strategy thinking. Lack of information is the trust between two partners in the SC and they should have an access to it. The lack of strategic thinking in the supply chain is that many suppliers think that they are working together in making the product, but, still there is a lot of inventory left behind and they've been asked to cut cost of production. Finally, the analysis of the categories improved the supply chain. (15)

In the real world supply chain information is withheld and distorted and it leads to extra cost. This paper on information flow in automotive supply chains- identifying and leading to overcome barriers to change concentrates on improved information flow in automotive supply chain and the many barriers to be overcome in achieving it. According to the authors, there are two pains in the supply chain one is the demand information flowing upstream and the critical flow downstream. To remove the pains of the supply chain the information must be distributed through out the supply chain by which all the members will feel motivated and the pain that is the short term gain will have no effect in them. The final objective in this paper is to ensure that the every player in the value stream has this information available in an up-to-the minute, distortion free format. The bullwhip should be monitored and reduced.(14)

Technological changes and organizational improvements are essential for effective integration of supply chains .Business process modeling can be used to analyze the existing processes and help in renovation and integration of those processes, with a special emphasis on an inter-organizational level. Sharing and strategic utilization of information in a supply chain can radically improve execution of vital business processes and help

integrate processes indifferent companies resulting in shorter cycle times, lower costs and inventory levels and better quality for the final customer. In this paper on information transfer in supply chain networks, the authors feel that supply chain is effective if there is a proactive relationship between a buyer and supplier and the integration is across the whole supply chain, not just first-tier supplier. Newly developed relationships can drastically change the underlying business processes and different new approaches are emerging, such as vendor managed inventory (VMI), computerized point-of-sale (POS) systems, material requirements planning (MRP), manufacturing resource planning (MRP II).

The Purpose of this paper on supply chain relationships and information capabilities – the creation and use of Information power is to present a framework depicting the development of information power-based relationships between firms, and to describe the effect of information power on long-term relationships between supply chain partners. The conceptual framework introduced indicates that information can be utilized as a coercive and non-coercive power base in supply chain relationships. The study includes definition and sources of power, Power in supply chain relationships, Information as power, Power in inter firm relationships and decomposition model showing the impact of information integration and power was developed. The work shows that information is a primary attribute leading to the development of other powers. When information is harnessed, organizations have the ability to use this power in a manner of coercion or No coercion. Depending on the style in which the power is used, organizational acquisition and behaviors will be impacted. (21)

3.0 Motivation and Objectives

In today's global market, managing the entire supply chain becomes a key factor for the successful business. World-class organizations now realize that non-integrated manufacturing processes, non-integrated distribution processes and poor relationships with suppliers and customers are inadequate for their success. They realize the impact of an organization's plan on the areas of the supply chain. The impact is unpredictable before the execution. Towards this, modeling information flow is very much essential for the success of any organization. Keeping the following objectives are set:

- To study the supply chain processes at advanced planning level with reference to information flow.
- To design and develop a model of an automobile supply chain network using Simulation package
- To measure the performance of integrated model and compare the performance of model under various parameters.
- To verify and validate the data statistically using the case of automobile organization.

The assumptions made in this work: Studying the processes at the advance planning level. Developing models only for three stage supply chain of an automobile company i.e., dealer, manufacturer and suppliers. Study considers only Tier 1 suppliers.

4.0 Business Processes and Information Flow in Automobile Supply Chain Network

The business process involved in automobile supply chain network with reference to information flow is studied with real time data. The processes are shown in tabular and flow chart forms as under: The processes involved dealer stage is:

Table 1 Processes in Dealer stage

Forecasting the need	Claim Warranty
Preparing Purchase Requisition	goods to be delivered
Acknowledgement of Purchase requisition	Update stock and delivery
Purchase requisition to Purchase Order	Customer need
Receipt of Invoice	Negotiation
Clearing bills	Place order
Wait for delivery	Wait for delivery
Receipt of delivery note	Delivery
Inspection	Payment
Return Goods	

Manufacturer stage consists of four sub stages.

1. Purchase Stage
2. Production Stage
3. Warehouse stage
4. Dispatch stage

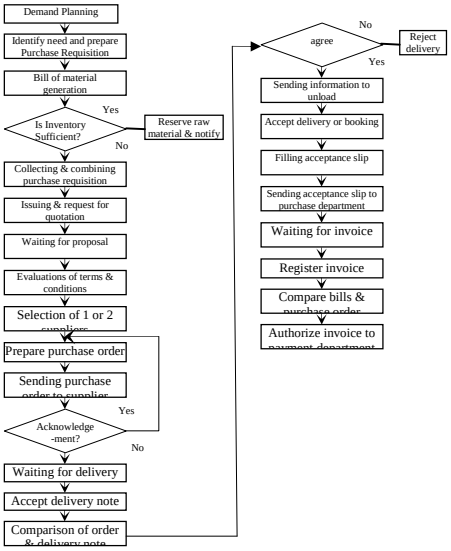

Fig. 1: Processes in purchase stage

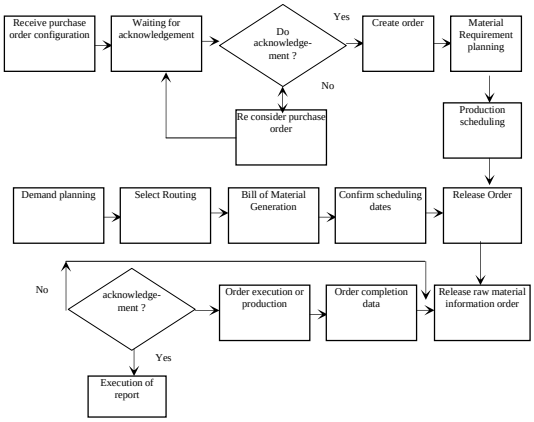

Fig. 2: Processes in production stage

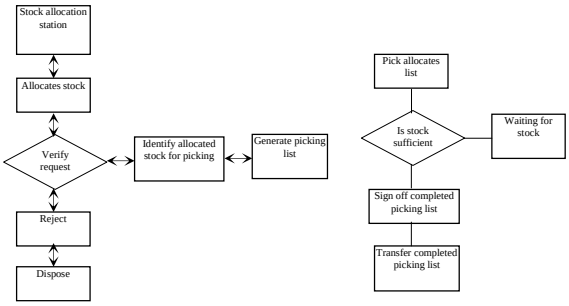

Fig. 4: Processes in warehouse stage

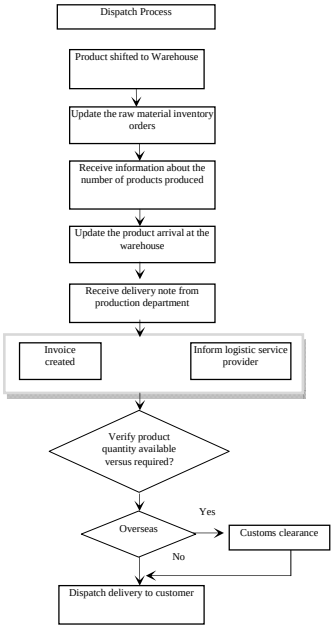

Fig. 5: Processes in Dispatch stage

Supplier stage involves receiving orders from the manufacturer and processes.

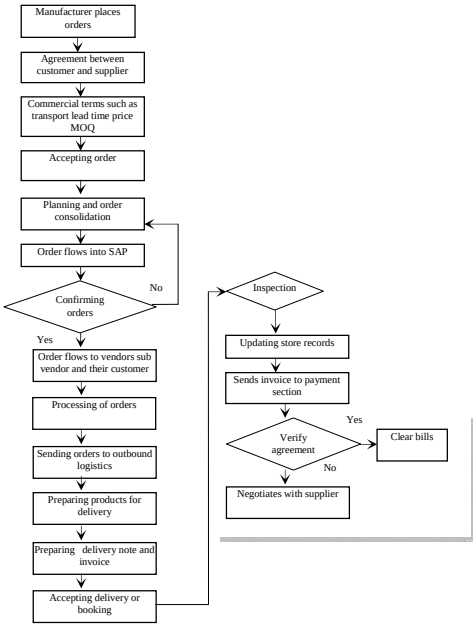

Fig. 6: Processes in Supplier stage

5.0 Methodology

Data Collection: The data collection consists of both qualitative data and quantitative data. Qualitative data is related to the nature of the processes taking place at various stages of the supply chain with reference to information flow. The data is collected for the supplier, manufacturers and dealer stages. Quantitative data pertains to annual demand, average information flow processing times of all the processes in the supplier's facility and in the assembly line, demand patterns and sales forecasts at each echelon, inventory levels, lead times of production and distribution / delivery and other relevant data pertaining to the suppliers, manufacturers, and dealers. The source of data collection is from automobile companies situated in Bangalore and secondary data.

For supplier and manufacturer stage, the data for non EDI information flow was collected from premier automobile company and for EDI incorporated information flow; it was taken by consulting the ERP developers. The data for dealer stage EDI and non EDI information flow was collected from premier dealer selling automobiles. The timing varied from hours to days based on the processes.

Modeling: The modeling involved structural modeling to identify the entities, attributes, activities and events. ARENA simulation package is used to model the sub – systems and integrated system. The Steps followed in running a successful simulation model in ARENA to study the information flow in automobile supply chain network are:

1. Creating a basic model: Arena provides an intuitive, flowchart-style environment for building an "as-is" model of the process.
2. Refine the model: Add real-world data (e.g., process times, resource requirements, and staff levels) to the model by double-clicking on modules and adding information to Arena's data forms. To create a more realistic picture of the system, replace the animation icons that Arena automatically supplies with graphics.
3. Simulate the model: Run the simulation to verify that the model properly reflects the actual system. Identify bottlenecks through the dynamics of graphical animation.
4. Analyze simulation results: Arena provides automatic reports on common decision criteria, such as resource utilization and waiting times.
5. Select the best alternative: Make changes to the model to capture the possible scenarios to investigate, and then compare the results to find the best "to-be" solution.

A sample ARENA model is shown below for simulation of purchase sub system.

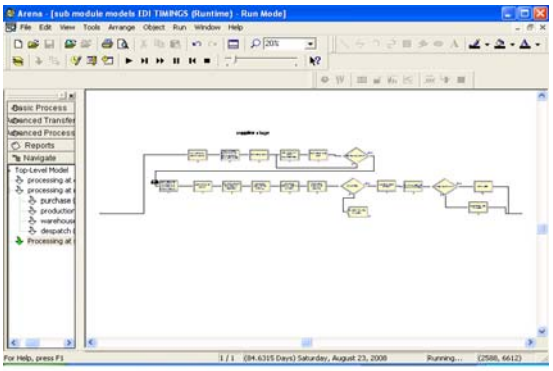

Fig. 7 Arena Model for simulation of purchase sub-system

All the data has been fed into arena in the form of the time. Process module is used to signify a transformation of information and delay is the time elapsed in transferring information from one location to another.

Verification and Validation of the Model: The models are verified and validated with real time data. Statistical analysis was done to check the measures of performance. Different priority parameters are incorporated into the model and results are obtained. The models have been tested by feeding in real time data from various stages as mentioned in the data collection.

6.0 Results and Discussion

The output is tested statistically by running the models under various scenarios and various real time conditions.

Table 2: Non-EDI supply chain timing

Sl no	Orders processed	Range in days
1.	1500	200-300
2.	3000	300-350
3.	4500	350-400
4.	6000	400-450
5.	7500	450-500

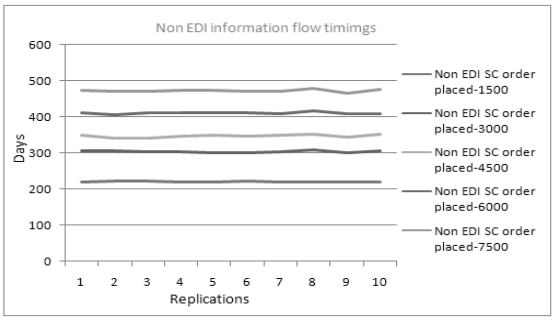

Fig. 8 Non – EDI Supply chain information timings

The above graph is a plot of replications versus the number of days taken to process the orders. The variable here is the number of orders placed. The results for the same have been obtained from simulation by running the model for ten replications for the non-EDI process.

Table 3: EDI enabled supply chain timing

Sl no	Orders processed	Range in days
1	1500	100-150
2	3000	150-200
3	4500	250-275
4	6000	300-350
5	7500	350-450

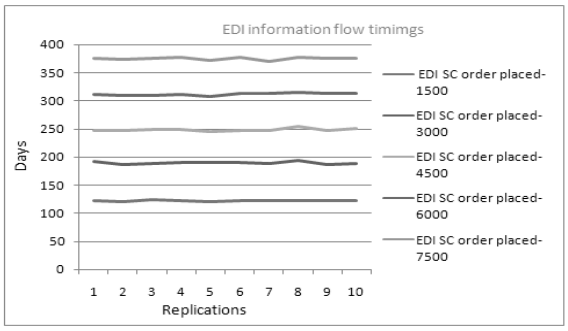

Fig.9 EDI Supply chain information timings

The above graph is a plot of replications versus the number of days taken to process the orders. The variable here is the number of orders placed. The results for the same have been obtained from simulation by running the model for ten replications for the EDI process. Thus, from the graphs, it is evident that the time taken drastically reduces as there is a shift from the non-EDI to the EDI process. Also the graphs have been drawn to obtain comparison with regard to orders placed on a quarterly, half yearly or annual basis.

The above table has been obtained by running the simulation for the individual stages in both the scenarios and comparing the same. It shows the percentage decrease in time for processing of orders from the Non- EDI information flow to the EDI information flow system. This is calculated by the ratio as:

% decrease in time = (Non EDI timings – EDI timing)*100 /Non-EDI timing

Table 4: comparison between Non-EDI & EDI timings

Sl No	Stages	% decrease in timing
1.	Dealer	28.57
2.	supplier	51.47
3.	Purchase	18.49
4.	production	19.94

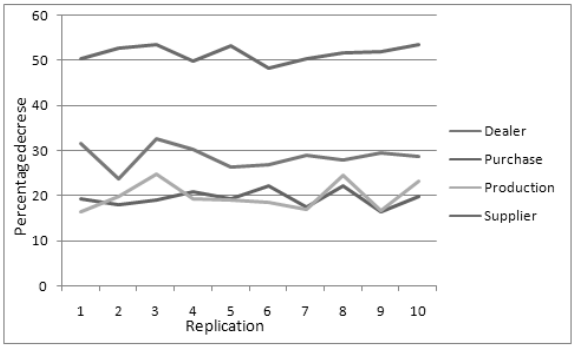

Fig. 10 : Comparison between Non-EDI & EDI timings

7.0 Scope for Future Work

The scope of future works can be:

- Inclusion of all the three flows in one integrated model taking into account lead times due to all flows. The delay in processing of the order is rather a delay due to inefficient material, information and financial flow. Thus a performance of a system can be better analyzed when all these flows are concurrently included for simulation in an integrated model

- Adaptation of the integrated models to industries apart from the automotive industry.

- Creation of the Supply chain co-ordination centers to interact with warehouse to get updated information about the inventory status and accordingly plans the delivery schedule and coordinates that information with logistic service provider so that the components product are delivered to next level of supply chain at the right time.

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