Extended Enterprise Integration Model Associated with Automation Index

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Abstract — **The enterprise of the years 2000 are facing competition in various fronts, like reduction of product life time, increase of diversification, reduction of customer response time, competition internationalization. Due to those factors, it became necessary to reach a higher degree of relationship between the enterprise and suppliers network and customers networks, avoid unnecessary costs and response time between then. Besides that, the utilization of automation is not necessarily done with balanced criteria, creating isles of excellence divorced from the rest of organization. The paper proposes a integration model of the Extended Enterprise that associates automation growth with business process model of the organization in order to create an integration environment that will minimize the application, maintaining the information flows as balanced as possible. The integration status is obtained applying the same level of automation in the various activities of the business processes, measured through automation indexes, resulting in a model which levels of integration of the Extended Enterprise and discussed in a holistic mode.**

Keywords - Extended Enterprise; Automation Index; Business Process; Integration; Information Technology.

I. INTRODUCTION AND OBJECTIVES

In this century, companies are facing changes due to the competition and so a need of fast response previewing the clients' demands is quite mandatory. Besides to focusing on the customer, it is also important to establish partnerships with suppliers and create strategic alliances in order to increase business agility and reliability and to meet market needs. However, fast responsiveness requires changes in both internal and external processes mainly with respect to the relationship with customers and suppliers. In this context, the concept of the Extended Enterprise arises.

Extended Enterprise need new ways of organization and collaborative management, providing them an integration status of their internal and external activities. It was a thought, mainly in the 90s, that this integration status could be achieved through massive application of Information Technology resources. Although the promise that Information Communication Technology (ICT) would connect people, processes and information, current implementations are strongly document-oriented, and the difficulties of integration between companies remain [1].

Nevertheless, the use of Information Systems is a key success factor, since they have potential to integrate business processes inside the company and between related suppliers and customers.

The extended enterprise can be seen as an evolution of the Integrated Supply Chain, because all interrelationships are based on rules and contracts, and nave as principle, that everyone should win whith the transactions, sharing equivalently all the gains and risks of the business, and this success depends on the collective performance rather than isolated parts. To this purpose it is important to manage all the interfaces between organization, consumers and suppliers, in order to ensure a synchronized supply for all the supply chain.

Integration of the Manufacturing System is a prerequisite to obtain the attributes of competitiveness, i.e., leadership and responsiveness. The Business System integration represents an organization state, reflected in the ability to move information synergistically between their process and activities [2].

The business processes integration and the information technology has been one of the key factors for a successful execution of an integrated enterprise system [3].

The objective of this paper is to propose a conceptual integration model for the extended enterprise. The integration model will be based on automation application, through the utilization of automation indexes.

This paper is structured as follows. In Section II, the literature review will be present. In Section III the automation indexes definition will be discussed. In section IV the proposition of the extended enterprise integration model is expanded. Section V presents the possible configuration for the extended enterprise integration model and in Section VI focuses the conclusions.

II. LITERATURE REVIEW

In order to contextualize the Extended Enterprise and the Integration model, it will be presented a review of the main concepts of Collaborative Network, Extended Enterprise, Supply Chain, Business Process, application of automation and definition of Automation Indexes.

Collaborative Network is "a network consisting of a variety of entities that are largely autonomous, geographically distributed, and heterogeneous in terms of

their operating environment, culture, social capital and goals" [4].

The concept of Extended Enterprise emerged at the same time as other concepts that emphasize the inter-organizational collaboration such as: virtual enterprise, supply chain and enterprise network [5]. It refers to the collaborative relationship between supply chain members, from which buyers and sellers obtain a competitive advantage and achieve higher customer satisfaction against other supply chains [6]. The extended enterprise is an evolution of the integrated supply chain and can be considered as a complete set of collaborative companies, both upstream and downstream, from raw material to the final consumer, working together to bring value to the market. The advantages of the Extended Enterprise derive from the ability of companies to use their full network of suppliers, vendors, customers and clients [5]. The extended enterprise may also be defined as: "A conceptual business unit or system that consists of a purchasing company and suppliers, who collaborate closely so as to maximize the returns to each partner". The extended enterprise is a philosophy where member organizations (EE actors) strategically combine their core competencies and capabilities to create a unique competency [7].

According to [4], extended enterprise represents a concept typically applied to an organization in which a dominant enterprise ''extends'' its boundaries to all or some of its suppliers. An extended enterprise can be seen as a particular case of a virtual enterprise.

During the two last decades, there was a fast growth of the inter-organizational collaboration. Managers and academic researchers representing different areas, as diverse as marketing, economics, marketing, economy strategy and sociology, have carefully studied the inter-organizational network, joint-ventures, coalitions, extended enterprise, partnerships and alliances [5]. In an extended enterprise, which usually involves complex supply chains, the main concern is related to the integration of all members of the supplier and distribution chains, which share a common goal - to obtain a market share through the product realization [8].

In the XXI century, it is expected that the competition will occur between value chains effectively integrated into their competences and resources, in order to compete in a global economy [7]. The extended enterprise also reflects the high level of interdependence between organizations and how to conduct businesses [9]. There are similarities between value chain, supply chain and extended enterprise. At low-levels of integration there are no major differences. The differences emerge when the level of integration and collaboration increase [6]. Managers and researchers recognize that there is a critical interdependence between companies, customers, investors and communities. Such dependence cannot be described only on the basis of a contractual exchange because it involves interactions and network effects. The effective management of the extended enterprise requires both a concept and a approach to practical issues that emerged in this scenario [10]. The Council of Supply Chain Management Professional (CSCMP) considers that: "Supply chain as encompasses the planning and

management of all activities. Importantly, it also includes coordination and collaboration with partners, which can be suppliers, intermediaries, third party service providers, and customers" [11]. This is the definition adopted for the present work.

The Association for Operations Management (APICS), has the following definition for supply chain management [12]: "The design, planning, execution, control, and monitoring of supply chain activities with the objective of creating net value, building a competitive infrastructure, leveraging worldwide logistics, synchronizing supply with demand, and measuring performance globally".

Companies need access to accurate information in real time in order to meet the growing challenges of globalization and the reduction in the product life cycle. To a large extent, especially in the last two decades, the use of information technology, mainly based on Enterprise Application Systems (EAS), have allowed companies to respond effectively to the dynamic changes in business [13]. In that sense, it is reasonable to say that information technology is the key to the integration of the extended enterprise. Along with business process reengineering, strategic alliances and management changes, IT can be deployed to enable the planning, control, integration of decisions, information integration and integration of business processes, which may allow companies to operate in the extended enterprise as if it were a single company [6].

Business process management (BPM) is seen as both an IT development, as well as an implementation of quality management, being knowledge and information key factors for its success [14]. According to [14], business processes constitute a "systemic approach to design and continuously improve the organizational processes, by potentialized people and team work, combining emergent technological competences and under a philosophical stance for quality, aimed at delivering value to customers". Also, according to [2], a business process is a set of activities, logically ordered according to precedence rules. The activities and were developed from the definition of manufacturing as a system which can be interpreted as the composition of all business processes and activities.

Business process management is an integral part of today's enterprises, in particular those related to e-business, because the efficiency and effectiveness of the underlying business processes have become a major source of competitive advantage of companies. The process design is the foundation and a critical component of BPM, where new business processes are developed to meet the needs of business problems or existing processes are reviewed to improve company performance [15].

Enterprise integration is the process of ensuring the interaction between enterprise entities necessary to achieve domain objectives. Enterprise integration can be approached in various manners and at various levels as - (i) physical integration, (ii) application integration and (iii) business integration [16].

As a consequence of changes in the competitive environment and marketplaces, in the middle of '90s the EE model started to be analyzed in the engineering

manufacturing and operations research literature [17].

III. AUTOMATION INDEX APPLIED TO BUSINESS SYSTEM

Automation, when seen as an available technology provides mean for the information flow in each activity of the automation system. In this research the programmable automation is used. Automation is programmable when the human attribute is substituted by the computer program [2].

The automation index developed by [2], applied to quantify automation, is defined as follows:

$$i_A = \frac{n_A}{n_T}$$

where:

i_A = automation index

n_A = number of human activities replaced by devices or instruments with an automation concept

n_T = total number of activities performed by humans

It can be argued that $0 \leq i_A \leq 1$, with the boundaries limits:

$i_{A=0}$ - all activities are performed by humans

$i_{A=1}$ - all activities performed by humans are replaced by automation devices,

This definition of automation index is applied to a Business System [2], whose model is shown in Figure 1, considering the main business processes grouped in four groups - Engineering, Shop Floor, Support and Commercial. To facilitate understanding, each group is broken in sub group of business processes, as shown in Figure 1. It is considered that information flows inside each group through the activities of the correspondent business processes, and outside the groups, performing the links between the four groups themselves.
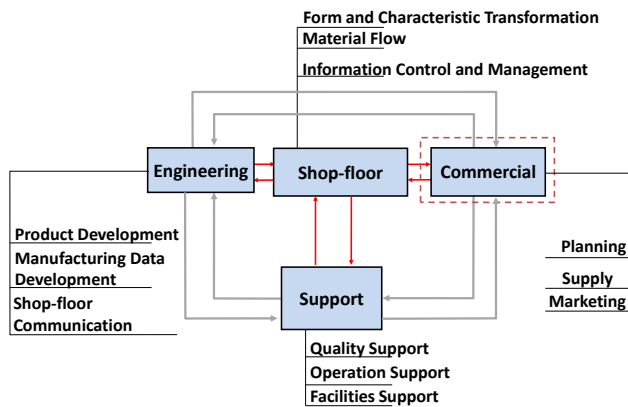

Figure 1 - Business System Model [2]

The automation index for each group and subgroup of business processes will vary as follows:

$$0 \leq i_A \leq 1$$

Each block of process and activities can be represented by a three axles diagram, with the automation index i_A

varying from 0 to 1 at each one of the axles. Taking in account the automation indexes, it is defined [2] *that the business systems will have structural integration if the automation index i_A is approximately the same in numerical terms, for each one of the business process groups and sub groups.* Automation indexes with approximately the same numerical values mean the information flow with the same technological degree of automation; consequently with the same interfaces, facilitating the synergies the exchange information flow between the activities. The level of organization maintains coherence with the degree of automation for each architecture.

The four blocks of activities, associating the approximate numerical values of i_A for the twelve axles is shown in Figure 2. This Figure is shows, one condition of structural integration of high the business system.
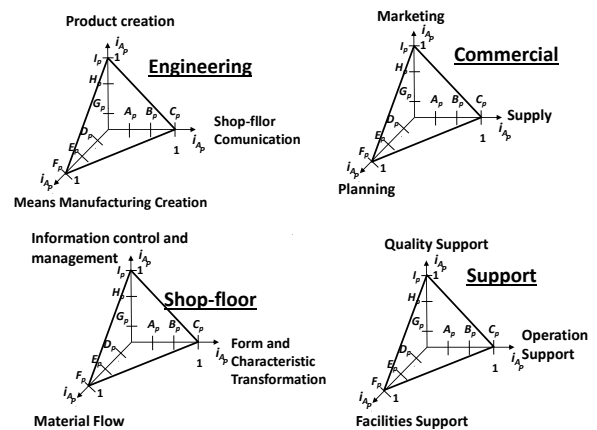

Figure 2 – Manufacturing system with total integration activities [2].

IV. INTEGRATION MODEL ASSOCIATED TO AUTOMATION INDEXES APPLIED TO THE EXTENDED ENTERPRISE

A. Integration Model definition

Integration of the Business System is a prerequisite to obtain the attributes of competitiveness, such as innovation and responsiveness. This article proposes a integration definition, by which the Business System integration represents an organizational state, reflected in the ability to move information synergistically between their activities and sub activities [2]. The information will flow synergistically if the level of automation of the several activities of the Business System is approximately the same in the activities of the Business System. The level of automation will be measured by the automation indexes.

Total Structural Integration Manufacturing System is achieved when it provides harmonic growth of automation, with approximately the same rate in the coordinate axles as shown in Figure 2. One can defined harmonic growth of automation if the indexes i_A increases simultaneously their numeric value at the same rate in the three activities axles [2].

Harmonic growth of automation, measured by their indexes, as well as ensure structural integration in various manufacturing system architectures, provides important

strategic tool to obtain the attributes of competitiveness [2].

B. Business Processes in the Extended Enterprise

As shown in Figure 1, the block of the business system processes that interfaces with customers and suppliers is the Commercial one, deployed in the sub-set of business process of Planning that interfaces with the Shop Floor business processes.

Each one of the Supplier and Customer set of business processes can be associated to the Business System model shown in Figure 1, as each one represents a Company or Organization, so can be represented according to Figure 3.

Extracting from model in Figure 1 adopts the commercial set of process as link with suppliers, customers business process as Figure 3.
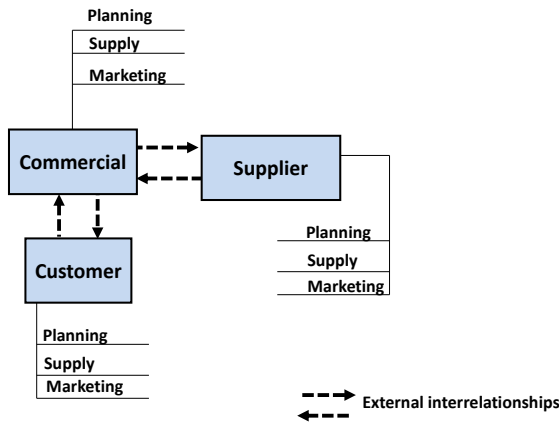

Figure 3 - Business Processes in the Extended Enterprise
Source: Based [2]

a) Commercial – Set of processes that interfaces with both customers and suppliers. It is the place in which the product is assembled and finished so that it can reach the final consumer, through final distribution.

b) Suppliers - Set of business processes that supplies raw material and finished parts to the Organization. The set of all suppliers of the constitutes the supply chain network. Among the suppliers, there are those with high level of automation and integration and those with near-zero automation and low integration.

c) Customers - Set of business processes that allow the Organization market to sell its products, and include the final consumer, chain stores, wholesalers, retailers, utilities, etc. The set of all customers forms the customer network. As in the supply chain network, the automation and integration rates vary among customers. The customer network is responsible for distributing the finished product and deliver it to the consumer.

After the conceptualization of enterprise integration model using automation indexes [2], the same concepts will now be applied to the extended enterprise. In order to perform these concepts, the extended enterprise model will

be those from the Figure 3, where the Commercial will interface with the suppliers and customers network. The determination of the extended enterprise model will use the integration concepts developed in [2]. So, the application of automation in the organization business process can be classified in three different discrete points, as shown in Figure 4, represented by the three-orthogonal axles of marketing, supply and planning.

- Automation indexes tend to 0.33, meaning mostly manual activities and use of paper lists;
- Automation indexes tend to 0.66, meaning mostly usage of individual computers without a network connection, running individual software, without integration between them.
- Automation indexes tend to 1, meaning mostly usage of integrated business systems, such as Enterprise Resource Planning (ERP), Customer Relationship Management (CRM), Supply Chain Management (SCM), Engineering software, Manufacturing Execution Systems (MES), etc., running in distributed environment, connecting mid range computers and data storages.
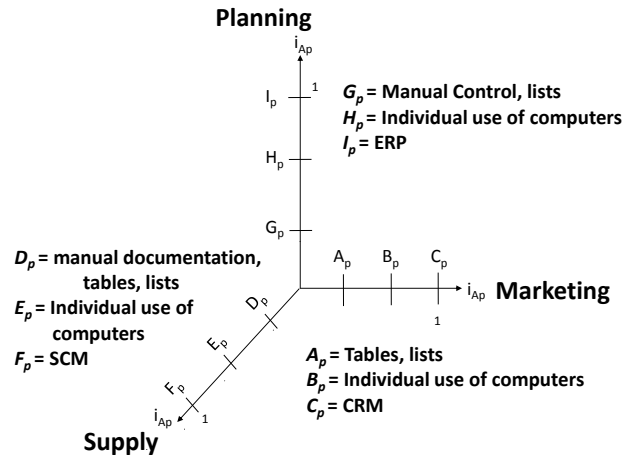

Figure 4 - Automation application of commercial business systems [2]

C. Proposal of Extended Enterprise Integration Model

The proposal of Extended Enterprise Integration Model associated with automation index achieves its excellence when the three activities – supply, marketing and planning – are in the approximate automation index level and in both internal and external business process of the organization.

To exemplify the integration concept using the automation index harmonic growth see Figure 5. Assuming that the suppliers and customers have the same structural model, the integration of the extended enterprise can be obtained when the automation indexes of the commercial, supplier and customer business processes have automation approximately the same automation index values.
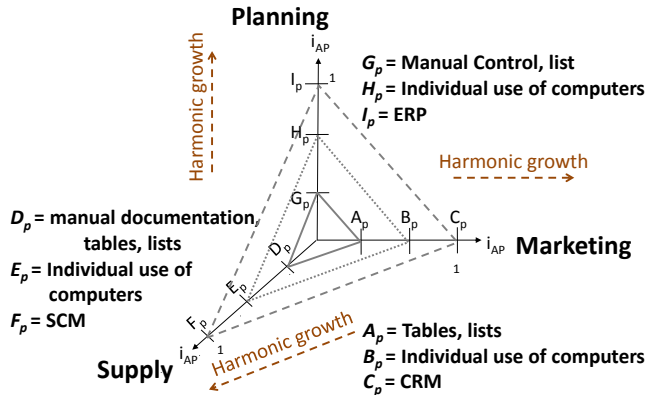
Figure 5 - Commercial business processes level, with approximately the same values of automation indexes in the three axles [2].

Figure 6 shows various configurations of Extended Enterprise Integration, when the commercial has the full integrations, and the Supplier and the Customers present different configuration.
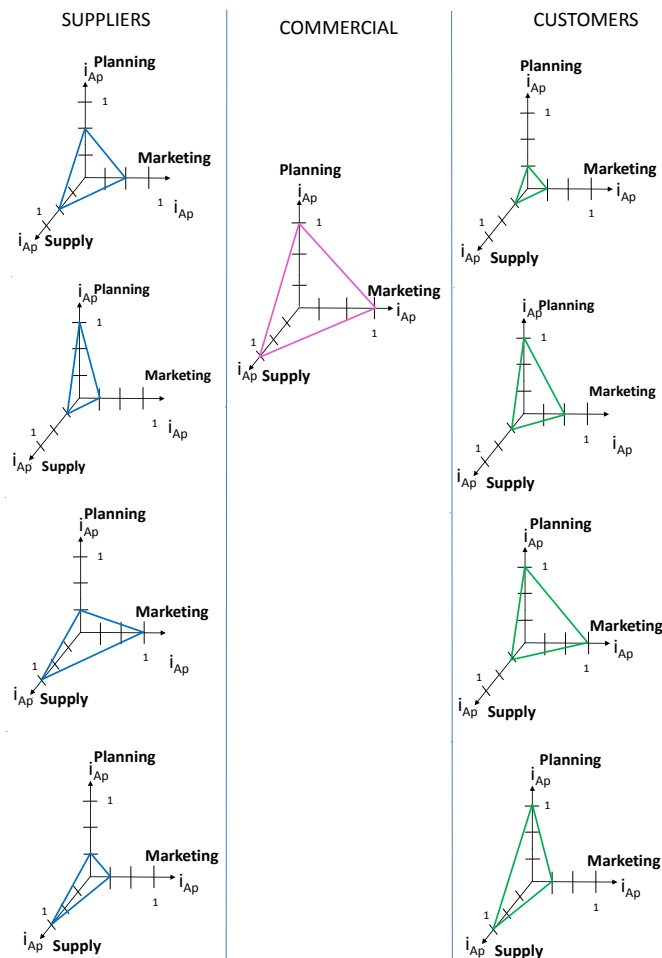

Figure 6 – Possiblities of configurations of Extended Enterprise Integration

To clean up the graphic representation, plan one will be used where the nine axles in "radar form" are shown according to
Figure 7.

Figure 7 describes the plan representation for the extended enterprise integration model associated with the automation index varying from 0 to 1, where:

- i_{CoS} - commercial automation index related to supply activity.
- i_{CoM} - commercial automation index related to marketing activity.
- i_{CoP} - commercial automation index related planning activity.
- i_{SS} - supplier automation index related to supply activity.
- i_{SM} - supplier automation index related to marketing activity.
- i_{SP} - supplier automation index related to planning activity.
- i_{CS} - customer automation index related to supply activity.
- i_{CM} - customer automation index related to marketing activity.
- i_{CP} - customer automation index related to planning activity.
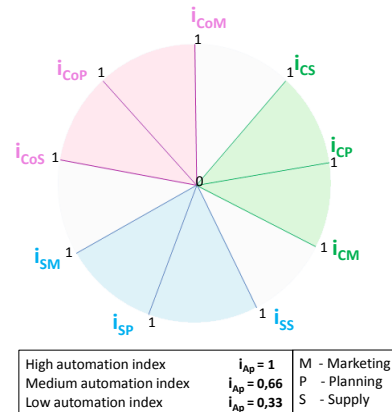

Figure 7 - Representation of integration model in "radar form"

Possible configurations of extended enterprise integration model in radar form will be analyzed in the following section.

V. POSSIBLE CONFIGURATIONS FOR EXTENDED ENTERPRISE INTEGRATION MODEL

A. Low integration of extended enterprise and among Commercial, Suppliers and Customers

Where Commercial Business is without integration due to high values for i_{CP} and low values for I_{CS} and i_{CP}, Supplier without integration due to high values of i_{SM} and i_{SP} and low

values of i_{SS}, and customers without integration due to high values of i_{CS} and i_{CM} and low values for i_{CP}. Figure 8 shows the plan representation for this condition where dashed lines represent the integration level between activities and the continuous lines represent the integration level between companies.
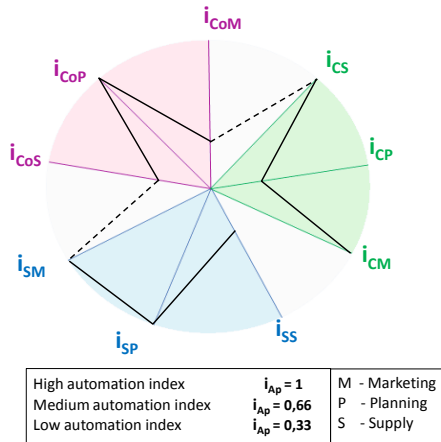

High automation index	$i_{Ap} = 1$	M - Marketing
Medium automation index	$i_{Ap} = 0,66$	P - Planning
Low automation index	$i_{Ap} = 0,33$	S - Supply

Figure 8 - Automation without structural integration in both: activities and extended enterprise

B. High integration of Commercial processes, but low integration with Customers and Suppliers.

The situation in which there is integration among the activities of each company is describe in Figure 9, but there is no transorganizational integration in the extended enterprise taking in account that each organization has the same numerical values for each axle but they are not the same for the three companies.

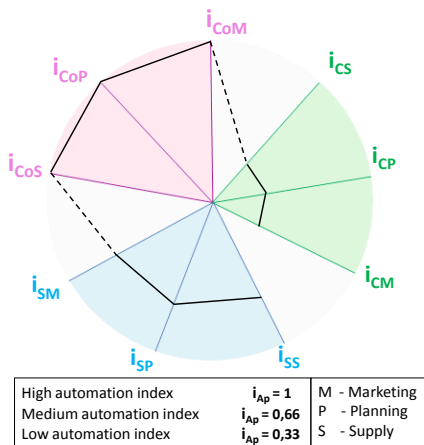| High automation index | $i_{Ap} = 1$ | M - Marketing |
| Medium automation index | $i_{Ap} = 0,66$ | P - Planning |
| Low automation index | $i_{Ap} = 0,33$ | S - Supply |

Figure 9 - Integration inside the companies, but without transorganizational integration.

The Commercial processes have integration between the set of activities with automation indexes close to 1, but the customers, even though present internal integration, have low values of automation indexes which does not allow

integration with the Commercial processes. It is the same situation with the supplier: even though this supplier is internally integrated, it presents a medium automation index, and does not reach integration with the Commercial processes. In this case, the Commercial provide resources that cannot be shared with customers and suppliers. So, there are situations where there are unequal investments in Information Technology. In this configuration, the Company acquired an ERP system but still uses tables and lists to communicate with customers and suppliers, e.g., via Fax.

Besides the usage of ERP system, the company still uses tables and lists to communicate with customers and suppliers, e.g., via Fax. On the other hand, the customer employs a manual planning but has a CRM to communicate with clients and a SCM to communicate with suppliers. In addition to that, the supplier has an ERP system, uses CRM with its Customers but communicates with its suppliers manually, and in this configuration does not use information systems with their customers.

C. Extended enterprise with total structural integration

This configuration is the best situation for the extended enterprise: there are three situations, as shown in Figure 10, where all extended enterprise has the approximately same automation index, both inside the companies and between companies. There are three automaation situations - high ($i_A = 1$), medium ($i_A = 0,67$) and low ($i_A = 0,33$) integration.
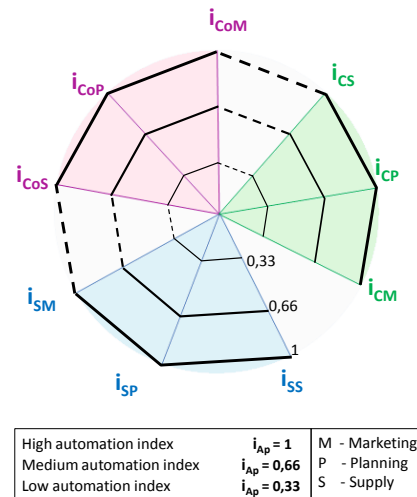

High automation index	$i_{Ap} = 1$	M - Marketing
Medium automation index	$i_{Ap} = 0,66$	P - Planning
Low automation index	$i_{Ap} = 0,33$	S - Supply

Figure 10 - Extended enterprise with structural total integration

VI. CONCLUSIONS

The proposal of an Extended Enterprise Model with characteristics of integrating the enterprise itself, its customers and suppliers was presented. The integration is obtained through the application of automation indexes with approximately the same numerical value in the nine axles. The integration concept developed in this paper is based upon equivalent numerical values of the automation indexes that will facilitate the information flow, due to the fact that,

with equivalent numerical values of the automation, the information exchange interfaces have the same nature and technology.

This concept of integration applied to the frame - Commercial, Supply Chain and Customers networks presents an extended enterprise architeture that will enable the supply chain and customers network to operate in optimal conditions, diminishing the response time and saving resources.

The application of this research will be made in an automotive extended enterprise.

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