INTEGRATED LOGISTICS IN THE VIRTUAL ENTERPRISE: THE PRODNET-II APPROACH

Alexandra Augusta Pereira Klen, Ricardo J. Rabelo, L. Marcio Spinosa and Aureo C. Ferreira

Federal University of Santa Catarina, Brazil –(klen, rabelo, spinosa)@gsigma-grucon.ufsc.br
G-SIGMA - Intelligent Manufacturing Systems Group

Abstract: This paper presents an overview on Logistics as a support tool for the configuration of Virtual Enterprises. This study was the basis used in the ESPRIT project PRODNET-II (Production Planning and Management in an Extended Enterprise) to guide the proposition of some advanced co-ordination functionalities (ACFs) which were created to avoid the business chaos when co-ordinating one or more distributed business processes of a Virtual Enterprise. *Copyright ã 1998 IFAC*.

Keywords: Logistics, Supply Chain Management, Decision support systems.

1. INTRODUCTION

Even more the use of technology is being encouraged for sharing and exchanging information right across individuals and organizations. This trend can be understood as a consequence of a new strategy of conducting business, which is the concept of Virtual Enterprises (VE). In the manufacturing sector, the Virtual enterprise is mostly composed of small and medium-sized enterprises behaving as suppliers and having no definite relations, policies and implications. So, it is not difficult to perceive the degree of complexity to manage this kind of value-chain as well as to coordinate the logistics of a distributed business process (DBP).

In this paper, firstly, a brief introduction concerning the emerging paradigm of Virtual Enterprise will be presented, followed by some definitions and terminologies used in this new field. Completing this frame, the distributed business process concept will be a little detailed so that the reader can have an idea about the involved elements.

Secondly, a summary of the logistics evolution according to periodic problems and demands of the market will be presented highlighting the better alternatives for the current customers' needs.

Then, the Integrated Logistics and Supply Chain Management concepts will be detailed taking into account the need for the development of adequate means to support the co-ordination of Virtual Enterprises systems as a whole.

Finally, the importance of suppliers qualification and general specification of partnership conditions, does not matter for how long the VE may turn out, will also be mentioned.

Concluding the paper, the identification of a general framework for the Integrated Logistics Management Support System (ILMSS) will be introduced as the main result of this work.

2. TERMS AND TERMINOLOGY

As a recent field of research, the networking of enterprises comes across many different terms aiming to describe this new strategy of conducting business: Extended Enterprise, Virtual Enterprise, Seamless Enterprise, Inter-Enterprise Networking, Dynamic Enterprise, Cross-Border Enterprise, and so on (Hunt, et al., 1997)

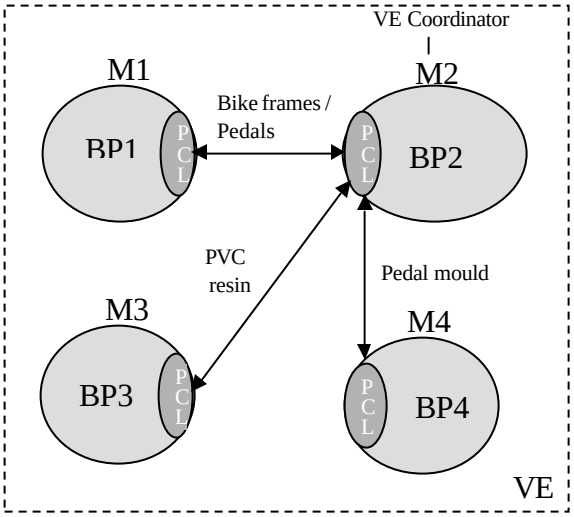
This work adopts the terminology and definition used by the Esprit project PRODNET II (Prodnet, 1996)

consortium for this matter of networking enterprises. They state that (Camarinha-Matos, et al., 1997):

> *Virtual Enterprise is a temporary alliance of enterprises that come together to share skills and resources in order to attend a business opportunity and whose co-operation is supported by computer networks and adequate Information Technology tools and protocols*

The next terms presented below are also refereed to the PRODNET II project and intend to help the understanding of this paper.

- *PRODNET-II project*: aims to design and develop an open platform to support industrial VEs with special focus on the needs of small and medium-sized enterprises.
- *VE life-cycle*: comprises the three main phases of a VE which are the creation, operation and dissolution.
- *VE members / nodes*: indicates the participants of the enterprise network.
- *VE co-ordinator*: is the one who manages and co-ordinates the distributed business process.
- *Advanced Co-ordinating Functionalities (ACFs)*: correspond to specialised software modules developed to help solving specific problems that require co-ordination actions within the VE, improving the management quality of the supply-chain.
- *Integrated Logistics Management Support System (ILMSS)*: one of the advanced co-ordination aspects which is being addressed by the Prodnet-II project. (see subsection 6 of this paper)
- *Prodnet Co-operation Layer (PCL)*: contains all the functionalities for the inter-connection between the enterprise and the entire net. It represents the communication and co-ordination role and works as the interlocutor of the enterprise within the net.
- *Production Planning and Control System (PPC)*: the most important component of the internal module of a VE node. The internal module represents the autonomous unit of a particular enterprise. It includes the complete structure of the enterprise's information and all the internal decision making processes / enterprise activity, such as the PPC system.
- *Distributed Business Process (DBP)*: a dynamic and temporary set of business processes (BP) that jointly gives rise to the end-product of the VE. In the figure 1, M1 to M4 represent the VE members 1 to 4, each one responsible for the BPs 1 to 4, respectively. The M2 is the VE Coordinator, i.e., the one responsible for the managing and coordinating of the DPB. In this case, 4 BPs (BP1, BP2, BP3 and BP4) compose the DBP.



VE = M1 + M2 + M3 + M4

DBP = BP1 + BP2 + BP3 + BP4

Fig. 1. VE representation.

3. OVERVIEW ON LOGISTICS

Many authors along the time have developed different definitions about logistics, according to fashionable topics or periodic problems. This may also have contributed to the large range of existing definitions and misunderstandings. Consequently, there is no universal definition for Logistics that could be adopted.

Although the plethora of definitions and terminologies, some authors concentrated their work on relevant aspects of logistics, enabling future views for designing efficient systems. This focus was also adopted in the review presented bellow, keeping in mind that the ultimate objective of this work is the development of an information system to support the co-ordination of a VE.

<u>The past</u>

Logistics has had its origin in a military discipline, being defined as (Pfohl, 1996):

> *The process by which human effort and facilitating resources are directed toward the objective of creating and supporting combat forces and weapons.*

In the 60's the new concept of "Business Logistics" was presented as an *integrated management tool.* Heskett et al. (1973) defined it as:

> *The management of all activities that facilitate movement and the co-ordination of supply and demand in the creation of time and place utility in goods.*

The so-called 7R's description of logistics (also referred to as the layman's description of logistics) says logistics have (Coyle, et al., 1992):

> *To ensure the availability of the Right product, in the Right quantity, and in the Right condition, at the Right place, at the Right time, for the Right customer, at the Right cost.*

The underline of availability is not the usual emphasis, but this definition expresses, without being very specific, the core of logistics. To ensure the availability of materials is a very practical objective. In logistics research, the problems and focus areas have changed in a subtle interplay between the "business situation" and the "stage of knowledge".

During the 70's there was much preoccupation with inventory turnover rates. Furthermore, the logistical costs increased in most companies and, at the same time, the cost of capital exploded. Computer-based administrative control systems were rapidly developed and, with the Material Requirement Planning (MRP) systems, *materials administration* became fundamental to the logistics discipline. At this time it was defined as (Møller, 1995a):

> *Materials administration may be defined as the view and the principles by which we seek to develop, plan, organise, co-ordinate and control the materials flow from raw material to final consumer.*

A more recent definition (Camarinha-Matos et al., 1995) states that:

> *Materials management is defined as the management of all materials/parts used in the manufacturing of a product, according to the production plan. It considers forecasting results and inventory levels. It is also responsible for the materials cycle management.*

The Information Technology revolution afforded a reappraisal of the logistics concept during the 80's. Even small and medium-sized enterprises (SMEs) had the availability to access computer-based administrative control systems like MRP systems. Electronic identification and communication opened up new opportunities for logistics. At this time, the organisational change towards logistical orientation and implementation of information systems was also of particular interest. According to the Council of Logistics Management (CLM) (Coyle, 1992):

> *The definition of logistics is the process of planning, implementing, and controlling the efficient, cost-effective flow and storage of raw materials, in-process inventory, finished goods, and related information from point of origin to point of consumption for the purpose of conforming to customer requirements.*

In this definition the emphasis is put on the process of planning, implementing and controlling, like in material administration. Furthermore, information is related to the materials flow as well as the customer is seen as the main or final objective, reflecting a universal tendency of viewing logistics activities.

The present and the future

In the 90's themes like globalisation, partnerships and environmental awareness are also being considered by SMEs (Møller, 1995b; Zubrod and Barron, 1996) and the emphasis on time is precisely presented as one of the most important factors in logistics (Scott and Westbrook, 1991).

Nowadays, logistics can be seen from either an internal or an external perspective (Christopher, 1994). The internal perspective focuses on efficiency achieved through co-ordination of the internal material flow and related aspects. It is attached to concepts like productivity, lead-times and costs. The external perspective contemplates material flow from the beginning to the end of the whole chain, i.e., it is focused on external and distributed efficiency. This perspective may be further divided into two views: a channel and a market view. The channel view approach premises for interactions along the value-chain focusing on relations between the main company and suppliers, transport contractors and customers. The market view approach premises for competing, focusing on causal relations to sustainable competitive advantages, and the influence of logistics, e.g. through customer service.

Another possibility of considering logistics concepts, most of them requiring future and further developments, is the one presented by Møller (1995a) (Fig. 2).

He categorises it into three main groups: 1) supplier-oriented, 2) production-oriented, and 3) distribution/customer-oriented. Besides that, these concepts are further classified into operational or strategic-oriented. Thus, it is possible to position (most of) the logistics related concepts such as: International Business Logistics, Marketing Logistics, Materials Administration, Logistic Management, Business Logistics, Supplier Management, Physical Distribution Management, Materials Management, Production Control, Physical Distribution, Material Handling, Logistics Engineering.

Taking into account the idea of internal and external perspectives presented before and considering the main purpose of this work for the PRODNET-II project, which was to guide the proposition of some advanced co-ordination functionalities for VEs, the Møller's classification was adopted due to the following reasons:

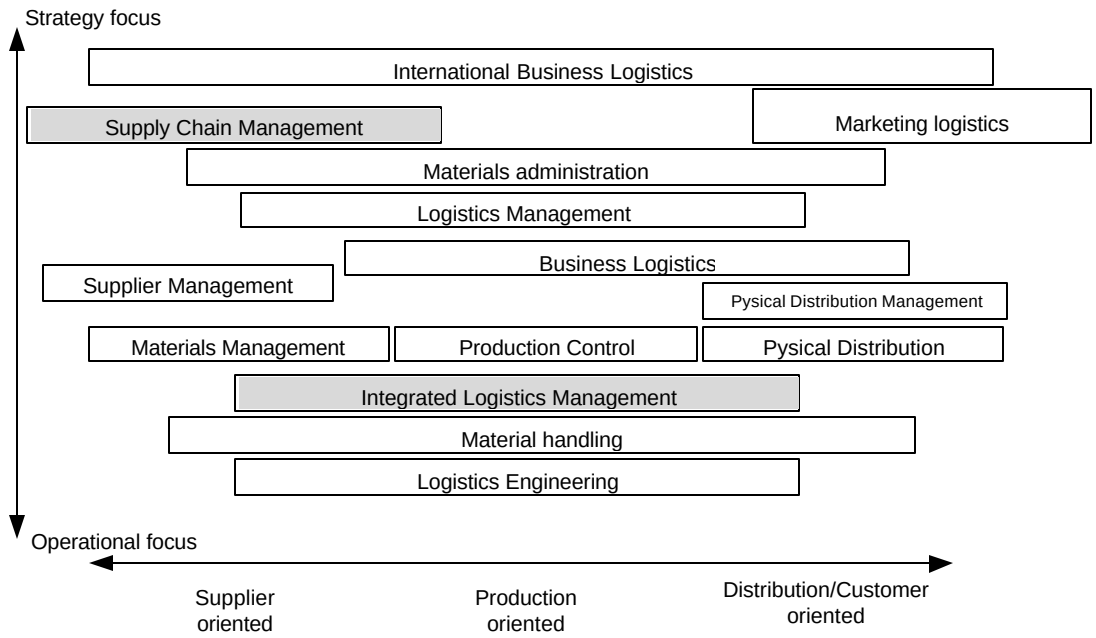


Fig. 2. A rough map of the concept of logistics (Møller, 1995a).

1. The Integrated Logistics Management (ILM) concept is focused on the operational level being mainly positioned as a production oriented concept, but not losing the links with the supplier and distribution/customer orientations.
2. The concept of Supply Chain Management (SCM) is clearly presented by having a strong strategic focus as well as being supplier oriented

In this sense, it was possible to idealise an Integrated Logistics Management Support System (ILMSS) which extends the intra-organisational logistics carried out by the classical PPC (Production Planning and Control) systems with a **higher-level vision about the VE's logistics**, giving rise to an inter-organisational logistics. The ILMSS is therefore embedded in a wider logistics framework, applying the emergent concepts of "integrated logistics management" at the operational level and the "supply-chain management" at the strategic level of the enterprise, covering some functions within the operation phase of a VE life cycle. The next subsection makes further reference to these two concepts.

4. INTEGRATED LOGISTICS / SUPPLY CHAIN

New logistics requirements, imposed by the virtual environment scenario, have provoked changes by what logistics is nowadays seen as an integrated or embedded flow of material and information that has to be managed as one entity from the raw material to the final consumer, i.e. along the whole value-chain, also evoking the concept of supply-chain management. For this new perception of doing business, offered by the VE philosophy, the employment of Integrated Logistics (IL), as a concept attending to the distributed relations, may help understand its implications in the true integration of the VE. The Integrated Logistics framework focuses on overall performance instead of on the performance of individuals, considering that the time is too short to exist multiple co-ordinating organisational levels and inventories (Christopher, 1994). This model increases the velocity to put the product in the market and the system seems to be flexible enough to respond quickly to ever changing customer demands. In this sense, logistics management becomes more business oriented, functionally integrated, customer focused, as well as more concerned with new technologies introduction and intensive information systems utilisation. Although no plan can be accurate as it is about anticipating the future in a highly dynamic environment, customer delivery date promises and logistics supply plans should reflect - in a much better way than most current systems provide - the detail of information available and also predict, in order to provide good control possibilities. Such controls need to have intelligent decision making as the basis and take into account the influence on flow (the material flow and, in the virtual environment scenario, mainly the information flow) through the supply network. Consequently, it is remarkable that Logistics is what definitely produces the links of the VE members, i.e. logistics activities are the threads, which tie the nodes of the VE web.

4.1 The Integrated Logistics Management

In the classical logistics framework, Figure 3, material flow is divided into supply, production and distribution, and logistics activities include inventories, transportation and an overall co-ordination of the materials and information flows within the company. In real life, these flows are fragmented by different organisations, functions and information systems, resulting in inventories. In this framework, the decoupling points have been used to co-ordinate tasks either by inventories or by other kinds of slack - time in particular.

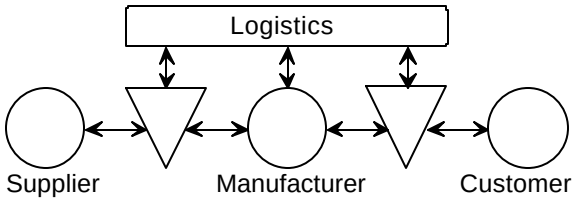


Fig. 3. The classical logistics framework (Møller, et al., 1994)

Here, single firms or single departments or functions, are no longer conceived as independent units, but as parts of a whole. The material and information flows are the shared objects that integrate the enterprise or the virtual enterprise. Logistics is then more than the storing and movement of materials. Logistics is an integrator of all activities and systems that directly or indirectly are related to material and information flows (Slats et al., 1995).
Summarising, in the integrated logistics:

- the focus is on the overall performance rather than on the performance of individual components, with material and information flows being managed as one entity. Integration is an important concept in the new framework and the material and information flows are seen as an integrator of several dimensions.
- there is no time for having multiple co-ordinating organisational levels, inventories, slack on other types of waste as used for co-ordinating material flow in the classical framework. Instead controlling the material and information flows is integrated in the supply chain structure.
- managing the structural premises for the material flow is more important than optimising the material flow to match the structural premises.
- integration of processes, departments, functions, organisations, disciplines, systems, etc., is strongly necessary, which means that managing relations and partnerships are therefore fundamental.

The conceptualisation of integrated logistics is illustrated in the shaded area of Figure 4. Logistics is seen as the competency that links an enterprise with its customers and suppliers. Information from and about customers flows through the enterprise in form of sales activity, forecasts, and orders. The information is refined into specific manufacturing and purchasing plans. As products and materials are procured, a value-added inventory flow is initiated that ultimately results in ownership transfer of finished products to customers. Thus, the process is viewed in terms of two interrelated efforts: inventory flow and, what concerns more to this work, information flow. The last one identifies specific location within a logistical system that has requirements. Information also integrates the three operating areas. The primary objective of developing and specifying requirements is to plan and execute integrated logistical operations. Without accurate information the effort involved in the logistical system can be wasted.

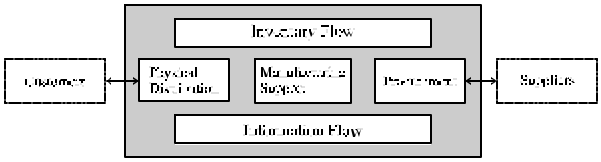


Fig. 4. The integrated logistics framework (Bowersox and Closs, 1996).

Viewing internal operations (the shaded area of figure 4) in isolation is useful to elaborate the fundamental importance of integrating all functions and work involved in logistics. While such integration is fundamental to success, it is not sufficient to guarantee that an enterprise will achieve its performance goals. To be fully effective in today's competitive environment, enterprises must expand their integrated behaviour to incorporate customers and suppliers. This extension, through external integration, is referred to as *supply chain management* and will be explained in the next.

4.2 The Supply Chain Management

It is recognised that for the real benefits of the logistics concept to be realised, there is a need to extend the logic of the logistics upstream to suppliers, and downstream to final customers. This is the concept of Supply Chain Management (SCM) (Leach et al., 1996; Christopher, 1994).

The scope of SCM covers the flow of goods from supplier through manufacturing and distribution chains to the end-user. This concept suggests a holistic approach to material and information flows management. Partnership and trust aspects are introduced as important elements in this kind of supplier relations.

SCM aims at maximising profit through enhanced competitiveness in the final market, what is achieved by a lower cost to serve it in the shortest time

possible. If the supply chain as a whole is efficiently co-ordinated, i.e. minimising total channel inventory, eliminating bottlenecks, compressing time frames and abolishing quality problems, that goals will be attained.

In many ways, SCM is the perspective for a new logistics paradigm, contributing for improvements in different forms:

- The supply chain is recognised as one entity, in lieu of fragmented and scattered activities along the material and information flows;
- A strategic decision making is required; and
- Integration between systems, instead of just interface is the rule.

Actually, the basic notion of supply chain management is grounded on the belief that efficiency can be improved by *sharing information* and by *joint planning*. Widespread realisation that co-operation is both permissible and encouraged has stimulated interest in the formation of supply chain relationships. It is even easier to remark as one observe the advances in terms of virtual relations. The VE, for a total concentration on their core competencies, require a reliable information sharing and trust on their logistical activities, what by its turn, may physically promote a full integration of the whole distributed business processes (DBP).

Figure 4 can now be modified to illustrate the extension of logistical integration from the internal co-ordination activities to include customers and suppliers. Figure 5 illustrates an overall supply chain focusing on the integrated management of all logistical operations from original supplier procurement to final customer acceptance.

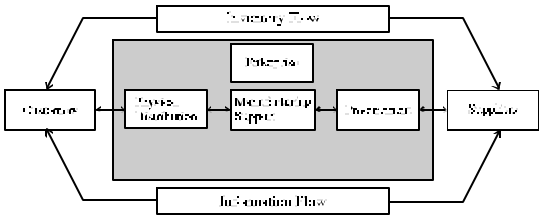


Fig. 5. Supply Chain integration (Bowersox and Closs, 1996).

5. SOCIAL AND ORGANIZATIONAL ASPECTS

From the social and organizational points of view, the application of the VE concept introduces new needs in terms of methods and contents of work as well as skills of the involved human resources. The new tendencies on management encourage people to participate throughout the supply-chain in decision making upon a business process, exploiting the synergy necessary to satisfy the customers. In a first step, it is necessary to provide methods to integrate and manage multiple and cross-functional teams (customers, suppliers and trading partners) activities, especially those which cause a directly impact in the customer. Then, it is necessary to make individual learning becomes collective learning.

Since the VE brings new requirements in terms of expertise to accomplish its associated activities, an important aspect is related to the adaptations or new people functions. These activities, such as business processes management, on-line negotiation, re-planning, information requests, information reception and rapid decision-making related to the demand and the constant changes imposed by the market, etc., are more and more performed with the support of computer tools, usually with strong link to a network (such as the Internet). Hence it demands a continuos training of people as well the adaptation of some functions (in their nature, levels of responsibility and number of people or procedures involved) according to the information technology needed, available and used.

6. CONCLUSIONS

All the literature research and the conceptual work presented in this work was actually motivated by the need to identify the some advanced co-ordination functionalities (ACFs) in order to try to avoid the business chaos when co-ordinating one or more DBPs of a VE.

One of the identified ACFs is the Logistics Support that aims to support means to get, provide, and to manage the information from and about a VE, enabling the enterprises to make their logistics more efficiently. Hence this ACF aims to create a system that incorporates part of the concepts from the Supply Chain Management and, mainly, from the Integrated Logistics Management. This system is then called as Integrated Logistics Management Support System (ILMSS).

The ILMSS has the objective to provide an enterprise with an integrated environment. The system is modular comprising, basically, two main interactive and co-operative modules: VE Supervisor (to monitor the DBP execution) and DSS (Decision Support System, to help the user in the decision-making process based on the information got by the VE Supervisor) (Figure 5).

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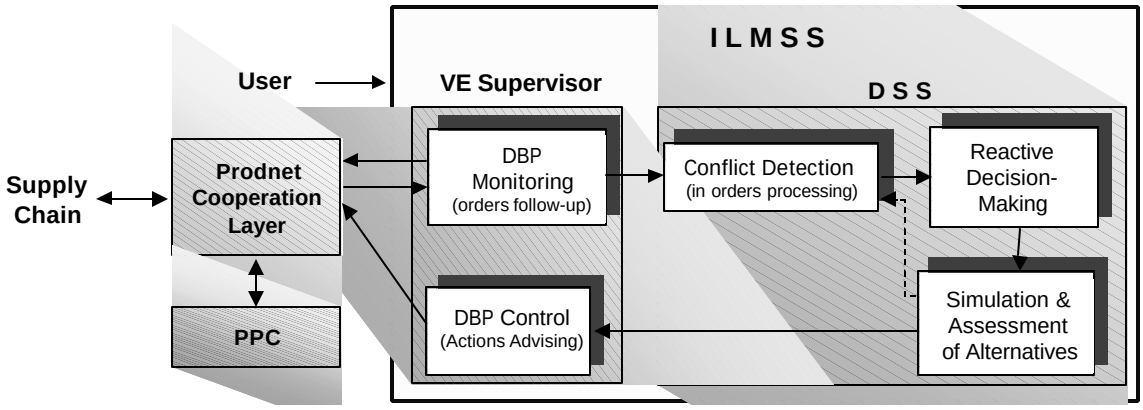

Fig. 5. ILMSS Architecture

It is important to point out that considering:

- the ILMSS complexity,
- the innovative aspects intended to be investigated, and
- the open questions still presented in the VE paradigm,

the experiments to be exploited by each ILMSS module should have their scope and scenarios very limited and tested only in the Prodnet project platforms. Besides that, they shall be oriented to the demonstration pilot prototype, even because it is still not clear the possible overlapping between some PPC functionalities and those ones the ILMSS should have.

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ACKNOWLEDGMENTS

The authors would like to thank CNPq (The Brazilian Council for Research), project ProTeM-CC 680120/96-3 PRODNET-II, and European Union, Esprit project 22647 PRODNET-II for the financial support.