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# The Structural Integration of Supply Chain Practices in a Manufacturing and Distribution Systems: A Literature Review

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## ABSTRACT

The main aim of this paper is to develop an integrated network in the supply chain practices of a selected organization, which is capable of providing perceptibility, resilience in the environment. The study examines the individual manufacturing and distribution networks of a proposed organization followed by introducing the projected integration system. It also confers the level of integration, planning and implementation of the supply chain elements using a numerical simulation model. Inventory levels are used in order to test the manufacturing network whereas the customer requirements were considered for analyzing the distribution outlining. The numerical simulation helps in extending the projected model for a number of enterprise scenarios. The results show that as a part of integration system provides concurrent scheduling of individual components in the distribution network and can be expanded to the manufacturing units. It also benefits the environment to precise the activity schedule times rather than following the conventional lead times. Furthermore, scheduling of components becomes more flexible due to the greater visibility of components intricate in the organization and also helps in decreasing the inventory lot sizes.

**Keywords:** Integration, Manufacturing & distribution networks, Scheduling, Supply chain Network, Lead time.

## INTRODUCTION

### Supply Chain Management (SCM)

In contemporary global business environment, every organization become a part of at least one supply chain. In addition, logistics and supply chains (SCs) has been increasingly recognized in the manufacturing networks [1]. Supply Chain Management (SCM) is a cross functional technique that controls the flow of goods inside a supply network domain, which encompass from the point of origin of raw materials to the point of consumption i.e., finished goods received by the customers. So, Globalization of Supply Chain Management have received considerable interest over the recent past. In order to contend in the global merchandise, Organizations were largely relying on supply chains. Supply chain practices are identified with many key aspects for the effective planning of many components and execution of those plans. These aspects includes integration, globalization, collaboration and relationships which will helps in making the underlying business practices much more productive and efficient. A typical supply chain practice reveals that these aspects must contribute each other and also requires integration of data information, application and infrastructure within and across organizations, thereby molding the concept of integration as the key aspect of modern supply chain management.

### Concept of Integration

The supply chain integration focus on both intra- and inter-organizational activities in order to have an efficient synergy of processes, information and decisions to achieve a high efficient products that meet

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the requirements of the customer. Enterprise level Integration usually takes place at three levels: data, application and technical integration w and are satisfactorily assist by the Enterprise resource planning (ERP) systems [2]. Data integration takes places within the database layer of ERP, functional applications are unified across other cross-functional activities of the enterprise draft whereas technical integration is used to distribute the functional applications within the business unit.

Organizational Integration was recognized as essential element for the successful operation of the globalized supply chain systems. Theoretically, it can be categorized into levels and areas of integration. There were various reasons for this categorization of levels, such as it is used for lead time improvements by integrating the processes and also sharing information between substations [3], intra- and inter- level integration for collective and functional efficiency [4], an organizational integration for productive improvements [5], operations integrating between suppliers and customers leads to the enhanced responsiveness to the merchandise changes [6].

However, the existing ERP systems are not able to provide process capabilities for the successful operation of SCM in the organizations. So, the proposed integration model would help to overcome the limitations in the SCM system, interpreting the modern ERP products to be inadequate for its operation [7].

## Literature Review

Nah [8] suggested that the integration among the materials, processes, information and technology within and across the organization will helps in accomplishing good results in the digital economy. An integrated ERP system was considered for eliminating problems associated with integration of many operations. Themistocleous et al., [9] conferred a comprehensive study of problems correlated with ERP system and with the integrated operations. A diverse integrated ERP system was proposed as a substitute to the ERP system and application integration by Alshawi et al. [10].

Akkermans et al., [11] determined that further integration of processes amidst suppliers and the customers provides more flexibility in the operations plan of the system and also diminishes cycle times and inventories with the increase in mass customization. They identified some key constraints in the ERP systems with contribution to productive SCM support: their inflexibility to the changes in supply chain system, functionality limitations beyond directing transactions, and their enclosed and non-modular system planning.

This causes to identify a substantial integration system of ERP and SCM software solutions with the globalization of supply chain operations. Samaranayake et al., [12] used a cross-link integration between ERP and SCM components i.e., production planning, project management and logistics systems for the successful operation of the globalized supply chain management. It is similar to the vertical integration approach of organizations where the market imperfections had great effect on the integration.

Stuckey et al., [13] highlighted the reasons for which the organizations opt for the following reasons: when the market is delicate and inaccurate, when market conflicts arises between the corresponding companies, during the start-up state of the organizations, when the organizations were planning to achieve market power. Some of the problems associated with this procedure would be security issues, flexibility and guarantee for further expansion. This study basically focuses on the theory behind the integration of manufacturing and distribution networks in supply chain management. An established integration system will reduce the supply and demand fluctuations across the supply chains. These fluctuations are minimized because of the linking system between independent layers and it also makes the flow of information more transparent which creates a fundamental bonding between the manufacturing and distribution networks.

The basic algorithm of this study demonstrates as follows: the supply chain network is discussed followed by the concepts of manufacturing and distribution networks and their integration in order to show how advancements in planning and scheduling should be taken care. Followed by, the basic strategies of manufacturing and distribution networks at the selected automotive manufacturing organization is introduced along with the proposed integration. Finally, a numerical simulation of the selected organization was tested using the real time date. The key recommendations for the future research is presented at the end.

## GLOBAL SUPPLY NETWORK ENVIRONMENT

Globalization of supply network systems involve activities such as cross-plant production planning, measures to cut off the working capital and distribution planning. Other related research activities have also identified such as governing complex supply networks, integrating local suppliers and eliminating unproductive time in order to make the system environment more economical. Thus, this analysis provides the integrated approach used in scheduling the management and distribution activities across a selected automotive industry.

### Overview of Manufacturing and Distribution Networks at the Selected Automotive Manufacturing Organization (Car Assembler)

An organization with global business objective which has process networking opportunities across the Asia pacific region has been selected. The selected organization involves with different manufacturing plants (SR, GM and KD), number of warehouses and distributors in the supply chain process. For the proper operation of these units, planning, control and execution of supply network is very crucial.

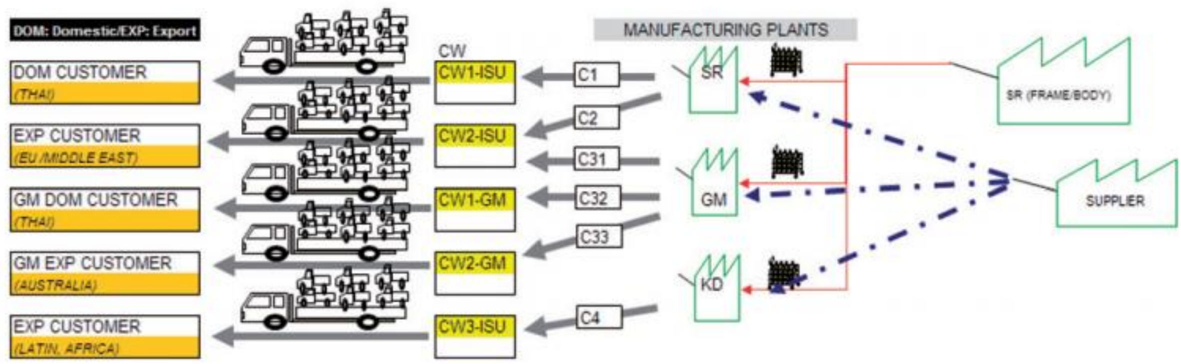


**Figure1.** *Schematic view of the selected organization [14]*

Figure 1 shows the manufacturing and distribution network of the selected manufacturing organization. It is noticed that GM and KD were providing with a group of part suppliers classified by the "supplier" and SR as a sub- assembly supplier which supplies frame and body parts. The manufacturing units from the plants are transferred to the various warehouses (CW1-ISU, CW2-ISU, CW1-GM, CW2-GM and CW3-ISU) and are distributed to various domestic and export customers based on the type of products and regions. In order to establish an integrated network system in this type of organization, relationship between the key categories such as plants, warehouses, materials and distribution centers.

Master data and organizational elements involved in the manufacturing and distribution networks of the supply network are presented in Table 1.

**Table1.** *Master Data & Organizational Elements of the Supply network [14]*

| Organizational Elements | Finished Products | Manufacturing Master Data | Distribution Master Data |
|---|---|---|---|
| Central Warehouse locations (CW11-CW13) | 1 ton pickup at SR plant (FP1) | Engine group 1 (En1) | Domestic Market (C1) |
| Central Warehouse locations- Partner org. (CWG1-CWG2) | 1 ton pickup at KD plant (FP2) | Frame group 1 (Fr1) | Export Market (C2) |
| Manufacturing plant (SR) | | Body group 1 (Bd1) | Domestic Market for GM (C31) |
| Secondary plant (KD) | | Assembly activities (A1-A16) | GM Market (C32) |
| Subsidiary plant (GM) | | Assembly resources (RA1-RA16) | Third world country market (C4) |
| | | Suppliers (S1-S4) | Distribution activities (DA1-DA34) |
| | | Components (CM1-CM2) | Distribution Resources (R1-R34) |

## Algorithm for Scheduling Paths [15]

An algorithm has been developed in order to schedule paths in the manufacturing network of an integrated network:

*Step 1* Identify SOURCE/CONSTITUENT relationships and sort them by SOURCE.

*Step 2* Set scheduling paths for the central warehouse (Current Item = 1) in the forward scheduling and the last part for the regressive planning.

*Step 3* Amend the list of SOURCE/CONSTITUENT relationships.

*Step 4* Set scheduling paths for either end item or next SOURCE in the rundown.

*Step 5* Interpret the next SOURCE/CONSTITUENT relationship.

*Step 6* If the end of file reached, go to Step 10. Otherwise go to next Step.

*Step 7* If the current SOURCE is a CONSTITUENT of another source, go to Step 5.

Otherwise go to next Step.

*Step 8* Set scheduling paths for the current SOURCE.

*Step 9* Set scheduling paths for either end item or next SOURCE in the list.

*Step 10* If there is no further unresolved relations in the list, STOP. Otherwise, carry out closed loop analysis.

Similarly an algorithm has created for scheduled in the distribution system of the incorporated structure:

*Step 1* Identify SOURCE/CONSTITUENT relationships and sort them by SOURCE.

*Step 2* Set paths for each customer in the regressive planning and the central warehouse (Current Item = 1) in the forward schedule.

*Step 3* Amend the list of SOURCE/CONSTITUENT relationships.

*Step 4* Set scheduling paths for either end item or next SOURCE in the rundown.

*Step 5* Interpret the next SOURCE/CONSTITUENT relationship.

*Step 6* If the end of file reached, go to Step 10. Otherwise go to next Step.

*Step 7* If the current SOURCE is a CONSTITUENT of another source, go to Step 5.

Otherwise go to next Step.

*Step 8* Set scheduling paths for the current SOURCE.

*Step 9* Set scheduling paths for either end item or next SOURCE in the list.

*Step 10* If there is no further unresolved relations in the list, STOP. Otherwise, carry out closed loop analysis

The procedure for scheduling paths wipes out any vagueness in planning all parts in the system structures, so that joined usefulness of CPM, MRP, PAC and DRP can be utilized viably, especially in expansive structures, for example, those utilized as a part of complex supply chain systems. General the scheduling algorithms ensure that a solitary pass is sufficient to calendar segments in the entire system, if there are no shut circles included. This proposes that the calculations can likewise be thought to be computationally feasible.

Proposed algorithm structures could be further amplified into complex circumstances, for example,

- incorporated systems with CPM joins;
- reverse logistics;
- Direct connections between components over two systems.

Figure 2 shows a typical manufacturing network from suppliers (S1-S2) to the central warehouse (CW) and the components involved in this network are finished products (FP1-FP3), a set of activities/assembly operations (A1-A12), a set of resources (R1-R12), and raw materials (RM1-RM2). The below figure depicts that the components (CM1) from the various suppliers (S1-S4) and the distribution resources (R1-R16) are carried to the assembly stations (A1-A16) in order to build the finished products (FP1-FP2). These finished products are distributed to the corresponding central warehouse locations. Manufacturing plant (SR) assemblies the Engine group, Frame group, Body group and the components to make the finished product (FP1) and are distributed to the Central Warehouse (CW11/CW12). Similarly components are assembled from KD plant and are transported to the CW13 warehouse and the finished products from GM plant are moved to the CWG1/ CWG2 warehouses.

Figure *3* shows the distributed network from central warehouse location to customers assimilating the associated resources, distribution activities, finished products and customers. The integrated network helps to accommodate all the individual networks to establish at a common plot. Once the Finished products (FP1- FP2) from the manufacturing plant reaches the Central warehouses. Using various distribution activities and resources, the manufactured groups are transmitted to the associated customer as shown in below Figure.

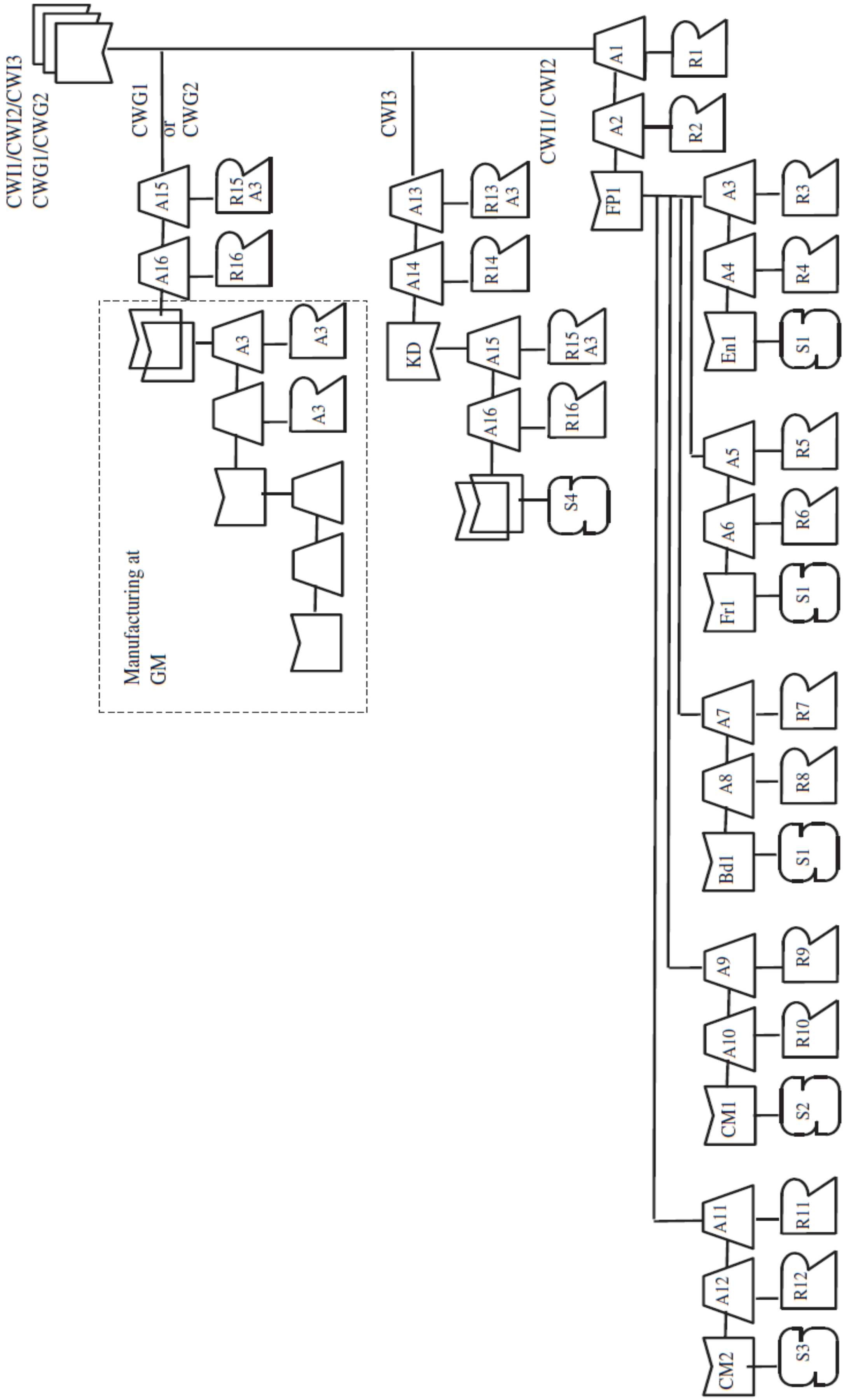


**Figure2.** *Schematic diagram of flow process in Manufacturing Network [14]*

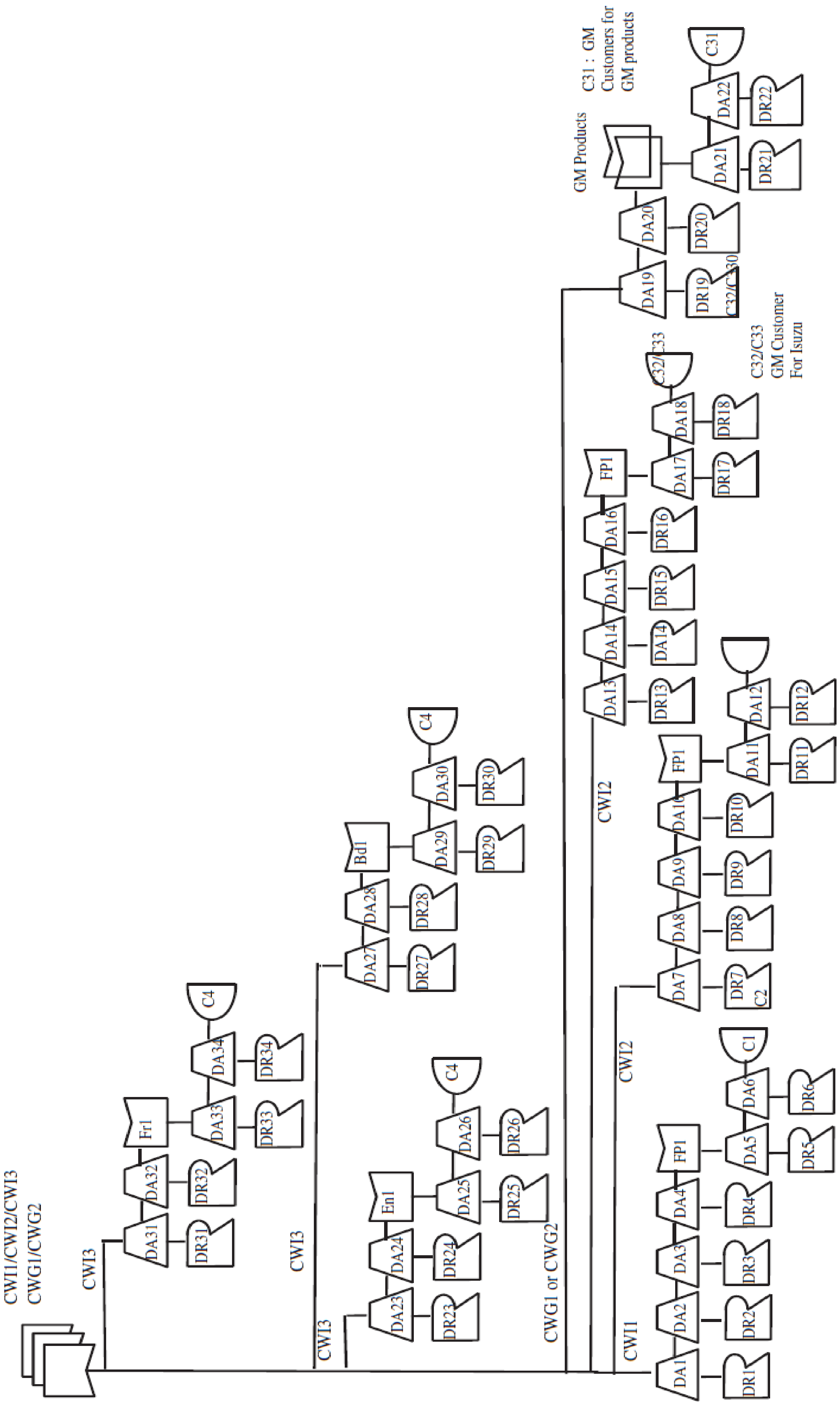


**Figure3.** *Schematic that represents the distribution flow network from Central Warehouse [14]*

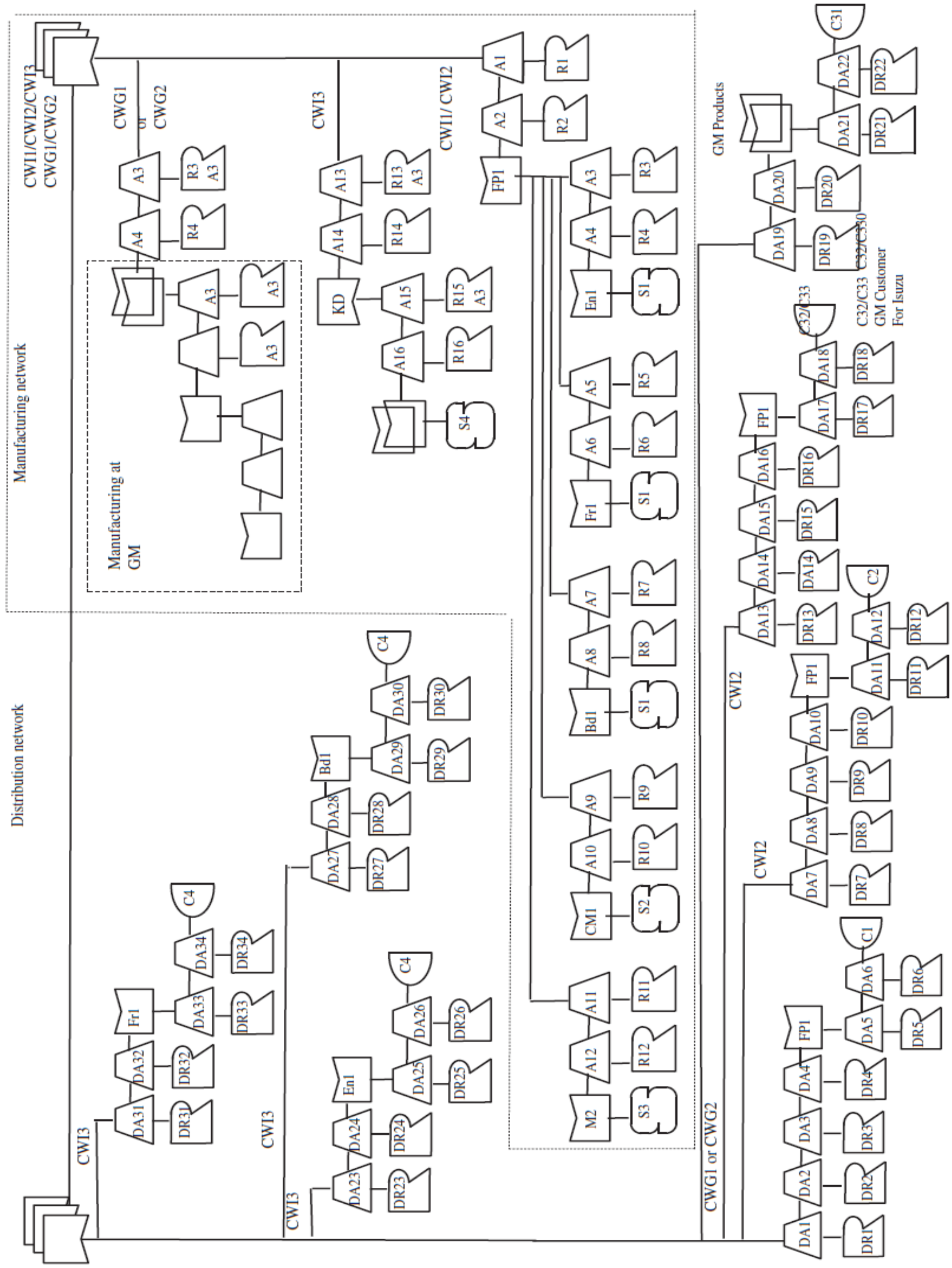

**Figure4.** *Integrated supply chain network of the selected organization [14]*

In order to obtain optimum results in the organization, these individual networks were integrated which uses the output of one network as an input of the other network. Whenever any changes applied in one network, it automatically reflects to the following scheduled paths. This could benefits in concurrent planning and implementation of all the components in the network in terms of planned orders, order requirements for raw materials and delivery orders of finished products etc. Finally the integration at structural level would be involved using the connections between MRP and DRP records. The integrated supply chain network is shown in Figure 4.

The basic advantages associated with the integration supply chain network can be classified into various factors: basis for the improvements associated with the planning, control and execution of various components, flexibility for the changes to be happen in the overall network and finite stacking of resources at the time of designing etc. The proposed Integration network is demonstrated using a real time data for a car assembler unit as a numeric examples of this system.

## Numerical Simulation of the Proposed Integration Supply Chain Network at the Selected Organization

Real time data of the selected organization has been considered in order to perform the numerical testing for the validation of the integrated supply chain system. The demand for the finished product (FP1) and sub-assembly parts (body, frame and engine) for three customers (C1-C3) are shown in Table 2. In the simulation, the functioning of the components is assumed to be 8 hours (9:00-17:00) per day over five days a week.

**Table1.** *Real time data over a period of time [14]*

| Customer - warehouse relationship | Vehicles per Truck | Trucks per hour | Hourly Demand | Daily Demand |
|---|---|---|---|---|
| C1 (domestic) from CW11 | 6 | 5 | 30 | 180 |
| C2 (export) from CW12 | 3 | 1 | 3 | 18 |
| C3 (export) from CW12 | 6 | 3 | 18 | 108 |

It is assumed that each exercise/ activity is associated with a single unit of resource and is shown by earliest start and finish dates/times. When the earliest start and latest dates/times are differ, which means that they were not in the critical path. Each activity is a combination of both set-up and operation times whereas each resource component can be a combination of both labor and machine categories. Two assumptions were made in this simulation: the resource is correlate with only one capacity and each activity is attached with a single resource.

Forward scheduling is used in scheduling the paths in supply chain network. So a fixed due date of 30/10/2009 and the time of 17:00 hours were considered to be customers due date and time, respectively. Table 3 and 4 shows the detailed manufacturing and distribution process of the finished product FP1 to the customers C1, C2 and C3. Forward scheduling starts with the independent demand at customer level and follows until it reaches the central warehouse. Because of the independent planning methods, there would not be any issues of incompatible planning values over the distribution network. In traditional planning techniques, planning (materials, manufacturing and distribution activities, resources, customers and suppliers) and execution of those plans requires individual planning techniques but also manual interfacing of those plans with finite capacities. Whereas, the projected technique eliminates the requirements for individual planning and uses the materials and operations, requirements at central warehouse for manufacturing planning and customer requirements for distribution network. In manufacturing unit, backward scheduling technique is used since the planning starts from the due dates of all the requirements at the warehouses.

The integrated network helps in carrying the modifications happened in one network to another network. It also uses the accurate times rather than traditional margin points for the planning of components. Finally, the integration of suppliers and customers in the supply chain network helps in providing greater flexibility, mass production with decreasing cycle times and backlog of stocks.

**Table2.** *Scheduling of Customer requirements through supply network*

| Component type | Comp. ID | Resource | Operation time/unit Hour:min | Quantity | Duration hour:min | Latest / earliest start (date & time) | Latest / earliest finish (date & time) |
|---|---|---|---|---|---|---|---|
| Customer | **C1** | | | 30 Vechicles | | 30.10.09 17:00 | 30.10.09 17:00 |
| Unloading | DA6 | DR6 | 0:07 | 30 | 3:30 | 30.10.09 13:30 | 30.10.09 17:00 |
| Transport | DA5 | DR5 | | 30 | 5:00 | 29.10.09 16:30 | 30.10.09 13:30 |
| Material | FP1 | | | 30 | | | |
| Documenting | DA4 | DR4 | 0:05 | 30 | 2:30 | 29.10.09 14:00 | 29.10.09 16:30 |
| Labelling | DA3 | DR3 | 0:02 | 30 | 1:00 | 29.10.09 13:00 | 29.10.09 14:00 |
| Loading | DA2 | DR2 | 0:03 | 30 | 1:30 | 29.10.09 11:30 | 29.10.09 13:00 |
| Cleaning | DA1 | DR1 | 0:04 | 30 | 2:00 | 29.10.09 09:30 | 29.10.09 11:30 |
| Warehouse | **CWI1** | | | 30 (ready) | | 29.10.09 09:30 | 29.10.09 09:30 |
| Customer | **C2** | | | 3 vechicles | | 30.10.09 17:00 | 30.10.09 17:00 |
| Unloading | DA12 | DR12 | 0:05 | 3 | 0:15 | 30.10.09 16:45 | 30.10.09 17:00 |
| Transport | DA11 | DR11 | | 3 | 1:30 | 30.10.09 15:15 | 30.10.09 16:45 |
| Material | FP1 | | | 3 | | | |
| Documenting | DA10 | DR10 | 0:10 | 3 | 0:30 | 30.10.09 14:45 | 30.10.09 15:15 |
| Labelling | DA9 | DR9 | 0:05 | 3 | 0:15 | 30.10.09 14:30 | 30.10.09 14:45 |
| Loading | DA8 | DR8 | 0:10 | 3 | 0:30 | 30.10.09 14:00 | 30.10.09 14:30 |
| Cleaning | DA7 | DR7 | 0:08 | 3 | 0:24 | 30.10.09 13:36 | 30.10.09 14:00 |
| Warehouse | **CWI2** | | | 3 (ready) | | 30.10.09 13:36 | 30.10.09 13:36 |
| Customer | **C32/C33** | | | 18 vechicles | | 30.10.09 17:00 | 30.10.09 17:00 |
| Unloading | DA18 | DR18 | 0:05 | 18 | 1:30 | 30.10.09 15:30 | 30.10.09 17:00 |
| Transport | DA17 | DR17 | | 18 | 2:20 | 30.10.09 13:10 | 30.10.09 15:30 |
| Material | FP1 | | | | | | |
| Documenting | DA16 | DR16 | 0:03 | 18 | 0:54 | 30.10.09 12:16 | 30.10.09 13:10 |
| Labelling | DA15 | DR15 | 0:02 | 18 | 0:36 | 30.10.09 11:40 | 30.10.09 12:16 |
| Loading | DA14 | DR14 | 0:05 | 18 | 1:30 | 30.10.09 10:10 | 30.10.09 11:40 |
| Cleaning | DA13 | DR13 | 0:04 | 18 | 1:12 | 29.10.09 16:58 | 30.10.09 10:10 |
| Warehouse | **CWI2** | | | 3 (ready) | | 29.10.09 16:58 | 29.10.09 16:58 |

**Table3.** *Scheduling of Stock requirements over manufacturing network*

| Component type | Comp. ID | Resource | Operation time/unit Hour:min | Quantity | Duration hour:min | Latest / earliest start (date & time) | Latest / earliest finish (date & time) |
|---|---|---|---|---|---|---|---|
| Warehouse | **CW11** | | | 30 units | | 30.10.09 17:00 | 30.10.09 17:00 |
| Receiving and inspection | A1 | R1 | 0:05 | 30 | 2:30 | 30.10.09 14:30 | 30.10.09 17:00 |
| Documenting for transport | A2 | R2 | 0:10 | 30 | 5:00 | 30.10.09 09:30 | 30.10.09 14:30 |
| Material | **FP1** | | | 30 (ready) | | 30.10.09 09:30 | 30.10.09 09:30 |
| Engine assembly | A3 | R3 | 0:02 | 30 | 1:00 | 29.10.09 16:30 | 30.10.09 09:30 |
| Welding and painting | A4 | R4 | 0:10 | 30 | 5:00 | 29.10.09 11:30 | 29.10.09 16:30 |
| Engine | **En1** | | | 30 (ready) | | 29.10.09 11:30 | 29.10.09 11:30 |
| Frame assembly | A5 | R5 | 0:02 | 30 | 1:00 | 29.10.09 16:30 | 30.10.09 09:30 |
| Welding and painting | A6 | R6 | 0:05 | 30 | 2:30 | 29.10.09 14:00 | 29.10.09 16:30 |
| Frame | **Fr1** | | | 30 (ready) | | 29.10.09 14:00 | 29.10.09 14:00 |
| Body assembly | A7 | R7 | 0:02 | 30 | 1:00 | 29.10.09 16:30 | 30.10.09 09:30 |
| Welding and painting | A8 | R8 | 0:10 | 30 | 5:00 | 29.10.09 11:30 | 29.10.09 16:30 |
| Body | **Bd1** | | | 30 (ready) | | 29.10.09 11:30 | 29.10.09 11:30 |
| Assembly of CM1 with FP1 | A9 | R9 | 0:02 | 30 | 1:00 | 29.10.09 16:30 | 30.10.09 09:30 |
| Receiving and inspection | A10 | R10 | 0:05 | 30 | 2:30 | 29.10.09 14:00 | 29.10.09 16:30 |
| Component 1 | **CM1** | | | 30 | | 29.10.09 14:00 | 29.10.09 14:00 |
| Assembly of CM2 with FP1 | A11 | R11 | 0:02 | 30 | 1:00 | 29.10.09 16:30 | 30.10.09 09:30 |
| Receiving and inspection | A12 | R12 | 0:05 | 30 | 2:30 | 29.10.09 14:00 | 29.10.09 16:30 |
| Component 2 | **CM2** | | | 30 (ready) | | 29.10.09 14:00 | 29.10.09 14:00 |

## Integrated Planning Network Problems

Integrated Manufacturing and distribution systems have independent center streamlining issues in a SC. Underway manufacturing system, choices in regards to enlisting and terminating of work labor, customary time and additional manufacturing units, subcontracting, and machine scope levels are made for an unequivocal arranging skyline (i.e. approximately an one year period) whereas distribution units relate to figuring out which facility would indulge the requests of which market(s). In order to maximize profits in the organization, these issues are to be discussed together in an integrated approach. Establishing a centralized SC model commonly prompts complex models which are hard to tackle ideally. Therefore alternate procedures grew in to optimize goals for little to medium-size coordinated SC arranging models [16].

The following factors will be considered into account while building a complex- integrated manufacturing and distribution network in a supply chain system [17]:

- Quantity of every item created in extra time in every plant at every period.
- Quantity of each product outsourced by each manufacturing plant at every period.
- Work-in-Progress (WIP) stock sum in every plant at the end of every period.
- Inventory measure of completed items briefly put away in the stack cushions in every plant toward the end of every period.
- Quantity of every item dispatched from stack cradles to distribution centers amid every period.
- Quantity of every item dispatched from stack cradles, distribution centers, and straightforwardly to end-clients amid every period.
- Inventory of completed items put away in stockrooms at each period.
- Quantity of every item delay purchased in every end-client area toward the end point.

Because of the high number of choice variables, the issue displayed by the P–D frameworks examination is complex to the point that ideal arrangements are tricky to get. The challenges related with this kind of choice making can be further increased by the complex labyrinth of the system, geological compass of the SC Network. The reviewed model in this paper has been categorized into Multiple-product, multiple-plant, multiple warehouse, multiple-end user, multiple-transport path, no-time period P–D models. These models can be solved by developing a mathematical technique have been using SC network. Mixed integer programming technique tools were used to simplify these issues.

## CONCLUSION

It is evident from the current study that the integration in supply chain management systems will helps in overall development of the organization. Integration has eliminated the incompatibilities between the material and resource plans. Simultaneous planning of such networks will reduce the overall lead times. It also reduces the material overloads and increase the flexibility over the system plans.

By considering the integrated structure algorithms, schedule paths for the supply chain system has been developed. These planning ways encourage the execution of a substantial range of assembling procedures, going from stream to venture based assembling, inside an organization and adjusted in an incorporated environment of ERP and SCM.

A numerical simulation is performed with the real time data in a selected automotive manufacturing organization. It was identified that the manufacturing and distribution networks can be integrated using the unitary structure technique and the proposed technique can eliminates number of interfacing steps. In addition, the proposed system proves that the model is accomplished with the flexibility and maintainability for the future development of the organization.

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